



THIS TRUCK SAVED MY LIFE!



LESSONS LEARNED FROM THE MRAP VEHICLE PROGRAM

MRAP PROGRAM EVENTS AND MILESTONES

2006	February:	Initial USMC I MEF UUNS issued for 1,169 MRAP Vehicles (not approved)
	May:	Multi-National Force-West Commander requests 185 MRAP vehicles
	July:	Multi-National Force-West Commander requests 1,000 MRAP vehicles
	November:	USMC sole-source contract awarded for up to 280 MRAP vehicles MRAP Vehicle Program initiated with staff of less than ten government and contractor personnel ASN (RD&A) appointed as program MDA AMCB calls for 4,066 MRAP vehicles to support Service requirements USMC issues first MRAP Vehicle Program RFP
	December:	FY 2006 funding \$170 million
2007	January:	USMC awards ID/IQ production contracts to nine companies (includes \$36 million for 36 test vehicles)
	February:	JROC approves joint requirement for 1,185 MRAP vehicles MROC validates USMC need for 3,700 vehicles ASN (RD&A) approves MRAP Vehicle Program Milestone C starting production First two production orders authorized for 395 vehicles (\$246 million) MRAP Vehicle Program designated as an ACAT II (major) program First test vehicles arrive from FPI and Phase I developmental testing initiated
	April:	Procurement of additional 1,000 MRAP vehicles authorized First MRAP vehicle fielding by MRAP Vehicle Program in Iraq
	May:	JROC validates need for 7,774 vehicles SECDEF designates MRAP Vehicle Program #1 DOD acquisition program DOD MRAP Task Force stands up Procurement of additional 1,214 MRAP authorized; total to date 2,853 vehicles JROC approves MRAP vehicle CPD defining MRAP vehicle requirements ASN (RD&A) establishes the Joint MRAP Vehicle Program
	June:	DX Rating approved Procurement of 912 MRAP vehicles authorized; total to date 3,765 vehicles Initial threshold testing of MRAP vehicles completed
	July:	Procurement of 1,925 MRAP vehicles authorized; total to date 5,690 vehicles
	August:	Procurement of 725 of MRAP vehicles authorized; total to date 6,415 vehicles
	September:	JROC validates requirement for 15,374 vehicles USD (AT&L) designates the JMVP as an ACAT ID acquisition program and appoints Commander, MCSC as the JPEO
	October:	Procurement of 2,400 MRAP vehicles authorized, total to date 8,815 vehicles JPO MRAP Forward established in theater
	December:	Procurement of 3,126 MRAP vehicles authorized; total to date 11,941 vehicles. MRAP II test vehicle procurement authorized FY 2007 MRAP funding \$5.4 billion
2008	February:	First MRAP vehicle fielded in Afghanistan
	March:	Procurement of 2,270 MRAP vehicles authorized; total to date 14,211 vehicles JPO MRAP Test Team receives NDIA Test Team of the Year award

Continued on inside back cover.

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LESSONS LEARNED FROM THE MRAP VEHICLE PROGRAM

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LESSONS LEARNED FROM THE MRAP VEHICLE PROGRAM

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Mine-Resistant Ambush-Protected Vehicles

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AUTHOR'S FOREWORD

The subject of this book, the *Mine-Resistant Ambush-Protected Vehicle Program*, was unique in many ways. “MRAP” meant a vehicle that could survive in the face of the mines, roadside improvised explosive devices (IEDs) and ambushes the enemy mounted throughout Iraq and Afghanistan. The program moved with lightning speed—one member of the team described it as “MRAP Speed”—not seen in large defense programs since World War II. It produced a flood of vehicles on such a scale that it was the largest single defense acquisition program in Fiscal Year (FY) 2010—an amazing fact given that the program did not even exist in FY 2006.

Now that the MRAP program has produced its final vehicle and the Joint Program Office (JPO) that directed the program stood down on 30 September 2013, and JPO responsibility for MRAP vehicles officially ended on 19 December 2013, several questions are worth answering:

1. Did the MRAP program matter?
2. How did it move so fast, when most Defense programs move much more slowly?
3. Does the MRAP program carry lessons that can make the overall defense program more agile? What is the price of agility, and is it more important now during a period of increasing fiscal constraints?

This book is written to answer these questions by providing a history of the program. To deal with the fundamental questions, that history has to be told in thematic terms. So much happened in parallel that a chronology would be misleading. It would fail to convey the special character and achievements of the MRAP program.

The answer to the first question is simple. The MRAP program mattered enormously. It dealt with the enemy's most effective weapons: mines and roadside bombs IEDs. The MRAP vehicle was far from the only counter the United States deployed, but it was particularly significant because it was the one that convinced the troops on the ground that they were protected, hence that they could go about their main job of dealing with the enemy. The answer to this question demonstrates the significance of the second question. Had the MRAP vehicles been absolutely wonderful, but had they not been produced in sufficient numbers fast enough, they would not have mattered. The engineering was excellent, but those running the program and delivering the “goods” got them to the troops soon enough to matter.



Much of this book is about how the MRAP program ran. It helped enormously that Secretary of Defense Robert M. Gates recognized the program's importance and made it the number-one Defense Department program, with the Defense Priorities and Allocations System (DPAS) highest-priority DX rating. Without his initiatives, the flood of vehicles could never have been produced, because it took a Secretary of Defense to deal with many of the resource issues and "rice bowls" involved. In that sense the MRAP program may be the clearest example of what a strong Secretary of Defense can achieve. However, the Marine Corps project management team had already set much of the shape of the program, and much of the internal culture that made it successful, in the fall of 2006. Without the Marines' program, Dr. Gate's initiatives would never have happened. Without Dr. Gates, no one but Marines—in addition to a handful of Navy SEALs—could have ridden in MRAP vehicles, and they would not have had the impact they did. Everyone involved deserves credit: BRAVO ZULU!

The new vehicles had to be sustained in theater. It turned out that the original sustainment plan, which was conceived when the MRAP program was a relatively small Marine Corps program, could not grow to encompass the much larger number of vehicles fielded when the Army joined the program

in a large way. An entirely new sustainment system had to be developed and fielded. Like MRAP vehicle production, it had to move far more rapidly than a conventional support program. Without it, the flood of vehicles in the field would soon have been reduced to idleness. Like the MRAP vehicle production program, the sustainment proved extremely successful. This mechanism was as radical as the production program. It included a substantial dedicated training element. Those involved likened developing the sustainment program to building an airplane while flying it.

The third question is more difficult to answer, and to some extent it is up to the reader to decide to what extent future programs should or can look like Joint MRAP Vehicle Program. After 9/11, for example, the U.S. Navy took the view that the surprise attacks on the United States demonstrated that it was no longer possible to plan on the basis of set scenarios; the United States had to become far more agile. In the past, long program schedules have been accepted because it seemed fair to assume that little would change other than technology: we will need a fighter in, say, 2020, but it will have to incorporate the technology being developed between now and then. During the past few years there has been increasing interest in disruptive—i.e., unpredicted but significant—technologies that make that sort of thinking obsolete. Although IEDs were not new, the scale on which they were used in Iraq and then in Afghanistan was. Something fundamentally new was needed on our side to frustrate and defeat our enemies. Among a host of initiatives aimed at solving the IED problem, the MRAP vehicle program was the largest and probably the most significant.

If the future involves more and more disruptive kinds of attack by our enemies, there will be a higher and higher premium on our own agility. Before 2006, many would have said that the United States had lost much of its agility. Its only hope seemed to be small numbers of very advanced devices, usually mainly electronic, that might deal with the enemy's new technology. If electronics were not the answer, it seemed that the United States had lost the ability to adjust by rapidly producing massive quantities of equipment and weapons. The MRAP vehicle program is proof that we retain a lot more industrial agility than we might imagine.

To explain the difference between the Joint MRAP Vehicle Program and other defense programs, this history includes some brief comments about the character and logic of conventional, business-as-usual defense programming. Otherwise it would be difficult to see how and why the MRAP vehicle program represented a dramatic departure. It should be emphasized that the current defense system, with all its sluggishness, is not the result of some kind of demented bureaucratic inertia. It is the result

of the experience of the Cold War, not least the need to achieve affordable defense during a long-term struggle, and also of a world technological situation that is now changing. Disruptive technologies were relatively rare in the past, but they seem likely to be more and more significant in the future. It is for the reader to decide whether the existing logic remains valid under whatever changed circumstances we now experience, particularly after 9/11.

This history was written on a very tight schedule, reminiscent in a very small way of the kind of schedule under which the MRAP vehicle program was conducted. One consequence was that the author was given far better insight than might otherwise have been imagined into the way an urgent program works. A second was that much of this history was necessarily based on interviews with key participants, stakeholders and partners. An appendix lists the participants interviewed. Their insights gave a very different flavor from a history written largely or entirely from documents, which would have been the author's normal practice. Given enough time and enough of a documentary record, documents tell the story. However, limited time limits the researcher to key documents, and the search for sufficient documentation is difficult. The available documents did not fully convey the urgency of the program, or the way in which it was conducted, because someone reading the documents cannot easily keep their dates in mind as he digests their substance. The dates convey the dramatic schedule far more than the content. The author can only hope that he has caught the sense the interviewees tried to convey. And, although every effort was made to check interviews against documents, human memory is fallible, and errors might have crept into the discussion.

The author benefitted greatly from the enthusiastic support of individuals inside and outside JPO MRAP. That said, the judgments and opinions expressed here are the author's alone. They should not be attributed to the U.S. Government, DELTA Resources, Inc., or Gryphon Technologies LC.

Dr. Norman Friedman
December 2013





CHAPTER 1

THIS TRUCK SAVED MY LIFE!

MRAP, the Mine-Resistant Ambush-Protected vehicle, might be relatively little known outside the Department of Defense, but it was essential to those fighting in Iraq and Afghanistan. For Warfighters who fell victim to mines and improvised roadside bombs, an MRAP vehicle was “the truck that saved their lives!”

That said, an MRAP vehicle was a lot more. It made it possible for troops to fight effectively in both theaters with their significantly different operational environments. When they rode in MRAP vehicles they did not have to fear increasingly frequent and fierce improvised explosive devices (IEDs) attacks. It was a necessary contributor to victory in Iraq. It recalled the first tanks developed during World War I—the troop carriers whose armor made it possible for the first time to cross no-man’s land in the face of enemy machine-gun fire. MRAP trucks were necessarily large—one type was built essentially on a school bus chassis with some cement-mixer features—but carried

only about four-to-ten troops. Others, carrying up to ten troops, were smaller, but in all cases, the weight and cube was significantly larger than for other tactical wheeled vehicles with similar personnel carrying capacity.

MRAP VEHICLES AND MISSIONS

MRAP vehicle variants are a family of armored commercial-off-the-shelf (COTS) vehicles with blast-resistant underbodies and other features designed to protect the crew from land mines and improvised explosive devices (IED), fragmentary blasts, and direct-fire weapons. There are three categories of MRAP vehicles:

- **Category I (CAT I)** vehicles support operations in an urban environment and other restricted or confined spaces including mounted patrols, reconnaissance, communications, and command and control.
 - **Category II (CAT II)** vehicles provide a reconfigurable vehicle that is capable of supporting multi-mission operations such as convoy lead and escort, troop transport, explosive ordnance disposal (EOD), casualty evacuation (CASEVAC), ambulance, and combat engineering (CE).
 - **Category III (CAT III)** vehicles support mine/IED clearance operations providing deployed commanders of various units and EOD/Combat Engineering (CE) teams survivable ground-mobility platforms.
-

In addition to these three MRAP categories, the primary mission of **MRAP ALL-Terrain Vehicles (M-ATVs)**, fielded later in the program, is to provide protected, enhanced off-road mobility capable of operating in a threat environment involving ambushes employing the use of mines, IEDs, rocket-propelled grenades (RPGs), explosive-formed penetrators (EFPs), and small-arms fire (SAF). M-ATV was developed specifically to provide improved mobility in the largely off-road environment of Afghanistan. It was a separate development from the original MRAP vehicles.

Critics argued that buying these huge vehicles was contrary to counterinsurgency doctrine: troops had to operate among the people and be highly mobile and

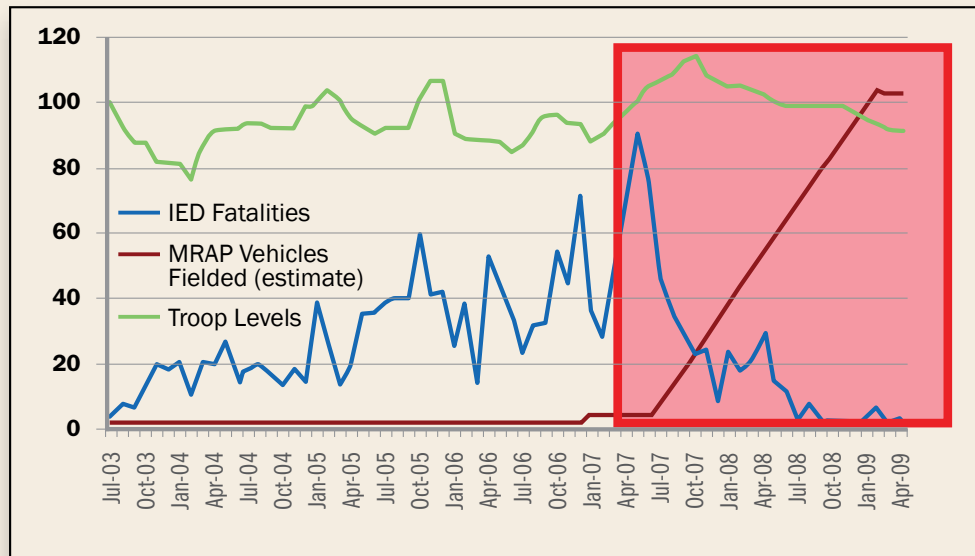
maneuverable. They did not understand: without MRAP vehicles the troops generally could not get to where they could dismount among the people, because the enemy could blow them up en route. Without the MRAP program, U.S. forces would have been so badly hamstrung that they could not have operated effectively. With it, they and their coalition partners were able to carry the fight to the enemy and prevail.

MRAP vehicles were developed specifically to survive in the face of the insidious and deadly IEDs that infested Iraq and Afghanistan. The United States had no such vehicle in widespread service at the outset of the wars, although a few specialized mine-resistant mine-clearance explosive ordnance disposal and route clearance vehicles based on technology previously developed in South Africa were in service. It turned out that there was a world of difference between a few specialized vehicles, with limited serviceability, and the large number of MRAP vehicles that became standard in both theaters of war. Developing them to deal with a rapidly changing threat was a considerable achievement. Building them in great numbers, very quickly, would have been a major achievement in any war. Rapid production in the face of a procurement system widely seen as incurably sluggish was surely an even greater achievement. This is the story of those achievements.

Earlier vehicles, which had limited side, top and underbody armor, could not survive explosions from underneath. Massed MRAP vehicles could move Warfighters freely in the face of such attacks. The Marines wrote that MRAP trucks provided “essential freedom of movement on high risk main roads.”¹ The MRAP vehicle was a key part of the coordinated campaign² that forced the enemy to change tactics. By late November 2007 the devastating under-bottom IED attacks had dropped dramatically during the previous six months. (See Figure 1.) The Marines were also reducing the need to put themselves on high-threat roads by airlifting their supplies and by using persistent surveillance, which reduced the threat level. By that time MRAP vehicles had done their job well enough to justify a reduction in the numbers needed.³

The MRAP vehicle program was a critical part of the effort that made it possible for U.S. forces to stay in Iraq. As a 2007 Marine Corps information paper explained, “The MRAP helped limit the potentially ‘game changing’ effect of enemy IED attacks.”⁴ By the fall of 2006, the steady drumbeat of casualties to improvised bombs was eroding public support for the war. Had those casualties continued, it would have become more

–Figure 1–
IED THREAT VECTORS



Source: JPO MRAP Brief to the Strategic Execution Conference, 24-25 April 2013.
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and more difficult to sustain the war. That was undoubtedly the enemy’s calculation. By its existence in numbers, the MRAP vehicle changed the equation.

A United States-led coalition invaded Iraq in March 2003 in Operation Iraqi Freedom. The bulk of the Marine force that took part in the invasion soon withdrew. Not long afterward an insurgency developed, and soon the Marines and other U.S. forces were built back up for Operation Iraqi Freedom II.⁵ Much of what happened during the next seven years amounted to countering that insurgency so that the developing government in Iraq could be allowed to function normally. U.S. and coalition operations in Afghanistan followed a similar pattern. For the insurgents in both countries, the weapon of choice was the IED, often described as a “roadside bomb.” No one who followed operations in both countries can forget how often U.S. troops fell to these devices. It gradually became clear that a necessary condition for success was some means of neutralizing the IED threat. The key achievement was to develop and field MRAP vehicles that could protect troops from the most effective IEDs the enemy could field.

The way in which the MRAP vehicle program proceeded was unusual: in order to get large numbers almost instantly, the program bought several different vehicles in parallel, initially from seven and ultimately six manufacturers. Some manufacturers produced more than one type of vehicle (the program distinguished three categories), and several manufacturers produced vehicles in more than one of these categories. Estimates of how many distinct versions of vehicles appeared vary between as few as 50 in seven “baseline” vehicle configurations, to more than 300 variants and sub-variants, as the designs evolved constantly to meet changing requirements and a changing threat. The desired Service and command configurations driven by tasks also drove the number of variants. For example, two variants not at all envisaged at the outset emerged: ambulances and recovery vehicles (wreckers). And, a manufacturer that had participated in, but failed, the initial selection, developed an entirely new vehicle, the MRAP All-Terrain Vehicle (M-ATV), for Afghanistan, and it too was built in different variants. Appendix A summarizes the characteristics of the main variants and several sub-variants.

PRINCIPAL MRAP/M-ATV ORIGINAL EQUIPMENT MANUFACTURERS (OEMs)

- BAE-Ground Systems Division (RG-33)
- BAE-Tactical Vehicle Systems (Caiman)
- Force Protection Industries Incorporated (Buffalo, Cougar)
- General Dynamics Land Systems-Canada (RG31)
- IMG/Navistar Defense (MaxxPro)
- Oshkosh Defense (M-ATV)

A key node in the MRAP vehicle program’s “factory to the field” process was the Navy’s Space and Naval Warfare Systems Command’s System Center Atlantic in Charleston, South Carolina (SPAWAR Charleston). Charleston was responsible for integrating government furnished equipment (GFE), including guns, turrets, radios, and a wide variety of other electronic systems into every MRAP vehicle regardless of manufacturer. SPAWAR Charleston then coordinated shipment to theater via the Air Force’s Charleston AFB for air shipments and via the Port of Charleston for surface shipments. In that capacity SPAWAR people touched every MRAP vehicle produced, with the exception of the U.S. Special Operations Command (SOCOM) RG-33s that were

integrated by BAE-Ground Systems Division at York, PA by request and contract.⁶

MRAP VEHICLE “SCORECARD”

The MRAP vehicle program offers insight into the defense procurement (and overall policy) process in wartime. From September 2001 onward, the U.S. Defense Department operated on two parallel budgets. One was the usual peacetime budget. The other was a budget to fight the Global War on Terror (GWOT), which meant largely but not entirely the wars in Afghanistan and in Iraq.

• U.S. Army:	20,801
• U.S. Marine Corps:	4,053
• U.S. Navy:	695
• U.S. Air Force:	815
• SOCOM:	1,083
• Test:	255
<hr/>	
• Total:	27,702

The latter budget was the “Supplementals” of the George W. Bush Administration and the Overseas Contingency Operations (OCO) budgets of the Barack Obama Administration. In theory the two budgets should have been governed by two different processes, one keyed to long-range defense needs and the other to immediate warfighting needs. That was never arranged on a formal basis, but the Supplementals and OCOs were used to fund urgent programs, including MRAP vehicles. What was special about the MRAP vehicle program was that although it was an urgent program, pushed urgently, it conformed to the rules of the budget execution and appropriation laws. For that reason it suggests ways of adapting the normal process to a time of rapid and unpredictable change—which is likely to be the situation in the future.

In particular, the MRAP vehicle program illuminates a central difference between peacetime and wartime procurement. Peacetime procurement is a relatively long-term process controlled by available resources in the defense budget. Great effort has gone into modeling the way a program should evolve over time, in terms of time remaining and proportion of budgeted cost spent. These models can be used to detect programs that are not developing quickly enough to be likely to reach maturity, or programs that are likely to overrun disastrously.

Wartime programs trade resources for time, because time is more precious than budgeted funding; this is why the two wars were run on Supplementals and OCOs. In this sense, rather than being an oddly run program, the MRAP vehicle program was a good example of a wartime emergency program in which time was the most important factor—time, in this case, to save lives that would otherwise have been lost to IEDs.

Critics of the MRAP vehicle program have pointed to the existence, before the program, of mine-resistant vehicles. What was not available was the large numbers of mine-resistant vehicles needed to protect troops. Nor was there the logistical base to keep those vehicles in action, particularly if they were damaged. It took time for those responsible for vehicle production to decide that they needed mine-resistant vehicles in numbers and then to produce them. Compared to virtually any other defense program, they acted at lightning speed. Fielding more than 27,700 MRAP vehicles and sustaining them in theater were remarkable achievements.

The MRAP vehicle program was a huge program, probably the largest U.S. military vehicle program (in terms of funding) since World War II. In Fiscal Year (FY) 2010 it was the largest single procurement program in the Defense Department budget. The sheer size of the program attests to the importance attached to it; and by 2010 it had had plenty of time to show that it was worthwhile. In retrospect it is amazing that so enormous a program could be brought to fruition so quickly. There were plenty of quick programs developed to fight the wars in Iraq and in Afghanistan, but they involved



relatively small numbers (or fairly large numbers of relatively small items). The MRAP program was different. It is worth remembering both because of its enormous impact on U.S. operations and because of what it demonstrates about what the United States can still accomplish in an emergency. Figure 2 shows the “demand signals” for ramped-up MRAP vehicle production and delivery.

The MRAP vehicle program began as a Marine Corps program with some Navy participation (for Seabee, Naval Special Warfare (NSW) and EOD forces), but its originators always believed that it would have to be widely used outside the Corps. The Marines set the flavor of the program in ways that survived as it grew. From the outset, they saw the MRAP vehicle program as a multi-service “joint” effort that had to be led by a joint program office (JPO) with considerable Army participation, because they felt that inevitably the Army would want and need very large numbers of these vehicles (even though initially the Army leadership was clearly very reluctant to become involved). In their broad personnel support to the JPO, the Army ultimately provided a great deal of the engineering back-up, but its most important contribution was in solving basic logistical problems that might have precluded widespread use of MRAP vehicles in the field. Because they too needed mine-resistant vehicles, the Air Force and the Special Operations Command became important MRAP vehicle users. For both the Air Force and SOCOM, the considerable carrying and, ultimately, electric power, capacity of MRAP vehicles were vital to their missions, which were heavily oriented towards command and control.

THE KEY QUESTIONS

This book answers three key questions:

1. Why did the MRAP vehicle program matter?
2. How was it such a success?
3. Can it be replicated in the future?

The MRAP program was spectacularly successful in three connected ways. First, it rapidly tested, produced and fielded the necessary vehicles to respond to, and sometimes

anticipate, increasingly deadly threats. Second, it supported the development of an industrial base that could produce them rapidly enough and in sufficient numbers to have major effects on the course of the war. Third, the program continued to develop new mine-resistant technology that more than kept up with the enemy's progress in developing new IEDs. Although mine-resistant vehicles existed prior to the invasion of Iraq, the vehicles used in the war were largely new designs. MRAP vehicles were one of several complementary solutions to the IED problem, but they alone offered troops the sense of security that made it possible for them to operate effectively.

End Notes

¹ In an MRAP Joint Program Office presentation for the Strategic Execution Conference, 24-25 April 2013, JPO MRAP Joint Program Manager David Hansen showed a comparative graph of IED deaths, troop levels, and the number of MRAPs fielded. This is reproduced here as Figure 1. To keep the slide unclassified, numbers were omitted in favor of a nominal numerical scale. The troop level rose and fell, but mostly within about 10 percent of its mean value. That made IED deaths at various times between July 2003 and April 2009, the limits of the graph, comparable. On the graph, deaths peaked at a nominal value of about 90 about June 2007, just as MRAP vehicle deployment began. They began to rise toward this peak about January 2007. It seems fair to associate earlier peaks and valleys in the graph of deaths both with improvements in High-Mobility Multipurpose Wheeled Vehicle (Humvee) protection and in lulls in operations. The previous worst peak, which was considerably narrower than the 2007 peak, came late in 2006 and was probably associated with the introduction of under-body IEDs. It reached a nominal value of about 70. IED deaths began very low in July 2003, and first peaked (to the nominal value of 20) that October. They first rose significantly about January 2005, with a brief spike to a nominal value of nearly 40. In July-October 2005 deaths were maintained at a nominal value of about 40, with a peak to 60 in October 2005, and then a steep decline about March 2006. IED deaths began to decline sharply as MRAPs were deployed. They were down to a nominal value of 20 by about April 2008, and by October they were at roughly the level last seen about August 2003. That coincided roughly with deployment of about 90 percent of the planned MRAP vehicles.

² Other elements of the counter-IED campaign that affected IED attacks included the surge in troop levels, the successful efforts to convince Sunni Arabs to oppose extremist organizations (resulting in the "Sunni Spring," and the multiple Joint IED Defeat Organization (JIEDDO) initiatives aimed at countering the IED network.

³ Marine Corps Information Paper dated 30 November 2007 explaining the reduction in the Marine Corps MRAP requirement from 3,700 to about 2,300 vehicles. Much of the argument was that the relatively heavy MRAP vehicles could not operate or pursue the enemy off-road, in confined areas, or across many bridges. For such operations the Marines were retaining up-armored Humvees, for their greater maneuverability and mobility. With the use of persistent surveillance and air supply, the Marines did not have to use high-threat roads as much as Army forces. Their counter-insurgency focus required close interaction with the Iraqi populace in areas not accessible to MRAP vehicles. In effect, the Marines were calling for something like the later M-ATV. The Marines also noted that they needed fewer MRAP vehicles than expected due to unexpectedly low combat losses—MRAP vehicles worked!—and vehicles associated with surge forces were no longer needed. See also, Edie Williams, *Mine Resistant Ambush Protected Vehicle Program*, rev. 2-1 (OSD internal point paper), 2008.

⁴ Marine Corps Information Paper 30 November 2007, *op.cit.*

⁵ In November 2003 the Marines were informed that they would be returning to Iraq. Anticipating increased vehicle-armor requirements, the Marines issued a Task Order for an ECP (Engineering Change Proposal) to Oshkosh Truck Company, which made their Medium Tactical Vehicle Replacement (MTVR) truck, calling for fully integrated armor to protect crews against mine blast, small arms, and artillery fragments. The Marines were formally ordered back to Iraq in January 2004.

⁶ Vehicles built in South Africa were shipped directly to Kuwait, where they were met by SPAWAR personnel working at the MRAP Sustainment Facility (MSF).





CHAPTER 2

LEADING UP TO THE MRAP SOLUTION

The United States and its coalition partners invaded Iraq in 2003, quickly overthrowing Saddam Hussein's regime. Initially it seemed that Iraqis could come together quickly to form a new government. President George W. Bush had already proclaimed "mission accomplished" and many troops came home. By late 2003, however, the country was in a state of insurgency, which would last for nearly a decade and continue. The Marines, for example, were told early in November 2003—having just completed their withdrawal in October—that they would be moving back into Iraq.

The insurgents' main weapon was the improvised explosive device (IED), a mine intended to destroy a vehicle and its occupants. The IED's immediate purpose was to immobilize U.S. and coalition forces in Iraq. At the outset, the coalition occupied Iraqi cities. It used Iraqi roads to supply itself from the major airports and seaport. The roads

had to be kept open: connecting ports and cities by air alone was never a viable option. Attacks on road traffic were even more effective once U.S. forces shifted to a dispersed strategy in which small numbers of troops moved freely within and outside Iraqi cities.

Countering IEDs was a means to a larger strategic end. Troops had to be protected so that they could spend their time hunting down the enemy. The enemy hoped that a steady drum beat of apparently pointless deaths due to IEDs would tire the U.S. public to the point where public opinion all-but forced the United States out of Iraq and later Afghanistan. Conversely, if the enemy realized that IEDs were useless, he would be forced into more conventional forms of combat, for which U.S. troops were well prepared. If the insurgents came to accept that they could not win, they might be induced to abandon the insurgency altogether.

The MRAP program was conceived as one way of neutralizing the IED threat. The program was controversial because there were alternatives, such as jammers and reconnaissance, that initially competed for attention and funding.

The “Poor-Man’s” Threat

For several decades of nearly constant war against governments by various insurgents, IEDs have been favored “poor-man’s” weapons of choice. They do not require high technology, they are often easy to conceal, and generally they do not expose their users to counterattack. At the least they slow down an enemy by requiring him to deal with them before proceeding. They can be deadly, causing apparently pointless casualties among troops. Explosives are easily available (or can be made relatively easily), and commonly available electronic devices, such as garage-door openers and cell phones, can remotely detonate them. They can also be detonated by pressure pads, trip-wires, and detonators wired to an observer. This weapon was used against coalition forces in Iraq almost from the outset.

The U.S. Army first encountered IEDs in the Balkans in the 1990s, and to some extent its reaction prefigured what would be done in Iraq. There were significant casualties, particularly near bases. The mines were small and very unsophisticated, and they seem to have been far less numerous than those encountered in Iraq later on. In January 1996, the Army reacted by modifying Humvees (Bosnian and Balkan variants). By 2003 Armor Holdings was producing limited numbers of up-armored “Humvees”

(High-Mobility Multi-Purpose Wheeled Vehicles) for the Army.¹ Armor Holdings' experience in the Humvee program made it a viable contractor once the MRAP vehicle program began. Moreover, the Bosnian and Balkan Humvee programs and their successors provided a near-term solution to IEDs once they began to appear in Iraq in 2003-4. The existence of this solution made it seem unnecessary, at the outset, to develop special mine-resistant vehicles. The argument for a special mine-resistant vehicle was based on the appearance of IEDs, particularly under-bottom mines and EFPs, which no up-armored Humvee could survive.

At the outset in Iraq, the insurgents obtained their IEDs by looting the numerous arms dumps left by Saddam Hussein's fallen Ba'ath regime. The relatively small U.S. force that overthrew the regime lacked the numbers to secure all the dumps. No provision (which would have required many more troops) had been made to secure or neutralize the dumps because the U.S. government did not expect either an insurgency or a protracted occupation of Iraq. Thus the former Iraqi Army's stock of artillery shells, the largest of which were 155mm, defined initial side-attack IEDs. Because they were based on military weapons rather than on improvised explosives, the initial IEDs in Iraq were, pound for pound, often much more powerful than those encountered in previous conflicts, such as that in Bosnia. A side-attack IED of this type showered a vehicle with lethal fragments that could penetrate it and kill or maim its occupants. Relatively light add-on armor and ballistic glass could stop the fragments. Similar armor could deal with the usual ambush threats posed by automatic rifles and machine guns.²

Initially all or nearly all mines were placed alongside roads, firing horizontally into vehicles. That placement made them relatively easy to trigger, because it was relatively easy to judge when a vehicle was alongside. If the mine were detonated from a distance, there could be a short delay between spotting the target and triggering the mine. Initially coalition troops in Iraq thought that if they drove fast enough they were reasonably safe in totally unprotected vehicles. When they were hit, however, these mines were quite effective. U.S. forces in Iraq rode mainly in unarmored Humvees, partly because it had been decided that they would be less threatening to the population than protected tracked vehicles.

Afghanistan was a different proposition, because the enemy did not have access to large dumps of artillery shells. Still, he certainly was able to improvise explosives and thus to field under-bottom IEDs. Thus the under-bottom IED threat featured prominently in

Afghanistan. The more sophisticated explosively formed penetrators (EFPs) threat—shaped-charge devices that smashed a hot high-speed metal penetrator into a vehicle—did not.

In addition to new types of IEDs, the enemy fielded more effective ambush weapons throughout Iraq and Afghanistan, for example, rocket-propelled grenades (RPGs) supplemented small arms.³ The shaped-charge RPG creates a jet of hot molten metal that burns through vehicle metal. Unfortunately, armor effective against an EFP can be useless against a small shaped charge, and vice versa. To deal with RPGs, MRAP vehicles sprouted nets and bar armor.⁴ Both were intended to render the threat ineffective. Overall these technologies proved to mitigate many casualties from these types of threats.

Countering the Threat

The classic counter to mines is to deploy limited numbers of special mine-clearance or engineer vehicles on the assumption that effective mines are laid in relatively few places. The special vehicle can precede a column of normal vehicles, or it can be called in to deal with a suspicious object detected in some way. For example, in Iraq the Army flew unmanned aerial vehicles (UAVs) over the roads it used. The images they collected were analyzed using special change-detection software, which could spot places where mines might be buried. At the outset both the Army and the Marine Corps bought small numbers of specialized mine-resistant vehicles specifically for route clearance. At least initially the expectation was clearly that with a few such vehicles the threat could be reduced to the point where up-armoring the standard Humvee personnel carrier would be enough. Some of the specialized mine-resistant vehicles became the basis for MRAP vehicles.

As soon as they began to encounter IEDs, both the Army and the Marines started programs to protect against them. Naturally these programs were conceived to deal with the first generation of IEDs, converted artillery shells that created showers of fragments hitting the sides of vehicles. The Humvee up-armoring program makes a useful comparison with the MRAP vehicle program in terms of scope and schedule. The rapid ramp-up of requirements for Humvees protected in various ways was a kind of forecast of the way in which the MRAP vehicle program expanded. The relative speed with which the two programs were executed gives some idea of what was special about the MRAP

vehicle program. The Humvee improvement program began with a well-understood vehicle that already existed in large numbers; the MRAP vehicle program created new vehicles, albeit based on existing ones.

Both the Army and the Marines used the Humvee, so both were interested in protecting it to maintain their mobility.⁵ Their approaches were somewhat different, and at least at first they used different types of armor, with the Army cornering the market on rolled homogeneous armor (RHA) before the Marines began buying add-on kits.⁶ The Marines' program was designated MAK (Marine Armor Kit).⁷

The Army already had an up-armored Humvee (UAH) designated M1114, conceived in response to experience during the 1991 Gulf War and Balkan operations.⁸ Its immediate response to the Iraqi insurgency was to move all its M1114s to Iraq, and then to begin further up-armoring. M1114 production was ramped up beginning in 2004. These vehicles had stronger suspensions and could accept armor kits. However, most Humvees in Iraq, and all of those in Marine Corps service, were the earlier unarmored type, and the most urgent requirement was to provide them with useful protection. The Marines had not bought the up-armored Humvee before the war, and so much of their effort went into buying up-armoring kits applicable to the original unprotected vehicle. In May 2004 the Marines began buying up-armored Humvees (the initial order was for 498 of them), and in June 2005 they decided to replace all their Humvees with protected ones, ordering 1,350 of them at once. The total of about 1,850 up-armored Humvees was not too far from the Marines' ultimate requirement for MRAPs. In effect, their successors.

It was always understood that the Humvee was not the ideal protected vehicle, but it was the only vehicle more or less instantly available in great quantity at the time. Moreover, it was supported by an established logistical chain and by mechanics trained to keep it in service. Without both the supporting chain (including massive amounts of spare parts) and the maintainers, no vehicle could operate in theater for very long. Without doubt, logistics and maintainers were as essential as the vehicles.⁹ Without them, vehicles would quickly fall by the wayside, and coalition forces in Iraq would lose the mobility on which commanders counted. Given this consideration, the existing Humvee with added armor was the best that could be done in the early 2000s. Any alternative would entail a large program, not only of vehicles but also of their logistical tail and their maintenance personnel. Anyone contemplating such a step in 2004-2005

had to ask how long the war in Iraq was likely to last. It would take time to create not only the vehicles but also their supporting structure. Would the war last long enough to make that worthwhile, or would a specialized vehicle be available only after the war was over? The 2006 decision to surge the U.S. force in Iraq probably marked the point at which the Defense Department accepted that the war would be protracted, to the point where major systems intended entirely to fight it were worth buying.

The first Urgent Operational Needs Statement (UONS) for add-on armor for Humvees in Iraq was raised in October 2003. (An urgent need is an exceptional request from a component commander for an additional warfighting capability critically needed by operating forces conducting combat or contingency operations. Failure to deliver the capability requested will likely result in the inability of the unit to accomplish its missions or increases the probability of casualties or loss of life.) Aberdeen conducted the first ballistic tests in August 2003, and the first Humvee up-armoring kits arrived in Iraq on 27 October.¹⁰ They were designed to defeat RPGs and snipers, not IEDs.

The Army managed the up-armoring program. Building on their knowledge from the Abrams and Bradley programs, Aberdeen Proving Ground tested the armor kits, thereby expanding their expertise in testing vehicles and dummy occupants against IED explosions, including further development of sophisticated instrumentation and equipment. Aberdeen and its special test equipment and expertise were available when the MRAP vehicle program began.

During 2005-2007 the Humvee and related up-armoring programs were run by Colonel Kevin Petersen (USA), who later became the Army's Deputy Joint Program Manager for the MRAP vehicle program alongside Joint Program Manager (JPM) Paul Mann. He spent 3 1/2 years working on this problem, and he was made head of the Army's MRAP JPO element in 2007.¹¹ Petersen was the Army's premier up-armoring expert, hence the natural choice for its end of the JPO.

Once the Army began to move, the program grew rapidly, so that by March 2007 there were 21,319 up-armored Humvees and even more add-on armor kits.¹² These numbers gave some idea of the numbers of mine-resistant vehicles that would be needed, once the MRAP vehicle program encompassed the Army and the Marines.

The only resistance to the up-armoring program from among troops came from their belief that speed itself might be effective protection and that every additional pound that lowered speed was dangerous. Unfortunately they were largely wrong. Additionally,

the Humvee chassis and suspension and transmission could take only so much additional weight.¹³ Some of the additions made the vehicles top-heavy, and sometimes they rolled over when a roadside bomb exploded. As the Humvees became heavier, roll-overs became a worsening problem. This was not generally a matter of stability: roads often gave way because they could not take the weight of a vehicle. That was particularly unfortunate when a stream or a drainage ditch bordered the side of a road, because when the edge of the road gave way, it could throw a vehicle into the water. Sometimes, the roll-over would damage the vehicle, preventing the doors from opening. Gunners needed restraints so that they would not simply be blown or thrown out.

Although small numbers of protected Humvees already existed in 2003-2004, it took time to produce more, and the additional armor reduced mobility and reliability. Meanwhile Soldiers and Marines up-armored their vehicles themselves, often with unfortunate results: improvised armor could actually worsen the situation. For example, some troops took the ballistic glass used for armored windows in other applications, and covered the insides of their vehicles with it. Hits turned the glass into splinters, which magnified the effect of the explosion. Others added filled sandbags in crew compartments, and when their vehicles were hit, the sand was driven into wounds, making them worse. Experience with such ‘hillbilly’ or ‘haji’ armor made development of effective up-armoring kits more urgent.

The protection problem always included the heavier logistical vehicles on which U.S. forces depended. In the Marines’ case the vehicles were the 7-ton MTRV (Medium Tactical Vehicle, Replacement) and the 22-ton LVSR (Logistics Vehicle System Replacement). They were the bulk of vehicles in convoys. Armoring initially seemed more urgent for the trucks than for Humvees, because the heavy trucks lacked the agility to avoid enemy attack. In 2004 the Marines began a program to armor their MTRVs.¹⁴ This up-armoring was simpler to implement than protection for Humvees, because the vehicles were higher off the ground, hence their occupants were further from any under-body blast. Perhaps the most significant impacts of the truck programs on the MRAP vehicle program were that they began the involvement of Plasan, a key armor supplier and designer, and also that they involved Oshkosh Defense, which had only a small part in the initial MRAP vehicle program but an enormous one in the later M-ATV program. The program was called MASS (MTRV Armor Supplement System).¹⁵

In May 2004, ballistic glass was authorized for all USMC vehicles in Iraq and Afghanistan.

The enemy responded to Humvee and other up-armoring with two new types of IED, under-body mines (which attacked the unprotected underbody of a vehicle) and EFPs. Both completely overmatched existing add-on side protection. A belly mine destroyed a vehicle with an underbody blast. It was relatively easy to fashion, and MRAP vehicles were initially designed specifically to defeat this threat.

Anything larger or different from a first-generation IED (such as an under-body IED) required far more effort on the enemy's part. The larger the mine required, the more difficult to assemble, transport, and emplace it—the greater the vulnerability associated with using IEDs. For that reason the enemy was careful to use just enough to kill those in a vehicle, for example, a Humvee. Simply replacing Humvees with first-generation MRAP vehicles increased the required explosive by a factor of ten, and that was just to damage the vehicle.

The two new threats were concentrated in different places. EFPs proved more a threat to the Army in Baghdad (mainly in Sadr City) and to the British in Basra than to the Marines in Anbar province. That was because they had to be emplaced in built-up areas and also because bottom-attack IEDs and mines were more difficult to emplace in paved streets. Conversely, the under-bottom IEDs were initially concentrated in Anbar province where there were few paved roads. The MRAP program grew out of the Marines' experience of under-body IEDs in Anbar, and later expanded to deal with the threat that the Army initially faced.

Defeating Under-Body Attack

The Marines initiated the MRAP program to counter the under-body mines they encountered in Anbar Province. The Army was initially less interested in a new vehicle that could resist under-body attack because the worst threat it faced was from EFPs. MRAP vehicles were initially designed to deal with the under-body threat because there was no way even minimally to protect a Humvee against it. Thus the under-body IED effectively evaded the considerable efforts being made to protect Marines in Iraq.

From the point of view of protection, there is an enormous difference between a mine exploding at the side of a road and a mine exploding under a vehicle. Side armor will

deal with the first threat. By resisting blast, it dissipates much of a side blast into the open air. That is why high-explosive shells are not considered effective against tanks. Even relatively thin armor is effective if the explosion is at any distance from the side of the vehicle.

An under-belly explosion attacks a vehicle where it is most vulnerable. The weight of the vehicle resists the blast, which expends its energy through the more or less flat (and flexible) bottom of the vehicle. Armoring the bottom does little good, as the explosion pushes against a flat bottom and breaks it. In the case of a Humvee, the problem was magnified because the bottom was so close to the blast; the power of a blast dissipates with distance. Anyone inside the vehicle is pushed up violently. At the least bones are shattered much of the time, and those inside the vehicle can be killed by the upward force. Existing vehicles could not easily be modified to provide any kind of protection against this threat.

There was no way to adequately protect a Humvee against an underbody mine, although as late as 2013 there was a program to provide some level of protection. The tunnel under the vehicle carrying its drive shaft and transmission formed the sort of cavity that makes an underbody explosion particularly effective. Typically an explosion blew the gunner up out of his post on top of the vehicle, shattering his legs—if he survived. The compartment on top of the blast would be totally destroyed.

Since the side attacks were easy to mount and were effective, the insurgents had little initial incentive to go to more sophisticated attacks that would use mines *in* roads, which would attack a vehicle from underneath. Under-body attacks (using small weapons) had been common in some previous wars, e.g., in Africa and in Bosnia, where they seem to have been associated with military mines—in Africa, generally Soviet-supplied weapons. Once it developed, the underbody threat in Iraq and then in Afghanistan generally involved improvised explosives with improvised detonators.

The MRAP vehicle program managers initially concentrated on the other new threat, the under-body IED. The Marine Corps became lead Service for under-body mine counter-measures because it encountered them first, in Fallujah and then in Anbar Province. IEDs in Baghdad and further north were generally side-attack weapons. A few under-body IEDs were encountered in 2004-2005, but they did not become prevalent until 2006.¹⁶ The under-body attacks on the Marines might have reflected a

particular expertise on the part of the Al Qaeda cell in their area, but in addition the Marines' operating area was less built up, hence offered less cover for a side-attack mine. In a less built-up area it was easier to dig up a road and to bury a mine without much interference. The first underbody bombs were "speed bumps," so called because they were so shallow. A vehicle slowing (as for a speed bump) would be easier to attack. The underbody attack was spectacularly successful. The Marines tested the first underbody armor kits. Aberdeen Test Center Commander Colonel John Rooney (USA) recalled a 2005 test of a relatively small bomb against a truck. When the dust cleared, the truck was gone, obliterated. Underbody protection of a Humvee against this threat was nearly impossible, because the bottom of the Humvee was so close to the explosion, and because its flat surface would absorb so much of the energy of the blast that would naturally concentrate on the drive tunnel under the vehicle.

At the outset, in 2006, the Marines estimated that the average under-body IED would kill the majority of those in a Humvee, but only 15 percent of those in the MRAP truck as then envisaged. Very rarely did an explosion kill anyone inside these new MRAP vehicles. In fact typically everyone in an MRAP vehicle survived, although some might be injured. That difference made an MRAP vehicle a major "game-changer."¹⁷

The MRAP experience showed, moreover, that no conventional flat-bottomed vehicle could be adequately protected against bottom explosions, because no flat bottom could be rigid enough to resist explosion, and because a flat bottom would tend to absorb the full force of an explosion.¹⁸ In 2005 the Army was already lead Service for a planned new Joint Light Tactical Vehicle (JLTV), conceived as the Humvee replacement. Some of the companies involved in the JLTV program and its predecessors applied the expertise they developed to MRAP vehicles, the most notable examples being IMG/Navistar Defense in Lisle, IL, and Oshkosh Defense, in Oshkosh, WI.¹⁹

Countering the EFP

EFPs were encountered first, and by late 2005 they had destroyed numerous trucks. The armor that protected a Humvee from the shower of fragments from a converted 155mm shell could not stop an EFP penetrator. When Colonel Rooney, who was then commander of the Aberdeen Test Center, visited an Army unit that had been hit by EFPs, a non-commissioned officer (NCO) told him, "We know that when an EFP fires at our truck, it is our day to die."²⁰

Rooney had his lab reproduce and test the 6-inch deep box that troops were filling with sand and welding to their vehicles as improvised protection. The box weighed 400 pounds, which was a tremendous burden on a Humvee door. It provided no protection at all; in fact an EFP blew the sand into the troop compartment, increasing the damage it would normally do. At this time the Army was resisting adding weight, because in the long term the extra load would wreck its Humvees. In Rooney's view, the long term would not matter if all the Humvees were destroyed first by EFPs. The Army Research Laboratory thus led an effort to develop a countermeasure, although side-attack shells—which were being effectively countered—were still by far the most prevalent form of IED. It developed special materials (sometimes called “peanut butter”) that could be packed into a box bolted to the side of a vehicle to provide some protection. Rooney had Aberdeen produce the initial kits (Interim Frag Kit 7), which provided the first real protection against EFPs. The material invented by the Army Research Lab was the basis for the EFP protection incorporated in many MRAP vehicles.

The Army's successful creation of a minimal form of Humvee protection against EFPs gave it reason not to consider an entirely new vehicle, which turned out to be MRAP, as urgent a requirement as that felt by the Marines, who faced under-body IEDs against which add-on protection of any kind was worthless. That said, a Humvee could not carry the weight of anti-EFP protection sufficient to deal with many of the weapons.

U.S. forces in Iraq became impressed with the EFP threat because these weapons turned up in many captured arms caches. It had to be assumed that not all of them were being found. Before even one MRAP vehicle had been fielded, work was proceeding on armor to protect the new vehicles against EFPs. EFP protection required a mass of “peanut butter”: it took about 8,000 to 12,000 pounds of armor to provide a reasonable level of protection. Protection was typically in the form of “effector boxes”—hollow boxes filled with material that absorbed the EFP blast. They were hung 6-to-12 inches outboard of the truck, the thickness depending on the “recipe” inside the hollow boxes. These effector boxes were proven to be quite effective against the threat, but the extra weight imposed a requirement to “beef up” other truck components, such as the power train, transmission, and suspension.²¹ When it was not carrying the add-on anti-EFP armor, a beefed-up truck had an even worse ride than the original MRAP vehicle, because its springs were so stiff to deal with the added weight the truck might carry. Ultimately independent suspension solved this problem. The new armor was so heavy, however,

that an electric door-assist actuator had to be installed so that crews could get out of their vehicles quickly, particularly important if they rolled over. Because the add-on armor was so heavy, a considerable effort was mounted to estimate the most likely angles of attack so that the “peanut butter” could be spread only in the right places.

For MRAP vehicles, the extra armor was called “MEAP”—the MRAP Expedient Armor Package. It was developed by the Army’s Tank-Automotive and Armament Research and Development Command (TARDEC) in Warren, MI, using solutions that were developed by the Army Research Lab (ARL). Some MaxxPro and Caiman variants were fielded with MEAP EFP armor. Caimans ended up as one of the most prevalent variants protected against EFPs, and they moved to areas where EFPs were most prevalent to provide the best such protection. Designs to add MEAP to other variants—RG-33, Cougar, and RG31—were developed. Those designs however were not initially fielded due to the limited amount of protected area that could be integrated on the vehicle based upon the limited payload capacity of those vehicles. For example, the first MEAP design for the MaxxPro pushed the axles/suspension load up to 112 percent of their rated design capacity. Testing quickly demonstrated that this was not feasible; the test vehicles had warped axle housings by the second day of testing. Vehicles had to be modified. The sheer weight of the armor led to considerable work to make it lighter.²²

The MRAP JPO focused on medium EFPs, which created the worst damage. It turned out, fortunately, that large EFPs were not very effective, so that it was possible to provide a vehicle with a useful level of protection. The EFP threat was limited but very serious, and it did not disappear as long as U.S. forces remained in Iraq. In the final days of U.S. combat presence in Iraq, EFPs were the most effective killers. During the final drawdown, one urgent task for the MRAP JPO was to cover gaps in EFP protection. This initiative improved the existing EFP kit, adding a new panel to close a gap, and another above it. The problem was so serious that these added panels had to be installed before any Caiman could be driven out of Iraq. EFPs were the all-consuming threat at that time.²³

The EFP threat did not arise in Afghanistan, but as insurance against that possibility the JPO developed an EFP solution for the M-ATV developed specifically for Afghanistan.²⁴

How Much is Enough?

The Marines understood at the outset that the bottom mine threat required something more, but the question was whether it was needed in large numbers. Did every troop carrier have to be protected, like an up-armored Humvee, only on a more elaborate scale? This was very much an affordability issue: even in a war emergency, budgets and resources are far from infinite. Thus the Marine Requirements Oversight Council (MROC) approved a two-phase initiative to armor all vehicles in Iraq, but it fell below the FY 2004 funding line.²⁵

The MROC approved a FY 2004 request for Hardened Engineer Vehicles (the predecessors of the later MRAP vehicles). It fell below the funding threshold, but it was understood to be urgent enough that an Above Threshold Reprogramming (ATR) request for 15 HEVs was approved in February 2004. This was the bare minimum requested by First Marine Expeditionary Force (I MEF), pending funding.²⁶ The Defense Department approved the 15 HEVs in March 2004, and in April the Marines issued a formal Statement of Need (SON) for 28 Cougar MRAP vehicles (27 operational and one test article) produced by Force Protection Industries, Inc. (FPI).²⁷

The Army was soon buying its own mine-resistant vehicles for mine countermeasures. They included the RG31 vehicle built by General Dynamics Land Systems-Canada, later an important part of the MRAP program.

Early in 2006 the Army set up demonstrations of survivable vehicles at Fort Knox, following a market survey.²⁸ It sought a bridge to replacements for the vulnerable vehicles, particularly the Humvees. The British participated in the demonstration program, and they adopted their Mastiff, a version of the U.S. Cougar (FPI), on that basis. The British Mastiff purchase was the first large order its manufacturer, received (the British had already bought a few related vehicles for mine clearance, and FPI had sold a few larger Buffaloes to the Army for mine clearance).

The difference between these initiatives and the later MRAP program was one of focus. When they initiated the MRAP program, the Marines decided that everyone, not just special mine clearance or route clearance personnel, needed protection against IEDs. Thousands rather than hundreds of vehicles were needed. Since the IEDs were relatively easy to make, and since the enemy could see that the under-body threat was

effective, the problem was likely to ramp up quickly. Production of vehicles had to be equally quick.

Decisions about what sort of vehicles to buy were shaped by the larger question of just what sort of military the United States was to maintain. Through the early part of the war in Iraq the answer was that the United States should pose an expeditionary, rather than garrison, stance. The outbreak of the Global War On Terrorism (GWOT) was interpreted, not as a reason to fight protracted wars in Iraq and in Afghanistan, but rather as a warning that the United States had to be prepared to deploy forces quickly to deal with unexpected contingencies that might crop up in rapid succession in widely separated places. This emphasis extended to a serious attempt to reduce the footprint of a deployed force by reducing its need for fuel through adoption of hybrid power plants. The Services necessarily concentrated on building and maintaining what was needed to fight a series of wars, not any particular near-term war. Heavy armored vehicles, which would be used in small numbers, could still be bought, but troop carriers, particularly wheeled ones, had to be light because they had to be deployed in large numbers. Light weight bought vital mobility.

Perspective mattered. If the wars in Iraq and Afghanistan were likely to last only a few years, whatever was developed to solve the IED problem would probably enter service mainly postwar; it had to be a bridge to the future. If the wars were likely to last a long time, it was necessary to field something adapted to the particular problems met in Iraq and Afghanistan. Any decision had to take into account the time lag between choosing a solution and fielding it, which, before the MRAP vehicle program, was understood to be several years. In hindsight, one might imagine that the MRAP vehicle program proves, above anything else, that a large number of new vehicles could be fielded *and supported* remarkably rapidly. That was not at all obvious in 2005-2006. Buying specialized equipment to fight one war would not make much sense if it arrived only when a completely different war had to be fought.

The experience of the engineer vehicles showed that to resist bottom mines took considerable size and weight. The Marines thought of themselves primarily as a quick-reaction expeditionary force. Every extra ton of vehicle worked against expeditionary capability: not only would vehicles be more difficult to transport, they would need a much greater tonnage of fuel. It should be no surprise that the Marines did not decide to begin buying thousands of heavy MRAP vehicles until the enemy had made it

impossible to protect existing Humvees against IEDs, by adopting under-bottom mines on a large scale in Anbar Province. By that time the Army was also experiencing under-bottom attacks on a large scale, but it did not have the same focus, partly because the EFPs it faced were an even worse (though less numerous) threat.

End Notes

¹For ease of reading, the popular term “Humvee” has been substituted throughout for the formal designation, High-Mobility Multipurpose Wheeled Vehicle (HMMWV).

According to the preface of *Jane’s Military Vehicles and Logistics 2007-8* (edited by Shaun C. Connors and Christopher F. Foss), in 1993 the Army’s Tank-Automotive and Armaments Command (TACOM) selected a supplier for the armor for the new up-armored Humvee (XM1109), a total of 159 were made. Some served in Bosnia. In August 1994 the Army awarded a contract for the follow-on M1114, the prototype of which was completed in November 1994. Production began in February 1995. M1114 was based on AM General’s Enhanced Capability Vehicle (ECV) version of the Humvee. Blast testing on the M1114 included 5.5 kg (11 pound) contact-detonated anti-tank mines under the front axles and 1.81 kg (3.6 lb) contact-detonated mines in the rear of the vehicle. O’Gara-Hess & Eisenstadt originally developed the up-armoring design. By 2005 the company had become Armor Holdings Aerospace & Defense Group. Between 1993 and mid-2006 Armor Holdings produced more than 17,500 armored Humvees, more than 14,000 of them since 2003, when the United States invaded Iraq. Between 1996 and 2002, orders for these vehicles averaged less than 500 per year, reaching 1,500 in 2003, almost 4,000 in 2004, and peaking at 32 per day late in 2005. By 2007 production was ramping down in favor of a later version of the vehicle (M1151, M1152, and M1165 in place of the earlier M1114 and M1117). This was in addition to armor kits. M1114s and related vehicles were made mainly for the Army, but also for the Air Force, the Navy, and even the Defense Intelligence Agency. They were not made for the Marines, who relied on up-armoring unarmored Humvees.

A simpler measure of up-armoring, including kits, was U.S. consumption of ballistic armor. Between 2002 and 2005 it was about 800 tons per year, rising to 1,400 tons *per month* in 2005 and early 2006, and to 222 tons per day (roughly 6,660 tons per month) late in 2006. This was before DoD established the MRAP vehicle program. These data help explain why the MRAP program needed special measures to get the ballistic steel it needed in large quantities. Of these vehicles, M1151 and M1152 were designed in accordance with the Army’s Long Term Armor Study (LTAS), which called for vehicles capable of being armored, but delivered largely unarmored. It had two components: (A) permanent fittings for later up-armoring; and (B) armor kits to be applied later as needed. This was a relatively new approach, although it was already being used by Mercedes-Benz for German military trucks. The Marine Corps adopted the A/B approach for the first time for up to 1,900 LVS (Logistics Vehicle Support Replacement) trucks bought from Oshkosh, with armor kits supplied by the Israeli company Plasan (a contract for 700 kits was awarded in August 2006). Plasan later had an important role in the MRAP story. These were anti-IED kits.

² Comparisons of vehicles produced in 2004-2006 typically rated their resistance against converted 155mm shells and bullets up through 0.50 caliber armor-piercing.

³ Toward the end of the war insurgents began using thrown shaped-charge grenades (Chinese-made RKG-3s). They eject small parachutes and attack vehicles from above. Note that the anti-RPG protection was on the sides of vehicles; it took extra weight to protect against top attacks.

⁴ It turned out that the relatively lightweight nets were considerably more effective than had been expected.

⁵ There was never any prospect of protecting all existing Humvees, in and out of theater; protection was necessarily limited to vehicles serving in Iraq and in Afghanistan. The total numbers were huge: by 2008, total Humvee production amounted to about 200,000, of which 175,000 were for the U.S. military. About 160,000 were in U.S. military service about 2008. The Humvee entered production in 1985.

⁶ Armor Holdings (which became an important MRAP program contractor when acquired by BAE Systems) supplied the Army up-armoring kits. Between January 2004 and June 2006 it supplied more than 1,800 protection kits for new two- and four-door Humvees (HArD [Humvee Armored Demountable] kits). Another contractor that did not become involved in the MRAP vehicle program was Armor Works, which supplied about 1,500 kits from April 2004 onward for deployed Army Humvees. These public figures apparently grossly understate what was done, but they show how large the program was.

⁷ The Marines' initial requirement was 3,100 kits, but that soon grew to 5,100, all of which were delivered by December 2005

⁸ There are many different HMMWV variants. The M1114 UAH was first produced in the mid-1990s in response to the first Gulf War experiences. It was designed as an armored HMMWV from the start, with built in additional armor, and increased suspension. Additional armor can be added via kitting. The Army began increasing production of M1114's in 2004, leading to the increased numbers noted here.

In addition to the M1114, the Air Force had its own up-armored M1116, initially bought under a late 1997 contract from O'Gara Hess & Eisenstadt. By late 2000 a total of 449 had been delivered. They were based on the Enhanced Capacity Vehicle (ECV) designed by the main Humvee manufacturer, AM General. The manufacturer later became the Aerospace division of Armor Holdings. M1116 was very similar to the version of M1114 up-armored by O'Gara Hess & Eisenstadt. Up-armoring Kit D protected against underbody attack by an M67 grenade, a low level of protection that gives an idea of what was available before the Iraq War.

⁹ This was not something learned anew from the MRAP vehicle program. All were aware of this concern. However, the initial MRAP vehicle plan was to produce small quantities (no more than 4,000), with the intent to support via contractor logistics support (CLS), as previous MRAP vehicles buys had done. When the quantities were greatly increased, this was not practical. The problem was the rapid expansion in requirement, not a lack of understanding of the logistics support requirement.

¹⁰ This was probably the first test of a slab of stand-alone armor (a "coupon," the term later used extensively by the MRAP program). The first all-up vehicle ballistic test may have been conducted on 15 October.

¹¹ Colonel Petersen replaced a previous Program Manager and worked more easily with the Marines and their very different management culture. Given the lack of formal agreement between the Army and the Marines, the success of the Army's end of the early MRAP vehicle program is probably attributable mainly to Petersen and to the team he assembled.

¹² In May 2003, the stated requirement in Iraq was 235 up-armored Humvees, and plans called for producing 30 per month. That October the requirement was 3,279 (80 per month), which increased to 4,149 in January 2004 (81 per month) and to 4,454 in May 2004. Increased urgency was reflected in plans to produce 138 per month. In July the requirement was 5,000 UAHs, to be produced at nearly three times the rate, 350 per month. In October, it was 8,105 (450/month), and in March 2005 it was 10,079 (600/month). In February 2006 it was 18,132 (470/month). Requirements peaked in March 2007 at 21,319 vehicles (834/month), and the program was completed by September 2007. The explosive growth of the program suggests the way in which the MRAP program later grew. Alongside UAH was a program for armor kits. On 1 April 2006 the requirement stood at 28,742 kits, and 26,234 had been installed. Since a succession of increasingly heavy kits was developed, the number of kits does not indicate the number of vehicles involved. John Young interview, 24 May 2013.

¹³ Figures in *Jane's Military Vehicles and Logistics 2008-2009* suggest the scope of the problem. At that time the typical up-armoring kit added 900 kg (1984 pounds) to the weight of the vehicle. Humvees were peaking at about 7,075 kg (15,590 pounds), but they had been designed for a gross weight of 5,488 kg (12,095 pounds, given as the technical gross vehicle weight [GVW]). About 2005 Humvee manufacturer AM General began work on an upgrade kit (REV) with revised components and also on a next-generation Expanded Capacity Vehicle (ECV 2). The original ECV was the M1151/2 and M1165 series. ECV 2 was designed specifically to deal with under-bottom mines, with a parabolic blast-deflection plate under the crew compartment, a variable-height semi-active suspension (to provide increased standoff when needed), a raised internal floor to reduce intrusion of the transmission into the crew compartment, and a raised roofline. It also offered improved protection against side-fired IEDs. To support all of these additions it offered an uprated engine with a six-speed automatic transmission. All of this was expected to buy 503 kg (1,108 pounds) more usable payload, i.e., to restore the original Humvee payload (expected gross weight was 7,200 to 7,700 kg [15,868 to 16,970 pounds]). ECV 2 became the M1211/12/13/14 series, but it did not go into production. It may not have gone through MRAP-style explosive tests. In effect, ECV 2 was a rejected interim alternative to the JLTV then under development. Note that *Jane's* uses metric figures, which were doubtless translated from U.S. Army figures in pounds; the pound figures above, which were translated back from the metric ones, are approximate.

¹⁴ The Marine Requirements Oversight Council (MROC) established a comprehensive vehicle survivability policy in June 2004. That month Armor Holdings and Plasan were selected to provide MTRV armor, and Oshkosh was told to increase the protection level to meet the current IED threat. (Armor Holdings was acquired by BAE Systems in 2007, renamed BAE Systems Mobility & Protection Systems, and reorganized as BAE Systems Land and Armament. Plasan specializes in customized, lightweight survivability solutions and provided the armor designs for both the MaxxPro MRAP vehicle and the Oshkosh M-ATV.)

This was a fast program; also in June ballistic testing of the improved MTRV armor system was conducted. The MROC identified a vehicle protection requirement equivalent to three Marine Expeditionary Brigades (MEBs) and seven Marine Expeditionary Units (MEUs): 1,850 MTRVs. In September 2004, Oshkosh received a contract modification covering 796 Marine Armor System kits for MTRVs. In December 2004, Oshkosh was approached to install armor kits in-theater. This request was made official in January 2005. Oshkosh received an order for another 124 truck kits in February 2004. Production of Generation III MTRV armor began in April 2005. It was described as a permanent addition to the vehicle, therefore capable of lasting its full 21-year service life. This Marine Armor System consisted of metal/composite panel armor, with separate cab and troop compartment kits, to be used for the different cargo and personnel versions of the truck. It was designed against small-arms fire, IEDs, and medium mines (up to 12 pounds).

Production continued at a rate of 22 per month through February 2006, against an interim requirement for 1,850 systems. By April 2005 the Marines had received enough funding for 920 kits, and the rest were included in the FY 2005 Supplemental. Installations at the Marine Armor Installation Site in Iraq began in May 2005, with installations in the continental United States (CONUS) scheduled to begin in July. The up-armored MTRV reached Full Operational Capability (FOC) in September 2005, and the Marines opened a second armor installation site at Al Jahra, Kuwait. MTRV installations were completed in May 2006.

¹⁵ The ECP for MASS was negotiated with Oshkosh in November 2003, as the Marines planned for their return to Iraq and developed vehicle requirements for what they called OIF II (Operation Iraqi Freedom II). As a result of a UUN, in January 2004 the MROC directed armoring of other vehicles, leading to development of the Marines' Humvee protection kits. The Generation I kit was chosen in March 2004, design having begun in January. Meanwhile, in June 2004, Armor Holdings and Plasan were chosen to produce MASS, and on 22 July a requirement for 1,850 MTRV protection kits was approved.

¹⁶ An unclassified Marine Corps MRAP Vehicle Timeline produced in March 2008 shows how the under-belly threat escalated. In 2004 under-belly attacks accounted for 14 percent of the total. That August the Marines began to buy their Marine Armor Kit. They also introduced jammers, personal protective equipment (PPE), convoy training, and the Mojave Viper training base. In February 2005, when the I MEF UONS was promulgated, underbelly attacks amounted to 10 percent of the total. The enemy was introducing massive IEDs, daisy chains (linked IEDs), and remote detonators. In March-June 2005 underbelly attacks were down to 7 percent of the total. The enemy was emphasizing vehicle bombs, bombs triggered by the victim (as in wire triggers), and EFPs. On this basis it was not surprising that the up-armored Humvee was the "gold standard." By February 2007, the situation had reversed: under-body attacks were 42 percent of the total. It was no surprise that the MROC approved 3,700 MRAP vehicles. Then underbelly attacks began to decline as MRAP vehicles and pre-MRAP protected vehicles were fielded: in May 2007 they amounted to 24 percent of the total (it is not clear whether that was because the total increased). As U.S. forces operated more effectively, the total number of attacks declined, but a much higher proportion of them were belly attacks. Thus, in February 2008 they amounted to fully 66 percent of the total of IED attacks. The under-belly attacks were certainly effective. Aberdeen Test Center Commander Colonel John Rooney USA recalled a 2005 test of a relatively small bomb against a truck. When the dust cleared, the truck was gone, obliterated. Rooney interview. See Appendix B for a list of all interviews conducted for this book.

¹⁷ Lt. General Emerson N. Gardner interview.

¹⁸ The M1114 was designed to provide protection against 4- to 12-pound underbody IEDs. The huge increase in the size of underbody IEDs changed the equation.

¹⁹ IMG was International Military and Government, the military/government arm of Navistar, formerly International Harvester; later it became Navistar Defense. JLTV is the planned replacement for the wide variety of existing Humvees. It is to have scalable kit armor and a degree of bottom protection. JLTV armor requirements differ for the Army and Marine Corps, with the Marine Corps fielding a lighter, less-armored vehicle that can use an armor kit to increase survivability when required by the mission. The Joint Requirements Oversight Council (JROC) approved JLTV in November 2006. Under Secretary John Young rejected the planned issue of a Request for Proposal (RFP) (2007) and told the services to go back and develop the required technology. The RFP was issued in February 2008. Three teams won 28 October 2008 awards for the initial technology development (TD) phase: BAE Systems; Lockheed Martin teamed with General Tactical Vehicle; and AM General teamed with General Dynamics Land Systems (GDLS). Two of the losing teams protested the awards: Northrop Grumman-Oshkosh and Textron-Boeing-SAIC. This protest led to suspension of the TD contracts until the protests were rejected (the contracts were reinstated on 17 February 2009, the Government Accountability Office (GAO) having ruled.

At this time, an engineering and manufacturing development (EMD) contract was expected late in 2011, but in February 2011 the EMD award was delayed because requirements had changed. EMD contracts were awarded in August 2012 to AM General, to Lockheed Martin, and to Oshkosh. The losers were Navistar (ex IMG), General Tactical Vehicles (joint between AM General and GDLS), and a BAE Systems team including Northrop Grumman. They were permitted to continue development at their own expense in hopes of winning production contracts. By this time the original three versions had necked down to two, a Combat Tactical Vehicle (CTV) to carry four and a 3,500-pound payload (essentially what a Humvee was originally designed to do, but on a protected basis) and a Combat Support Vehicle (two passengers, 5,100-pound payload). Improvements over Humvee were to include all-terrain capability and electronics linking the vehicle to command and control networks, both requirements that became important in Iraq and in Afghanistan. The size of the JLTV is limited by the requirement that it be transportable aboard aircraft such as the C-130. Skeptics have suggested that, given the experience of the MRAP vehicle program, the consequent weight limit (about 17,500 pounds) makes it impossible for the vehicle to be protected as desired. Before that one of the three planned variants had been dropped because at 15,639 pounds it was too heavy to be slung under Army CH-47F and Marine Corps CH-53K helicopters. As of 2013, the initial Army target was 20,000 JLTVs with options for more; the Marines wanted 5,500. The JLTV will replace a like number of HMMWVs, so the total number of USMC TWVs will not increase. The remaining 9,500 USMC HMMWVs will remain in service until 2030. It seemed likely that the other services would buy small numbers. The most interesting thing about these numbers is how far they are below the number of Humvees in service in 2008-2013.

²⁰ Colonel John Rooney recalled crawling through a bone yard of destroyed vehicles and seeing many EFP hits. Rooney went to theater and briefed General Correlli, Corps Commander for MNF I (Iraq) that there was an EFP problem. Rooney went to Iraq specifically to visit Camp Rustamaya in southeast Baghdad, from which two battalions (one Military Police, one mechanized) made daily runs into Sadr City. He found a lot of improvised (“haji”) armor that the motor pool had installed in hopes of defeating EFPs. The most prevalent was a 6-inch deep box filled with sand, welded to the side of a vehicle. Rooney, who was then commander of the Aberdeen Test Center, took one of his engineers with him, and when they returned to Aberdeen they tested the improvised protection—with disastrous results. They sent a classified video back to the camp. Rooney was much affected when an NCO said “Sir, you keep saying what doesn’t work. When will you find something that works?” John Rooney interview.

²¹ As an indication of the weight involved, the initial solution weighed about 150 pounds *per square foot* of surface. In addition to armor, there were other assaults on the EFP problem. For example, it emerged that a unit of Iranian Revolutionary Guards had provided the technology involved to those in Sadr City. A threat to expose Iranian involvement alleviated but by no means eliminated the EFP problem. Ultimately EFPs were too simple to make and too effective for the enemy to abandon.

²² Navistar developed the best solution as a company initiative. It was incorporated in the company’s MaxxPro Plus, which also had a beefed-up drive train and engine and better overall survivability. Only one low-rate initial-production (LRIP) buy of MaxxPros, for example, was completed with fittings for the EFP armor package. Appendix C lists all 23 LRIP contracts. MaxxPros produced under the next LRIP (as MaxxPro Plus) had the lighter protection, which was much more satisfactory. They also had beefed-up engines and drive trains. Meanwhile earlier MEAP kits languished in warehouses. That might seem wasteful, but when MEAP was being developed, no one could be certain that any lighter alternative would work. Had MEAP kits not been produced in quantity and had the unexpected lighter solution not materialized, EFPs would have been much more effective. No one could take that risk. The view in the MRAP JPO was that it was always better to buy insurance than to try to be fiscally efficient at a cost in blood. Speed could not be achieved without accepting considerable inefficiencies—in fiscal but not in human terms. This was one of several examples of purchases of parts or spares the need for which was quickly overtaken by events. Where possible, what was bought was used for other purposes, but that was not always possible.

²³ By the end of the war, the total number of events (explosive attacks) was well below what it had been, but the percentage of EFPs among those events was rising, and the enemy was well aware of how effective they were. The kits could not be gapless, but it was difficult to aim an EFP at gaps in coverage aboard a moving vehicle. There were, however, deliberate attempts to overcome the side protection by shooting high, so that the penetrator approached above the slab of side protective material.

²⁴ John Rooney estimated that EFPs accounted for 10 percent of events (attacks) in Iraq between 2005 and the departure of U.S. forces. He found them more effective killers than side or under-body attacks.

²⁵ An engineering change proposal (ECP) had already been requested for integrated protection for the logistical trucks. I MEF, the Marine Force which would operate in Iraq, submitted a UONS in December 2003 for 27 HEVs (Cougars), based on the large request for EOD versions for EOD units. The first Cougars were deployed in October 2004. A market survey determined that FPI had the most viable solution. The two-phase initiative was approved by the MROC in January 2004 (all vehicles in Iraq were to be armored). Procurement of COTS protection and design of a Marine Corps 3/16-inch armor suite were begun. The HEV UONS was listed as priority 57 of 61. Programs are generally listed in priority order so that those above the budget line are funded when the size of the budget is set. Number 57 was low on the list, out of 61 stated requirements to fight the war. Dates from an 18 March 2008 history of the Marine Corps armoring program. Edie Williams, *Mine Resistant Ambush Protected Vehicle Program*, *op.cit.*

The market survey produced a chart showing Cougar H (as per a USMC contract), Dingo 2 (a West German protected truck), the UAH version of the Humvee (XM1114), the Humvee with the planned USMC armor kit, the Marines’ LAV-25 wheeled amphibious armored personnel carrier, the Bradley M2 Infantry Fighting Vehicle, the XM1117 Armored Security Vehicle (Commando), and the South African RG31 Nyala (then being offered by General Dynamics Land Systems–Canada). The comparison sheet showed protection against various weapons, including anti-tank mines of up to 30 pounds, various bullets (up to 0.50 caliber armor-piercing [AP]), gross weight in U.S. tons, road speed, range (paved roads), quantities (presumably under order at the time), and unit cost. At this time 28 Cougars and 714 Nyalas were on order.

The Humvee was credited with limited underbody protection against a mine detonated near its front axle, the most likely place, and with protection against anti-personnel mines. The ASV but not the Bradley or the LAV, was credited with protection against a mine detonated near its front axle, but neither it nor the Humvee were considered protected against mines further under their bodies. The only full underbody protection was offered by Cougar, Dingo 2, and RG31, of which Cougar and RG31 ended up as MRAP vehicles. At this time Textron was offering Dingo 2 for \$600,000 each. The unit cost of a Cougar was given as \$394,826, compared to \$99,000 for a Humvee XM1114 and \$102,000 for the up-armored Marine version. The ASV cost \$650,000, but the RG31 cost only \$325,000. At the high end of the scale were the LAV (\$900,000) and the Bradley (\$3.2 million). None of these vehicles was proof against 0.50 caliber AP rounds, and only Cougar and LAV-25 were considered proof against normal 0.50 caliber bullets. Neither Nyala nor the Humvee was protected against 7.62 mm NATO AP bullets. Cougar and Humvee offered the highest road speeds (75 mph), and Cougar offered the greatest range (550 miles, twice that of a Humvee).

²⁶ The Marine Corps Logistics Center provided cut steel for a combination of applique panels, 3/16-inch thick L-shaped doors, and ballistic blankets. Vehicles received this protection before deployment to Iraq. Generation II was improved Marine Corps Logistics Center armor (3/8-inch rolled homogeneous steel). Generation III began the series of Marine Armor Kits (MAKs) and the MTRV armor system. Production of Generation I armor was completed in April 2004, and fielding of Generation II began. That month the Marines fielded 37 export-type up-armored Humvees to I MEF in Iraq. In August 2004, in the face of a deteriorating situation, the Marines reprogrammed funds to upgrade all Humvees (except the up-armored M1114s and M1116s) with armor. More than 4,100 vehicles in I MEF received the thicker Generation II armor, which included flanks, underbodies, tailgates, rear cab plates, ballistic glass, and gunner shields. In addition, in a joint effort with the Army, the Marines received vehicles under a Multi-National Corps–Iraq program: 200 Add-On Armor Kits and more than 400 M1114/M1116 up-armored Humvees.

In October 2004, the MROC decided to procure 498 M1114s (UAHs: ordered by January 2005) and MAKs for all other Humvees. Generation II armor was fielded that month to the 15th MEU in Iraq. The MAK was developed due to increasingly sophisticated IEDs and also due to extreme usage levels and environmental conditions. MAK resulted from a cooperative Marine-Army program, and it was based in part on the Army Research Laboratory's Add-On Armor Kits. The Marine Corps Logistics Base began production in November 2004. For non-M1114s MAK consisted of integrated kits that could be bolted on by Marines in the field. It offered significantly better protection against the main threats, including small-arms fire, IEDs, and small mines (up to four pounds). Installation in the United States began in December 2004, and that month the first eight MAK vehicles were fielded to Afghanistan. In-theater installation of MAKs began in Iraq at the Marine Armor Installation Site in March 2005; they were completed at a rate of 200 per month. In May, the Marines began replacing base model Humvees with Humvee A2s with MAK. The next month they decided to replace all Humvees with M1114s and 1350 were ordered (deliveries began in July 2005). The last of 5,500 MAKs were produced in December 2005. Fielding of Humvee A2s was completed in January 2006, and 524 M1114s were ordered in February 2006. By December 2006, 2,605 of 2,914 M1114s had been delivered. The Marines began fielding M1114 and M1151 Fire Suppression Systems to deal with secondary fires after blasts. There were also specialized kits for the M1114. Kit 2 was designed to improve ballistic protection in the front driver and A-driver wheel-well. Kit 5 was designed to reduce the effects of IEDs and also to reduce the effect of armor debris due to overmatching explosions. It replaced door and rocker panel assemblies in an M1114. The high-hard steel and aluminum rocker panels are replaced by rolled homogeneous armor/mild steel rocker panels, which tie into the roof support and make it possible to hang heavier armored doors. The hinge of the rear door was also replaced. After deliveries of the original orders for M1114s, additional up-armored Humvees (M1114, M11151, M11152) had Kit 2 and 5 integrated into them when they were produced.

²⁷ The purchase of the initial HEVs (Cougars) was subject to key military requirements: (1) militarization (e.g., toggle starter switch, red and blackout lighting, reversal of automotive safety features [so that brakes would release instead of locking when a brake fluid line broke], communications and antenna mounts, external power sources, and robot tie downs and ramps); (2) verification of the manufacturer's test data concerning blast and ballistic protection; and (3) design of M240G gun mounts and gunner shields (not used in previous versions of Cougar or the British Tempest). The contract for the 15 vehicles was signed in March 2004. In December 2004 an Above-Threshold Reprogramming (ATR) for another 12 vehicles was submitted and approved. This HEV Delivery Order 2 was funded and awarded in February 2005.

²⁸ The market survey was announced in January 2006, but participants in the tests were not, apparently, announced formally. JLTV combined an Army program for a Future Tactical Truck System (FTTS, a technology demonstrator) and the Marines' Combat Tactical Vehicle (CTV); it was envisaged as more multipurpose in concept than the Humvee, although the latter had become multipurpose. A Joint Program Office was set up (it was endorsed on 24 April by the three-star Army-Marine Board). The Army Tank and Automotive Research Development and Engineering Center announced the market survey on 24 August 2006, with a view toward enhancing tactical wheeled vehicle (TVW) survivability in the 2010-2017 timeframe. The British were interested because they wanted a replacement for their vulnerable Land Rovers, which were broadly equivalent to the U.S. Humvees. They bought a mix of Cougars (Mastiffs) and British-built Vectors. Procurement of 100 Mastiffs and 100 Vectors was announced on 24 July 2006; 66 Vectors were already on order. These vehicles were intended specifically for Iraq and Afghanistan. This date suggests that there was a comparative trial earlier in 2006, or possibly in late 2005. Vector is a moderately protected vehicle developed under a fast-track contract.





CHAPTER 3

CRISIS!

Through 2003-2006 the improvised-explosive device threat kept rising, killing U.S. troops in a way that to increasing numbers of observers made the war seem pointless. Troops obtained plating and other protection for their Humvees with what experts later called “hillbilly armor.”¹ The Army and the Marines developed up-armoring programs. These programs were reasonably successful against the initial threat of side attack, which predominated until the fall of 2005. Presumably that was when the enemy learned that he could no longer rely on side attack against increasingly well-protected vehicles, particularly Humvees, and that he had to shift to bottom and explosive-formed penetrator attacks.² The two wars faced different upgraded threats. The Marines were encountering bottom mines, but the Army faced mainly EFPs, because they were concentrated in different places. This difference made the bottom mines the initial focus of the MRAP vehicle program, because it was initially a Marine Corps program.

The main counter offered by the Defense Department against IEDs was jamming. In addition to individual Service programs, a huge DoD program—Joint Improvised Explosive Device Defeat Organization (JIEDDO)—was created specifically to attack the total IED “kill chain,” including IED control (jamming), detection, personnel network identification and disruption, and surveillance. The electronic remote controls used to trigger IEDs included such mundane items as garage-door openers and later cell phones. It began soon after the 2003 invasion and the beginning of insurgency and IEDs, with devices with names like “Warlock Red and Green” and “Shortstop,” then “ICE” and “Warlock SSVJ” (2004) and “Warlock-Duke” (2006). At least at first the philosophy was to deploy limited numbers of jammers in special locations and on board special vehicles. No one imagined putting a jammer or jammers on every vehicle in the country. Ultimately that is roughly what happened: all MRAP vehicles, for example, carried jammers. There were also other initiatives. One was pre-detonation, a device that could be installed on board a vehicle to detonate mines in its path so that it would not be damaged. If pre-detonation worked, it would be unnecessary to armor vehicles at all. There was also interest in an intelligence or Special Forces solution: to hunt down the bomb-makers. To some extent extending surveillance in Iraq and Afghanistan was seen as a means of supporting this offensive. To some extent, too, visible surveillance might deter those planting bombs, because they would fear discovery and attack. Aerostats (tethered balloons) carrying cameras and other sensors were part of this campaign.

The congressional committees involved in funding the program became increasingly frustrated, as it seemed to them that nothing was solving the problem. For one, Representative Gene Taylor of the House Seapower and Expeditionary Warfare Subcommittee remembered a 2005 visit to a Mississippi National Guard unit deployed to Iraq.³ He rode in a convoy the day after an under-bottom IED destroyed a Humvee, with the gunner thrown 20 yards, his legs shattered. Taylor had supported every counter-IED program, which meant every jammer program: jammers with fixed frequencies, then broadband jammers. Jamming aircraft were flying over Iraq, and jammers were being installed on board vehicles.

To Taylor, the most important effect of the IEDs was that they crippled the U.S. effort by the way they affected troops. During his 2005 visit, Taylor was riding in the back seat of a Mississippi National Guard Humvee. In front of him a young soldier cried out “IED!” every time a piece of wreckage or a dead animal or even a bump appeared

alongside the road. Taylor found that single trip unnerving. How could anyone manage an eight-month tour? The jammers might or might not be effective; it might well be that some large proportion of IEDs *was* in fact being neutralized. That could not affect the troops, because what they saw was the proportion of IEDs *not* neutralized. No matter how good the neutralization rate, there were enough effective IEDs to impress the troops. In order to win, the troops had to feel that they were safe from this sort of random attack.

“Left of the Boom”

By 2006 there was a sense of crisis. JIEDDO was created out of the earlier Joint IED Task Force to find some way to neutralize IEDs. It provided some of the initial funding for the MRAP program, but it concentrated on a systems approach, one element of which was jammers and other technological solutions. “Left of the boom” was the JIEDDO catch phrase meaning all of the actions leading up to a detonation. Their objective was to disrupt the system anywhere along this “kill chain.” A publicly known example was the automated means of quickly detecting changes revealed by overhead photos, mainly taken by unmanned aerial vehicles patrolling routes U.S. convoys would take. UAVs were bought on an emergency basis specifically for this role.

In terms of percentage of IEDs defeated, the high-tech solution worked. Rough estimates of its success range from 50 to 85 percent. However well the solutions worked, what the troops and the public saw was their failures. As a senior tester put it, “the troops never see what is to the left of the boom.” Unless the high-tech defeat mechanisms worked 100 percent of the time—which was impossible—the troops needed assurance that they would survive the inevitable failures. That was probably a lot more obvious on the ground in Iraq than back in the United States, where a system with a high but not perfect success rate was considered quite good. If there were enough IEDs, moreover, even a high percentage of success did not translate into a low enough casualty rates.

Commanders on the ground understood the time-critical response to the IED threat. They urgently requested mine-resistant vehicles like the Cougars then being used for mine clearance. They quickly ran into two kinds of obstacles.

The first was the inertia of the procurement system. It was oriented toward producing existing types of vehicles. They could be modified (as in the up-armored Humvee),

but the acquisition system was all-but designed to discourage initiating entirely new, massive programs, where evolutionary versions of existing programs might suffice. That inertia was not accidental. It had been designed into defense procurement in the early 1960s to avoid the waste associated with large, poorly designed, new programs. The late 1940s and particularly the 1950s had been a time of rapid, even violent, changes in technology and national strategy. Numerous programs were started. By the late 1950s many of them were approaching the production stage. Not only were not all of them affordable, but it also turned out that costs had often been badly underestimated. This was understandable when the programs involved so much new technology. The then-new defense procurement system—which became the system long in force by 2006—was deliberately designed to emphasize long-term planning so that resources could be allocated efficiently. The hope was that costs and risks could be assessed early enough in the development cycle that over-risky or over-expensive programs could be weeded out or restructured.

A second obstacle to a vehicle program was the Department's long-standing orientation toward high technology, which meant leveraging American strengths, as they were understood. Since World War II the United States had generally chosen to leverage its technological sophistication, whether countering the Soviet Union or fighting in Korea and in Vietnam. Jamming was perceived as a high-tech solution to a tactical problem. An oddly shaped truck was not, although it turned out that it took a great deal of "high-tech" to understand how and why that truck could be shaped and equipped to resist mine blasts. There was some irony here. Relying on rapid technological progress to solve problems ran counter to the hope of avoiding undue risk and cost in system production. DoD recognized this issue and was trying to address it with a special category of programs called "Rapid Acquisition Programs" (the Navy name, but the other Services had similar initiatives), which by-passed some of the acquisition wickets that most programs had to clear. The MRAP vehicle program began as such a program. Cynics often pointed out that program managers had to sell their programs by promising both enormous advances in performance and limited costs (of things impossible to estimate in advance). The typical result was either to reduce performance later on or to stretch out a program to hold down annual costs, with the result that its performance would not seem nearly so sparkling once it entered service.

This sort of result was acceptable only if system performance was not a life-or-death matter. When the United States was fighting a war, something had to be done to

provide enough performance quickly. All acquisition professionals knew that there were three factors in any program: cost, schedule, and performance. A choice in any of them carries a certain amount of risk. Any two of them could be controlled if the third was left free, because almost all risks associated with the first two could be made up for using the freedom of the third factor. Usually the emphasis is on containing annual cost. In wartime, however, cost is much less important than schedule and performance. Limited wartime programs have been conducted by bypassing the normal acquisition system, as though the small production lots involved are in effect numerous prototypes. That is possible as long as there is no need for large numbers, or for a logistical tail to keep the product in service on a protracted basis. MRAP vehicles were needed in numbers and they had to be kept in service for years (actually for much longer than the MRAP Joint Program Office expected). It could not bypass the system; it had to be built within the system, in a way those who had designed the procurement system had not envisaged—with schedule and performance (against IEDs) the key parameters.

Transformation?

Even before the invasion of Iraq in 2003, the Army and Marines were concentrating on the problem of a small expeditionary force fighting a large but less advanced conventional army—the problem both faced in Iraq in 2003. Expeditionary forces had to be small and light because they would have to react against crises around the world. Heavy Cold War forces had been garrisoned in a few key places, but the post-Cold War world was much less predictable, and at the same time forces had to shrink to remain affordable. That made mobility more important than ever. In 2003 it must have seemed that this change had been successful. The United States was able to build up to invade Iraq much more quickly than in 1991, and it was able to do so despite being denied some regional bases. Ironically, being able to overthrow Saddam Hussein's regime with a limited ground force turned out to mean that the post-invasion ground force was too small to stabilize the country. No one, it seemed, had imagined the internal forces that would cause Iraqi insurgencies against the coalition force that had liberated the country from its cruel dictator.

The expeditionary outlook led the Army and the Marines to develop a new kind of ground force that emphasized surveillance (massive sensing), netting, and mobility. Its mantra was that the enemy could be detected and attacked before he could react.

Instead of massing to concentrate sufficient firepower, ground units could disperse and concentrate their fires beyond units' horizons. In the new kind of ground force, passive protection (armor) was a last resort, insurance against the failure of remote sensing of the enemy. Given remote sensing and over-the-horizon weapons, ground units could disperse, and dispersal in itself would help protect them against a conventional enemy. The enemy's presumed lack of effective surveillance would make it difficult for him to hit first.

There was clearly a gap between the appearance of IEDs and the beginning of a high-priority effort to counter them using protected vehicles. That was not due to some dereliction of duty, but rather is traceable to a different view of the appropriate solution to the IED problem. The question can be asked only in the context of the broader focus of U.S. force development at the outset of war in Iraq and in Afghanistan.

It was widely understood that Secretary of Defense Donald Rumsfeld favored high-tech solutions. He entered office in 2001 with the avowed purpose of making defense more affordable through technological transformation, what the Soviet military dubbed a "Revolution in Military Affairs." Transformation would leverage advanced U.S. technology to provide increased military power without increasingly expensive manpower. Secretary Rumsfeld was hardly the sole apostle of transformation; when he entered office, the U.S. Army was already developing its family of Future Combat Systems (FCS) based on networking and surveillance systems. The networking idea, as a way of reducing the size of forces, had been popular in the Defense Department since the mid-1990s, when it was first elaborated at the Chiefs of Staff level as Joint Vision 2010. Secretary Rumsfeld made it his own, to the extent that attacks on the idea (once it seemed to have failed to fulfill its promise) became attacks on him.

Many saw Iraq as the great test of transformation. As the decision was made to go into Iraq, Secretary Rumsfeld maintained that a small but technologically advanced Army could defeat the larger but more primitive Iraqi Army. The U.S. Army argued that, however quickly the Iraqis might be defeated, it would take a massive force to occupy the country. Rumsfeld and others in the George W. Bush Administration rejected the Army's argument as an attempt to claw back the mass force the Army would lose due to transformation. The difference was crucial, because even to assemble the force the Army wanted would have delayed the Iraq operation by many months (it would have had to wait at least for the fall of 2003). To have fielded a larger force would also

have required much more agreement by local powers and also much more logistical support. Neither could easily be supplied; readers will recall the Turks' refusal to join in the attack. A key argument that the smaller force would suffice was that occupation would not require the numbers the Army envisaged. Surely the Iraqis would welcome liberation from Saddam Hussein. Many did, but some, particularly those who had benefitted under the dictatorship, fought the coalition force.⁵ Given the passions raised by the prewar arguments, it was difficult for the Secretary to call what was happening in Iraq an insurgency or to admit that it might be protracted.

Moreover, given his earlier investment in trading technology for numbers, Rumsfeld naturally backed high-technology solutions to disorder and resistance in Iraq. The Secretary's faith in technology rather than numbers reflected long-standing U.S. military thinking. His attitude had important budgetary implications. Individual high-technology systems might be expensive, but he could reasonably hope that they might be effective even in small numbers. The prototype of transformation was net-centric operation, which was expected to amplify the power of individual small units by linking them and also by giving them the ability to see beyond their horizons (using stand-off sensors such as those on board UAVs) and thus to call down fire on remote targets. The invasion of Iraq demonstrated that this kind of technology worked extraordinarily well, in forms such as "blue-force"(friendly) tracking, GPS-based land navigation, and GPS-based air attack.

These arguments in Washington had real implications for the U.S. force in Baghdad. If the insurgency was a passing phase of Iraqi recovery from Saddam Hussein, then it was pointless to invest heavily in vehicles designed specifically to deal with it—in this case, with IEDs. Any anti-IED program should concentrate on separate solutions, such as jammers, which did not have to be bought in huge expensive numbers. As importantly, solutions like jammers did not affect the vehicles that would leave Iraq to rejoin the new-model Army. After all, Iraq was not the whole post-Cold War future.

Reality was different. The elaborate surveillance systems often failed to detect or track insurgents on foot. In an insurgency, the main sensor is intelligence, which is always spotty and often imprecise—hardly the basis for firing a precision weapon. Jammers were never 100 percent effective. It turned out that the troops faced with IEDs needed the reassurance that armor brings: MRAP vehicles. It also turned out that the Iraqi insurgency was much more resilient than anyone in Washington had imagined.

Perhaps oddly, Secretary Rumsfeld's promotion of transformation did not include any dramatic change in the defense procurement system intended to promote agility.⁶ He might have hoped that it would be enough to promote relatively small but disruptive programs for new technology. In any case, Rumsfeld did not leave a path for rapid procurement on the scale ultimately demanded by the MRAP vehicle program. That may have reflected acceptance of another basic tenet of the defense procurement system, that long-term planning was always appropriate. There would never be surprises so massive that long-term thinking should be abandoned. Oddly, too, that view survived the biggest surprise, 9/11.

Rapid Agility

Although there were procedures for rapid acquisition programs throughout DoD, these did not apply to major programs. Initially, there were procedures in place to support accelerated acquisition for less than major programs, which is how the MRAP vehicle program began. (All of the Services had established a process for identifying and responding to "Urgent" needs, with special procedures to speed response.) The key point throughout is to recognize that, at the start, the MRAP vehicle program was not envisioned as a huge program. It was expected to be a relatively small program responding to specific, small urgent need statements. Many of the early MRAP vehicle program decisions were made in a context completely different from that which eventually evolved. Initially, for example, the intent was to have only contractor logistics support (CLS), which made sense for a small number of limited mission vehicles. It was only after the program ballooned that the decision was made to move to a largely organic approach, and to consolidate all CLS under a central manager.

The insurgency that followed the invasion of Iraq did not offer such obvious lessons as the invasion itself. The question was whether the Army was right in arguing for a large post-invasion force, and success required the U.S. ground forces to spread throughout the country; or whether the post-invasion unrest was a temporary problem, which would settle itself, as Iraqis realized that they were freer as a result of regime change. As the insurgents fought back with IEDs, the natural expression of the classic U.S. attempt to leverage technology (rather than use mass) fit the Secretary's own preference for transformation rather than more traditional forms of military power. The enemy should be defeated by concentrated high technology rather than by massed manpower. A few

jammers could, in theory, defeat IEDs spread widely throughout Iraq. Mine-resistant trucks were the opposite. They had to be multiplied in the thousands to protect all the troops in theater. The Marines might buy them on a small scale, but as long as Mr. Rumsfeld remained Secretary of Defense it was unlikely that any new vehicle program would be established on a sufficient scale to cover the Army, as well.⁷

In this sense Secretary Rumsfeld's departure was a necessary but not sufficient condition for the MRAP program to grow beyond its Marine Corps beginning. It was extremely important that Rumsfeld's successor, Secretary Gates, was not wedded to technological transformation as the only solution to defense problems. The congressional committees who had become skeptical—and angry—during Mr. Rumsfeld's tenure welcomed Secretary Gates' enthusiasm for the MRAP as a vital element of the solution to the IED. Gates convinced the relevant congressional committees that not only was he willing to try something entirely new, but that he had the drive to make it happen quickly enough. This time was different. Now they were willing to provide the large amounts of money the MRAP program needed in order to produce enough vehicles. It helped that Gates' deputy in the MRAP Task Force was John Young, who had spent a decade as a staffer for the Senate Defense Appropriations Committee and had served as the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN (RDA)). That is why he was sent to testify to the committee even though he had just been nominated to become Under Secretary of Defense for Acquisition, Technology, and Logistics (USD (AT&L)). Normally anyone in that position would be kept under a “cone of silence.” Gates understood that Young had the Committees' trust. The stage was now set for the dramatic expansion of the Marines' limited MRAP vehicle program to respond to the continuing IED crisis throughout Iraq and Afghanistan.

End Notes

¹Reportedly Secretary of Defense Rumsfeld initially vetoed armoring Humvees in Iraq, hence the troops' “hillbilly” self-protection measures, which included steel plating on the inside of the vehicles and sandbags on the floor. In some cases, body armor was lined up on the insides of the Humvees. Humvees protected in these ways (and by more conventional up-armoring) became top-heavy and rolled over. Ultimately Secretary Rumsfeld was “roasted for inadequate Humvee protection.” Gordon Wolverton interview.

²Colonel Kevin Peterson USA interview. Peterson was the first Military Deputy in the MRAP vehicle program, and served as Army Program Manager for Light Tactical Vehicles in 2003-2006. As such, he managed the Humvee Up-Armor and Armor Add-On programs. On the staff of the Program Executive Officer (PEO) for tactical vehicles, he validated the increase in the Army requirement for MRAP vehicles from 2,500 to 10,000. The frequent incremental increases in the MRAP requirement made the program much more difficult to manage. The program manager usually (not always) knew that an increase was being considered, but until it was formally approved, could not take actions relative to increased funding, contracting, or production. Given the long lead from requirement to contract to production

to fielding, the program office had to be very creative in building the infrastructure and funding to support increases that they knew were on the way without being able to officially act on them.

³ Representative Gene Taylor interview. Taylor held a January 2007 hearing on the requirements for protected trucks. He saw a need for 17,000 of them. Taylor believed that, had he still been Secretary of Defense, Rumsfeld would have blown off the idea, as he had in the past. He considered it decisive that Robert Gates had been named Rumsfeld's successor. Gates had no personal investment in the choice of high- or low-technology solutions, and his background had not been in technology development; he had begun his career as a CIA analyst with a history degree.

⁴ Richard Sayre interview.

⁵ This applied particularly to Sunnis, a minority who had dominated Saddam's Iraq, and who certainly stood to suffer badly if those they had oppressed fought back (some of that had happened in 1991 after Saddam's defeat in Kuwait). Others clearly saw the post-Saddam power vacuum as an opportunity blocked by U.S. forces. That would seem to apply to Shi'ites in places like Sadr City, an area of Baghdad. Prewar predictions that Iraqis had a much stronger sense of nation than of sub-national group had justified the view that heavy occupation would not be necessary.

⁶ Given the huge and well-known inertia of the procurement system, Secretary Rumsfeld may have seen curing it as a step too far. If procurement shifted largely to limited numbers of advanced systems, it might be possible to buy the necessary ones outside the main procurement system. There certainly was considerable interest, during and before the Secretary's tenure, in initiatives such as eliminating military specifications where they were excessively restrictive. It has also been suggested that he did not realize how much more inertia had been added by the Goldwater-Nichols Act of 1986 that long postdated his earlier Defense Department experience.

⁷ The Marine program was too small to come to the notice of a Secretary of Defense. That became evident when Secretary Gates, who was open to exactly such a program, was unaware of it until he read about it in a newspaper article. A massive purchase covering the Army would have been a very different proposition, and there was widespread sentiment that Secretary Rumsfeld would have resisted it. That was evident in the Taylor interview.





CHAPTER 4

MINE-RESISTANT VEHICLES

When U.S. forces entered Iraq in 2003, there already existed vehicles designed to resist the blasts of under-bottom mines. They had been developed first in Rhodesia (now Zimbabwe) and then in South Africa to counter “belly” mines during wars extending from the 1960s to the end of Apartheid in the 1990s. The key technological solution was a vee-shaped monocoque (i.e., rigid self-supported) hull, which dissipated the under-body blast. The Rhodesians found that mounting the hull well above a commercial chassis gave them the desired degree of mine resistance. No one else in the world seems to have been producing such vehicles at the time.

The South Africans faced similar threats, but they had a much larger industrial base. They built on the Rhodesian ideas, but instead of modifying existing vehicles they built special ones. Their first ones employed vee-bottomed armored compartments

well separated from the truck chassis. The separation proved unfortunate, because the bottom of the compartment could trap blast, and the separate chassis was a source of weakness. It was soon clear that the monocoque compartment was sufficiently rigid to function as a frame *and* a body. All suspension parts and the transmission were external. A blast might destroy them, but the tough hull would survive and new external parts could be put back in place. More importantly, of course, people and equipment inside the vehicle were protected.

South African Vehicles

This improved concept originated with the South African Council for Scientific and Industrial Research (CSIR). The first such vehicle was Casspir (CSIR and South African Police, SAP, the first buyer), followed by Mamba.¹ The designer of these vehicles, Dr. Vernon Joynt, worked in the Applied Chemical Unit of the CSIR, which later became the Mechem Company. Mechem was part of Denel, a South African defense combine. In addition to mine-resistant vehicles (principally Casspir and Mamba), the company developed mine detection and disposal technology (it changed its focus from R&D to de-mining after 1991). When Dr. Joynt emigrated to the United States, he took with him his connection to Mechem.

The South African government's vehicle builder was the Olifant Motor Company (OMC), created initially to build the indigenous Olifant tank. It made a series of mine-resistant vehicles, including Casspir, Mamba, RG-12, RG31 (Nyala, based on Mamba), RG-32 (Scout), RG Outrider, and RG-33.² OMC ultimately became an important part of the MRAP program's industrial base; both RG31 and RG-33 became MRAP vehicles.

RG31 (Nyala) was the first mine-resistant vehicle bought by the United States. The U.S. Army bought a few of them in 1996 for operations in Bosnia.³ It designated them Medium Mine-Protected Vehicles (MMPV). At that time RG31 was also being bought for the United Nations and other peacekeeping and security services (including at least one for the London Metropolitan Police). The Army resumed buying RG31s in 2003 for Operation Iraqi Freedom, initially buying nine of them for route clearance and electronic warfare (IED fuze jamming).⁴

In addition to RG31s, the Army deployed Textron M1117 Guardian Armored Security Vehicles (ASVs) for military police operating in Iraq. They were not considered

mine-resistant, and the M1117 was not selected for MRAP vehicle production awards, although Textron was among those awarded an initial IDIQ contract.⁵

After the end of Apartheid, OMC passed through the hands of British defense companies Vickers and Alvis. During this period General Dynamics Land Systems (GDLS) acquired an exclusive production license for the company's RG31 in North America through its Canadian subsidiary, GDLS-C. This company supplied large numbers of RG31s to the U.S. Army and to U.S. Special Operations Command (SOCOM) and then to other U.S. forces under the MRAP program. Late in 2004, BAE acquired Alvis, and in the process acquired OMC, which became BAE OMC.⁶

Casspir seems to have been the first of the South African vehicles fielded (almost accidentally) by U.S. forces in Iraq. A private U.S. company, probably Blackwater, bought 13 Casspirs in 2004 and another 15 in 2005 for operation in Iraq.⁷ In 2004 this company seems to have been offering up to 53 Casspirs to U.S. forces in Iraq at the bargain price of \$200,000 each. Two Marine majors who had previously advocated buying such vehicles approached Marine Corps Colonel Brian Green, who was serving with the Army Rapid Equipping Force (REF), with this information. REF had its own funds, and Green was able to buy eight Casspirs, which the Marines in Anbar Province received.⁸

Casspir had been out of production since 1993-1994, and the vehicles brought into Iraq had been reconditioned.⁹ Experience with them might have inspired the Marine General commanding I MEF (Forward) to issue an urgent call for MRAP vehicles the following year (see below). However, a Marine familiar with the later MRAP program pointed out that they were anything but an off-the-shelf solution to the IED problem. The South African vehicles had all sorts of automotive problems, such as bad transmissions. They always seemed to be broken. No one could lightly buy them to replace ordinary high-mobility vehicles such as Humvees. The Marine did not specify which South African vehicles, but he was probably referring to the Casspirs, the South African vehicles the Marines actually used in very small numbers about 2005. The bad experience with Casspirs probably left the Marines less than enthusiastic about the South African vehicles the Army was then introducing (RG31s).

With apartheid dead and the South African Army no longer as interested in mine-resistant vehicles, Joynt and retired Rhodesian SAS Colonel Garth Barnett emigrated

to the United States in the late 1990s to form Technical Solutions Group Inc. (TSG) to sell their technology; Joynt became Chief Technology Officer. They retained their earlier connection to Mechem in South Africa. Joynt and Barnett expected the United Nations, which often operated in heavily mined areas, such as Cambodia, to be a major buyer. Apparently TSG initially concentrated on the new mine detector (a “sniffer” intended to detect explosive vapors) that Mechem was marketing in the 1990s. TSG developed a pair of vehicles, Lion and Lion 2, of which Lion was a 4x4 personnel carrier that outwardly resembled a civilian car, on the same general lines as the South African RG31 or Mamba. Lion II was a 6x6 truck capable of carrying the new mine detection and disposal equipment TSG was marketing. In February 2000, as part of an effort to identify a mine-protected clearance vehicle, the U.S. Army awarded a contract to TSG for one Lion II, at the time called a Buffalo, which was to take part in a Foreign Comparative Test Program. The Army bought a second Buffalo in November 2001 for further tests, and in September 2002 it bought ten for contingency use as its standard mine-protected clearance vehicle. The first Buffalo deployed to Iraq in 2003 as a control vehicle for mine neutralization robot vehicles under what became the Ground Standoff Minefield Detection System (GSTAMIDS) mine countermeasures program.¹⁰ These Buffaloes incorporated a robotic arm carrying a mine rake/probe and a video camera, which allowed its operator to find and uncover concealed IEDs with precision while protecting the operator by keeping him clear of any explosion.¹¹ Buffalo became a standard counter-IED vehicle in Iraq, and it was folded into the MRAP program as its Category III vehicle.¹²

No one appears to have bought Lion, but in 2002 the British bought eight 4x4 mine-resistant Tempest EOD vehicles derived from it.¹³ This purchase was probably connected with ongoing British operations in Bosnia, where mining had been indiscriminate. Tempest became the basis for a new Typhoon vehicle, which in turn was later marketed as Cougar.

In 2004 the Marine Combat Engineers in Iraq submitted an Urgent Universal Need Statement (UUNS) for 26 vehicles capable of resisting bottom mine explosions.¹⁴ (There was also a February 2005 UUNS from 1st MEF for 1,169 vehicles, and a July 2006 multi-service requirement for 1,185 vehicles. The latter became the initial requirement for the MRAP program. The former was not validated due to the start-up of the Up-Armored Humvee (UAH) program.) The Marines wanted a vehicle

that could be delivered within six months of an order. The request was discussed by Assistant Commandant of the Marine Corps (ACMC) General Robert Magnus, who was involved in developing Marine requirements for a Humvee follow-on vehicle. The Army sat in on the discussion. General Magnus developed the need statement for the new vehicle, which was considered a specialized EOD vehicle. Competition for the contract was suggested but rejected, given the urgency of the requirement. A sole-source contract for Cougars was let to TSG. The Marines ordered them under the designation HEV (Hardened Engineer Vehicles).¹⁵ Later they were designated JERRVs (Joint EOD Rapid Response Vehicles). Further contracts followed.¹⁶ A JERRV cost \$1.5 million.¹⁷ These were special vehicles, to be bought in small numbers in the classic role of eliminating mines ahead of convoys of vehicles. At the initial price, there was never going to be enough money for a thousand of them, let alone to replace in-theater just the armor-upgraded Humvees, as some suggested.

TSG won the HEV/JERRV contract because it could meet that requirement by modifying its existing Tempest vehicle under the new name of Cougar. Cougar was designed in both 4x4 (Cougar H) and 6x6 (Cougar HE) versions. It is not clear precisely how TSG's vehicles were related. For example, at one time Tempest was advertised as better protected than Cougar. However, when TSG won a contract for 27 Tempests, they materialized as Cougars.¹⁸

TSG was incorporated into a new company, Force Protection Industries (FPI), about 2002.¹⁹ The combination of Cougar and Buffalo made FPI the only U.S. producer of mine-resistant vehicles in 2005-2006, when the belly-mine/IED threat in Iraq ballooned. Given their experience with Cougars, the Marines came to associate mine resistance specifically with it.

During the summer of 2006 Cougar variants were bought by the British and for the Iraqis, not as special-purpose engineer vehicles, but as general-purpose armored personnel carriers. The British bought Cougar in preference to the South African RG31, which was broadly comparable.²⁰ The British called their vehicles Mastiff Protected Patrol Vehicles (PPVs). Later ones were called Ridgeback and Wolfhound (Heavy Tactical Support Vehicles, HTSVs).²¹ Deliveries began in November 2006. Soon the British purchases were being treated as foreign military sales under the U.S. MRAP vehicle program, since the United States was buying Cougars under that program. The British program was important to the later U.S. program because British experience

contributed to U.S. decisions that made Cougars more reliable. In some cases the British discovered problems before the Americans did, and the fact that the same program ultimately covered both countries' vehicles meant that the U.S. program was quickly aware of what the British discovered.

Acting as agent for the new Iraqi government, the U.S. Government bought Iraqi Light Armored Vehicles (ILAVs) to patrol the country.²² Because vehicles would patrol either singly or in small numbers, the usual technique of having a special EOD vehicle precede a convoy would not apply; the vehicles, themselves, had to be protected. As in the JERRV case, procurement had to be very fast; an existing vehicle had to be bought. BAE won the large contract with a version of FPI's Cougar, which was called Badger.²³ Although BAE's RG31 was in roughly the same class, BAE believed that Badger was a better fit.

FPI had only limited production facilities; it was building its vehicles one by one, by hand. BAE set up production at other facilities, mainly at Spartan Motors. In addition to FPI, Spartan supported several MRAP vendors. FPI began to realize that large orders for mine-resistant vehicles might be coming up, and it dropped the license-production deal for anything but the Iraqi contract. To meet expected demand, late in 2006 Force Protection signed subcontractor agreements with General Dynamics Land Systems (GDLS) and with Armor Holdings. It bid for MRAP vehicles teamed with GDLS. The Marines were well aware that FPI's current production capacity was very limited; it took the company nearly two years to deliver all 26 JERRVs, despite a strong push by the EOD units. Until they were delivered, the engineers used what they had, which was significantly less protected. Typically their vehicles used arms to pick up IEDs they could see, or else huge plows. U.S. Central Command (CENTCOM) asked for another 122, and then 79 more. These batches took nearly three years to deliver.

An Urgent Request

On 17 February 2005 I MEF (Forward), the Marine unit in Iraq, issued an UUNS asking for 1,169 MRAPs, which it defined as vehicles resistant to a variety of threats, including small-arms fire and IEDs of various types (including under-body, "belly" IEDs). This UUNS originated with Brigadier General Dennis Hejlik USMC, who was Deputy Commander of the 1st Marine Expeditionary Force (MEF) in Iraq. The new feature of the UUNS was the idea that large numbers would be needed not as specialized EOD

vehicles but rather as armored personnel carriers. The UUNS envisaged replacing about a quarter of the Humvees in the Marine force with the new vehicles. It called for more protected vehicles for his relatively small force than the Army thought it needed for all of Iraq.²⁴ Unlike the Army, the Marines were interested from the outset in a protected vehicle which all its troops would ride—a personnel carrier armored against the new IED threat. The Marines' Humvee up-armoring program was not yet proving effective, so they were suffering badly from insurgent attacks. Still, this UUNS was not approved because of the expectation that UAH would do the job.

Two Marine majors on I MEF staff had been campaigning for some time to convince the Marines to buy South African-style vehicles in quantity as armored personnel carriers, arguing that it was inevitable that any enemy would begin to use under-body mines. They apparently saw the UUNS as an opportunity to make their case, and they inserted a demand for under-body protection.²⁵ Thus the UUNS specifically mentioned the mine-resistant vehicles (which could resist under-body mines) already in service in Iraq for mine clearance: Cougar; Buffalo; and Casspir.

The UUNS could be read simply as a demand for what became MRAP vehicles, but its essence was the need to protect against IED and ambush threats, which in early 2005 were not yet largely under-body threats. Typically commanders state their requirements in very specific terms: "I want this particular vehicle or this particular weapon." They do not, and cannot, look beyond at the full range of possibilities, nor are they likely to balance part of the threat against other parts. That is why requirements are staffed, as this one was. There is a real tension between a commander's desire for something he can see and touch and the service's need for a reasonable solution to the problem he states. The UUNS fell into this category.

The Marine Corps Commandant immediately asked his Inspector General (IG) for a first-hand assessment of the situation, and in March 2005 the Commandant convened a working group. At that time, the underbody IED threat was less significant than it would become in 2006.²⁷ The issue raised by the UUNS was how quickly Marines could receive a worthwhile level of protection, not how to achieve the best conceivable level. Once there was some protection, better solutions could be explored. This was a classic case of "the best is the enemy of good enough." For the present, the Marines had numerous Humvees in theater, well supported by spares and maintainers. Anything that could improve their protection would provide protection to more Marines more quickly

than the alternative of buying new vehicles. Unsurprisingly, the UUNS process quickly turned toward the issue of improving Humvee protection.

The formal IG report received in May 2005 recommended continuing with the Marine Armor Kits and buying the up-armored Humvee (M1114) as the quickest possible solution with the best possible blast protection.²⁸ The Marines already had 546 under contract, and they ordered another 1,302 for delivery between November 2005 and February 2006. The need was urgent, and the up-armored Humvee existed. It was not perfect, but it was better than a canvas-side Humvee, and it offered the desired mobility. In the FY 2006 Supplemental the Marines asked for another 524, to be produced between April and July 2006. They requested another 446 in the FY 2007 budget. The Marines continued to buy up-armored Humvees and armor kits through 2006.

Meanwhile, both the Army and the Marines continued to buy mine-resistant vehicles for mine clearance and route clearance. In 2005 the Army bought 80 JERRVs (Cougars, bought through the Marines) in response to a Joint Urgent Operational Needs Statement (JUONS). The Army planned an ultimate force of 338 Engineer and 506 EOD vehicles, most of which were probably to have been RG31s and Buffaloes. These 844 vehicles were to cover the whole of Iraq. This was a program designed to handle the IED threat using the classic limited number of high-tech assets. It was nothing like the Marine vision of using mine-resistant vehicles as armored personnel carriers.²⁹

In effect, the South African vehicles already in use in Iraq in 2005-2006 could be seen as proofs of concept: they demonstrated that something could be built that would survive the bottom-attack IEDs. That is not the same thing as an acceptable prototype, but it does provide a basic pattern for manufacturers to follow. At the outset, the pattern was simple, at least as the South Africans saw it: the truck should have a vee-shaped hull. The vee would divert the blast of the IED to the sides, sparing those inside the truck. There was apparently little or no detailed test data to back up this idea, other than the fact that South African trucks regularly survived the IEDs used by the Iraqi insurgents in 2005-2006.

It later turned out that the South Africans had faced relatively small mines and that they did not realize how important details such as seats were in the face of larger ones. The vee-hull and standoff from the ground was the beginning of an answer to bottom mines, not the full answer. Hull material (and how it was assembled) turned

out to matter. As mines became larger, a bulkhead area had to be inserted between hull and floor (for example, the MaxxPro vehicles had a false floor), and the floor was floated from the hull structure. Later there were blast-mitigating seats, blast mats, and crush zones. All of these new developments distinguished an MRAP vehicle from the apparently similar vee-hulled South African “cousins.” The South Africans apparently had done no *instrumented* testing, and a major difference between their program and the U.S. MRAP program was the degree of testing and extremely rapid development involved in the U.S. program.

The UUNS referred specifically to Casspir, Cougar, and Buffalo, the vehicles the Marines had actually operated. None of them was available in quantity. There were many Casspirs in South Africa, but it was clear that while they might survive blasts, they were not acceptable from an automotive point of view—a truck must survive the rigors of the road as well as of the minefield. FPI was unable to produce anything very rapidly, and its order for up to a thousand ILAVs was still in the future. There was no reason to see the Army’s slow procurement of RG31s (which presumably were acceptable from an automotive point of view, at least when new) as proof that the necessary vehicles could be mass-produced in South Africa. Ultimately, any U.S. MRAP program would either require the creation of a new industrial base or drastic changes in the existing one; the latter ultimately happened. The project would compete with the Humvee and truck up-armoring programs for one of its key resources, armor. To create the necessary base would be a large undertaking, and all experience suggested that it would take considerable time. In 2005 it was not at all clear that any fruits of such a project would be available while the urgent need was still there. That was aside from the challenge of creating a logistical and maintenance base.

When the mine-protected vehicles were briefed in the spring of 2005, one of the issues raised (and not answered) was who would train the necessary maintainers for a fleet of entirely new vehicles without any standard components? That would take time and personnel, neither of which was available. How much better would entirely new vehicles be than the up-armored Humvees? There was probably never much question that something new could be much better, but that something new had to be usable within a short time, and it had to be kept in service.³⁰

The initial MRAP vehicle requirement (1,185 vehicles) did not justify major investments to develop an organic sustainment system, and there was no time to

institute such a system. Consequently, the first production awards included Contractor Logistics Support for spares and maintainers. This was costly on a per vehicle basis, but less expensive in total at these quantities, than the cost would have been for developing an organic support infrastructure. As the quantities required increased, this system was gradually replaced by a combined organic and CLS system. By the time vehicles were entering service in quantity, a massive sustainment organization had been set up. Sustainment costs for any new vehicle are a major portion of the total vehicle procurement costs. Had under-body mines *not* been a major priority—as they were not until early 2006—it seems unlikely that sufficient investment to support entirely new commercial vehicles of any kind would have been supportable. This was quite aside from the cost of buying the vehicles in the first place.

The MRAP program did encounter some criticism about the cost of CLS support (vice organic military support) for these vehicles, but that was always in the context of the cost for more than 20,000 vehicles. The original logistics approach was made based on a requirement for 1,000 to 4,000 vehicles. At those quantities, the CLS approach, which was being successfully used to support those MRAP vehicles already fielded, made sense. There was another major driver for the increased logistics cost of the MRAP vehicles: the decision to go with multiple vendors and vehicles. That decision, which built the industrial base and dramatically accelerated production, meant that the program could not achieve economies of scale for maintainer training and parts due to the lack of standardization—exacerbated by some 300 variants of the seven baseline vehicles.

In the spring of 2005 up-armoring was not working against the great bulk of IEDs, and there was no hope of finding enough money to replace every Humvee with a JERRV. The Marines had to find some way to achieve hardness *and* large numbers of vehicles. Unless there was some special waiver, any large production order had to be filled in the United States—and the only American manufacturer of proven mine-resistant vehicles, Force Protection, was making them very slowly, by hand.

In June 2005 the Marine Corps Commandant decided to replace all Humvees in Iraq with the up-armored version (M1114 with the Marine Armor Kit (MAK)). Shortly after that the Deputy Commandant for Installations and Logistics advised that the up-armored M1114 was the best available asset to protect Marine Corps forces.³¹ In August the Marine Corps Combat Development Center (MCCDC) stopped processing the UUNS for an MRAP vehicle. From its point of view, the up-armored Humvee was the

MRAP requested in the UUNS, and the Commandant's announcement of Humvee replacement was the appropriate response to the UUNS.

Defeating IEDs

To the extent that the South African vehicles seemed to solve the problem, it might be imagined that all the Marines had to do in 2006 was buy or adapt their design and then order quantity production. In fact, no one was certain that the original vehicles were effective enough or that they could perform well enough as troop carriers. Moreover, war is a learning experience for both sides. It could be assumed that the enemy would field more and more effective IEDs to defeat in-service and future vehicles. Any program to counter IEDs had to make provision for upgrades or redesigns—for some sort of research and development (R&D) program. Yet it could not follow the conventional path of conducting R&D before soliciting bids before letting production contracts. Too many Marines would be killed by IEDs before vehicles procured in a conventional, “business as usual” way could reach Iraq.

The mine-resistant vehicles seem to have been essentially unknown outside the specialists who used them. Representative Gene Taylor, who was at least as interested in IEDs as anyone in the U.S. Congress, remembered that he first heard about the South African mine-proof trucks when a retired Army officer (Colonel James Littig) turned up in his office one day late in 2005 with a Xerox copy of a page from a *Jane's* book. None of the defense vendors Taylor would normally have seen had told him about the vehicles, and clearly he was unaware that some of them were already in service in Iraq. Taylor knew enough about ships and their protection (because he represented the important warship building center of Pascagoula, MS, Taylor's home state) to understand at once; he recalled slapping his head “because I should have thought of that!”

Taylor was ranking member of the Subcommittee on Seapower and Expeditionary Forces of the House Armed Services Committee. His chairman, Representative Roscoe Bartlett, shared his frustration with counter-IED programs and proved extremely helpful. When the Democrats swept Congress in the 2006 election, Taylor became chairman of the Subcommittee. Now his interest in the odd-looking vehicles mattered much more. He remembers that those in the Defense Department who had brushed him off in the past were now very anxious to help him, even in November 2006, before he formally took office. It was very clear that he would give the vehicles priority.

By that time Donald Rumsfeld was no longer Secretary of Defense. Taylor considered Rumsfeld the single great obstacle to mass production of the special vehicles. He persuaded new committee chairman Representative Ike Skelton to make mine- and IED-resistant vehicles the subject of the first hearing of 2007. He knew that unit commanders had not requested them; in his view they did not yet know what they could have. Taylor thought that 15,000 vehicles were needed.

By this time Taylor was aware of the Marines' program, which he considered too small. Late in November 2006, the Marine Commandant thought he had all the MRAP vehicles he needed, but Taylor disagreed. None was yet in the field. In Taylor's view, it was absolutely vital that he hold a hearing early in January 2007 to lay out the need for large numbers of MRAP vehicles. He was stunned happily somewhat later when recently appointed Secretary of Defense Gates told a press conference that he wanted even more than Taylor wanted: as many as 18,000. That was absolutely different from what Taylor had experienced in the past. Now Taylor moved beyond being a salesman to being an expeditor, to ensure that the program got what it needed from Congress.

Common Threat...Different Approaches

Mine-resistant vehicles were one of several approaches to countering IEDs. Another was surveillance to detect mines so that they could be neutralized before unprotected vehicles encountered them. For example, specialized UAVs were flown over possible routes in order to detect the sort of changes in the earth on the road that might indicate burial of a mine or IED. There was some hope that frequent enough reconnaissance of this type would make it possible to keep key routes mine-free most of the time, since it would take insurgents time to replace any mines that had been detected and neutralized. UAVs also flew ahead of convoys to reveal ambushes, so that support could be arranged in time to save them. A related approach, particularly in cities, was to flood areas with surveillance cameras ("cameras on sticks") that could spot mines being emplaced and might even identify those emplacing them. The existence of the cameras would, it was hoped, deter insurgencies planting mines, since they could no longer remain anonymous. Given good intelligence, Special Operations could hunt down the bomb-makers. The most extreme version of deterrence through surveillance was the use of aerostats (captive balloons) hovering over key areas such as forward operating bases (FOBs).

Another approach was to counter the detonators, using electronic warfare techniques against the remote controls used to detonate the mines. The Defense Department formed an IED Task Force, which became the Joint IED Defeat Organization in the fall of 2006. Much of its budget went into electronic warfare techniques, and jamming aircraft were flown extensively throughout Iraq specifically to neutralize IEDs. JIEDDO also developed jammers specifically for vehicles. They became part of the outfitting task for MRAP, and some JIEDDO funds paid for the initial MRAP vehicles. However, from a programmatic point of view JIEDDO was opposed to the MRAP program, because the organization was oriented towards jamming. The organization never stood in the way of MRAP and its passive-protection approach to countering IEDs. Its view was that the enemy could win a race between IEDs and armor, and simply overwhelm the protected vehicles. Surely the enemy would work out the limits of protection. In fact it did not work out that way, partly because enemy attempts to build bigger IEDs encountered physical limits. Jamming also had its limits, because there were ways to detonate IEDs that did not depend on radio links.³²

Ultimately the great bulk of IEDs were found and cleared or successfully jammed. That was never enough, because troops experienced the others, and those IEDs affected their operations. It is very difficult to say how important it was for the troops to be protected directly. MRAP vehicles became available in quantity at about the same time that the “Sunni Spring” reduced Sunni insurgents’ motivation to lay IEDs (that did not apply to Shias, many of them controlled from Iran). It was also sometimes argued that people in Iraq just became tired of the bombings, and began to turn bombers in.

In 2005 it seemed that jammers would defeat remotely detonated IEDs. Mines were not new, and it seemed that classic counters such as looking for trigger wires and disturbed soil would protect the Marines. It turned out that there were never enough of the new kinds of devices—e.g., UAVs to find disturbed soil—and that wires, too, could be buried. Pressure plates were even more difficult to find.

The “Sunni Spring” was associated with new tactics in which troops came out of their armor and went into neighborhoods in Baghdad to connect with the people there. How could that be connected with the MRAP program, whose role was to protect those riding inside? It seems reasonable to argue that troops who doubted their ability to survive in their vehicles would find it difficult to penetrate neighborhoods in the first place, before coming out to talk to the population. Attacks on their vehicles would

keep them out of the neighborhoods. As for “bomb fatigue,” the continued drum roll of suicide bombings suggests that it was hardly universal. The effect of MRAP was to turn the enemy toward tactics like suicide attacks, which are more difficult to mount, because it is more difficult to find willing attackers. The same is true of the enemy tactic in Afghanistan, “green-on-blue” attacks by individuals who have infiltrated friendly forces.

It is equally difficult to say publicly how many lives MRAPs saved, even directly. One of the ways in which the enemy’s use of IEDs was attacked was to shut down public discussion indicating how many IED attacks occurred.³³ That prevented the enemy from finding out how well his own efforts to combat anti-IED measures, including surveillance and jamming, were working. An unintended consequence was to devalue the MRAP program contributions. If only a small fraction of IED events against vehicles were recorded, that turned out to mean that only a small fraction of MRAP vehicle successes, in protecting individuals, were also recorded. That in turn grossly devalued the MRAP vehicles success.

From a tactical or troop morale (motivation) perspective, there is a great difference between the direct protection approach and indirect approaches such as surveillance and jamming. It is entirely possible that the indirect approach eliminates more IEDs and thus offers better protection at a lower price. However, troops do not see the fruits of that protection, unless it virtually eliminates IEDs. As long as the threat persists on a noticeable scale, troops are far more aware of being saved by their vehicle from an actual explosion. Their motivation depends on feeling that they are being protected, rather than being told about it. For that matter, it must be particularly dispiriting to an attacker to watch the occupants of a truck emerge firing their weapons after what looks like a satisfying explosion.

There was another important point. The enemy was extremely agile. As JIEDDO evolved new jammers, he evolved new ways of detonating mines; he went from pressure pads to remote detonators of different kinds, and then, when the remote detonators were being jammed, back to pressure pads and similar unjammable devices. No matter how agile JIEDDO became, the enemy could move more quickly, because he did not have a massive industrial, R&D and acquisition system, with its inevitable inertia. Those involved often pointed out that “the enemy has a vote”—he could react unconstrained by the U.S. course of action. That is, the enemy could choose his own way of fighting, and it might not be the one the sluggish R&D process has chosen to

try to defeat. He makes his own choices, whatever choices the R&D system may make. Worse, if the enemy is agile enough, he may change his techniques more rapidly than the R&D system can adapt. In effect, the enemy plays against the weakness inherent in our sophistication and in our sheer numbers, which mean that our countermeasures programs are necessarily large.

Vehicles that directly resisted explosions were a different proposition. Like countermeasures, they were ultimately needed in large numbers. However, they played against the enemy's limitations, how easily he could transport larger and larger amounts of explosive, and how quickly he could emplace them. Now the enemy was the one who could not easily adapt to a change in what threatened him. It was one thing to devise new detonators, quite another to find some new way of moving heavy weights. The heavier the weights, the more vulnerable to discovery those moving them became. In this sense concentrating on armor and other forms of protection returned much of the initiative to U.S. forces. The jammer effort was never abandoned (indeed jammers were an important part of MRAP vehicle outfits), but in the end the passive protection offered by the vehicles was more important. The "bottom line" counter-IED and MRAP vehicles is that two approaches were key elements in a largely successful whole.

In 2006, the Marines were far more concerned with the bottom mine problem than the Army. They operated in southern Iraq, where such mines were relatively common; the Army in the north encountered mainly side-attack IEDs and EFPs. There was also a difference in tactics. The Marines embraced a counterinsurgency strategy in which they spread in small numbers around their areas of responsibility, seeking to enlist the population in the fight. That minimized the value of special road-clearance vehicles, and it offered insurgents deploying IEDs more targets. At least until 2006 the Army pursued a garrison strategy in which troops in heavily protected areas were connected by road convoys. The troops suppressed generally operated en masse.

The main Army IED targets were convoys (plus liaison vehicles moving singly between garrisons). A shift in Army tactics in 2006 (credited largely to General David Petraeus) brought the Army more into line with the Marines, and increased Army exposure to IEDs in much the way the Marines were exposed. The new Army strategy ultimately resulted in the "Sunni spring," which greatly reduced the level of insurgency and the level of IED attacks.

By the fall of 2006, more and more vehicles were being attacked by under-body IEDs. The existing program of up-armoring Humvees offered no real protection from this expanding threat. The Marine commander in Iraq drew up a UUNS asking for something better. Because the Army would undoubtedly need similar protection, the UUNS became a JUONS, but it remained a Marine Corps program. That seems to have been very significant, because the Marines' approach to procurement differed greatly from that of the Army, even though both were operating under the same set of regulations. Because the Corps was so much smaller than the Army, its chain of command was shorter and its organization was flatter and better adapted to quick decision-making. The much larger Army requires far more coordination in order to reach decisions, which generally involve considerably more investment. The Marine Corps approach shaped the later joint program.

End Notes

¹ In the 1980s the South Africans used a vehicle they called Buffel (Buffalo). According to Helmoed Heitman, the *Jane's* correspondent in South Africa and an expert on their SA vehicles, Buffel was seen as the wrong vehicle for the new urban security operations of the late 1980s early 1990s. Initially a few Buffels were converted with inward-facing seats, side windows, and a roof, but they retained their bad "camel-like" ride and were unsuccessful. It was then decided to scrap the hulls and to re-use the existing automotive components (Unimog chassis and Mercedes-Benz engines, for example) with new bodies better adapted for urban and semi-urban operations. The result was Mamba, produced in 2x4 and 4x4 versions. There was also an open-back Mamba Sabre prototype for Special Forces, with space for a weapon pallet or cargo; it did not enter production. The RG31 was a more robust ("beefier") vehicle developed by TFM (Truck Makers). Its stable mate was Nyala (RG-12), a riot control vehicle for the police. The military initially called RG31 Nyala, because it used the same powertrain, but in a mine-protected off-road vehicle. There were two versions, one resembling Mamba and the other the open-back type with space for a weapon pallet. When the South African wars ended, TFM left the military vehicle business and sold that to Olifant Manufacturing Company (OMC).

² OMC is one of three divisions of Land Systems, which in turn are 75 percent owned by BAE. OMC was established specifically to develop and make the South African Olifant tank. It was soon taken over by another South African company, Reunert, and after 1994 was bought by a series of British defense companies, beginning with Vickers and ending with BAE in 2004. OMC was responsible for making South African mine-resistant personnel carriers during the wars in Angola and Namibia. The RG-series vehicles were named after the initials of the first names of the vehicles' designer and his wife. That may have been intended to distinguish them from Dr. Joynt's Casspir and its relatives.

³ The U.S. contract was awarded late in 1996 to an international consortium consisting of LNY Inc. (US), Trading Force Ltd (UK), and the South African manufacturer, at that time known as TFM. Trading Force Ltd also sold RG31 and -32 vehicles to the United Nations. The company provided support activities including driver training. Although published accounts claim that the Army bought only three or four vehicles, the actual figure is probably closer to ten, because several were used for tests. According to *Jane's Armour and Artillery 2005-2006*, the first RG31 was completed in 1998. The first vehicles were called Nyalas. Later the U.S. Army simply called them RG31s. Published names (Charger and Pathfinder, the latter an apparent reference to the route-clearance role) were unofficial and may be fictitious. The U.S. Army Central Command ordered 78 in 2003 through GDLS-C. RG31 is generally described as a variant of the earlier Mamba, which was developed by Mechem (i.e., by the group headed by Dr. Joynt, who later designed vehicles for Force Protection Industries). A total of 653 were delivered between 1993 and 1997; 67 were exported. Like the Casspirs, some of these vehicles were later reconditioned. Export customers were Congo, Ivory Coast, Sweden (some being used in Kosovo), and Uganda. Reportedly, Force Protection's Cheetah was based on RG31. It was an unsuccessful contestant for the contracts awarded for MaxxPro Dash in 2007 and was rejected by the JLTV program in 2008.

⁴ GDLS-C received a contract for nine vehicles on 12 February 2003, presumably as part of the preparation for the invasion of Iraq. The buyer was CECOM, the Army Communications Electronics Command, which acquired the Army's mine clearance vehicles at this time. Of these, two were delivered in June and another two in July, followed by two in November 2004 and three in December 2004. All were Mk 3s. The company received another contract (ONS 1: Operational Needs Statement/Program 1) for 148 RG31 Medium Mine-Protected Vehicles on 16 February 2005. The next U.S. contract (ONS 2, for Mk 5s) followed on 1 September 2006, for 266 vehicles, which were delivered from January 2007 onward. A follow-on ONS 2 contract for 50 vehicles was awarded on 26 April 2005. The final non-MRAP U.S. contract was ONS 3, for 111 Mk 5E vehicles, awarded 1 June 2008. In addition, Canada ordered 75 vehicles on 29 November 2005. They differed from U.S. vehicles in having a Kongsberg Protector remote weapon station. Thus non-MRAP sales by GDLS-C totaled 659 vehicles. The initial production version was Mk 3A, reportedly based on the earlier South African Mamba armored personnel carrier. Mk 3s used by the U.S. Army have a U.S. (Detroit Diesel) engine; the later Mk 5 has a Cummins Diesel engine. Other users have foreign engines. The United Nations bought 30 Nyalas, and others included Spain (150 plus an option for 30) for use in Lebanon and Afghanistan), and the UAE (76 Mk 5, delivered 2007). Data provided by GDLS-C.

⁵ M1117 was a derivative of the earlier Cadillac Gage Commando armored car used for police work in Vietnam. It had side armor but no special bottom protection. M1117s were used in Kosovo, but the Army stopped buying them because it found up-armored Humvees far less expensive. Once in Iraq, the Army found the up-armored Humvees vulnerable to various attacks, and it ordered new M1117s. The M1117 offered better ballistic protection than the standard Humvee (though up-armored Humvees may have been a different proposition) and also better blast protection against an artillery shell exploded nearby as an IED. However, it offered no protection whatever against an under-body attack; the occupants sat far too low, between the wheels. Reportedly the M1117 enjoyed some U.S. congressional support as an MRAP vehicle, in preference to the vehicles bought, probably because troops who saw Humvees as too vulnerable to side attacks wanted it. The distinction between the problems of side and bottom attacks was often apparently lost on observers outside Iraq.

⁶ Apparently OMC was not the object of the BAE purchase, and reportedly it took some months for BAE to realize that it had bought this company.

⁷ *Jane's Armour and Artillery 2010-11* provides a list of Casspir purchasers. Blackwater is not named, but at that time the company was the State Department's security contractor, and it seems plausible that it bought the Casspirs as transports. Casspir had been out of production for some time, and it appears that reconditioned ones were easy to buy. Numbers might have been higher than those in the Jane's report; their list of production numbers was incorrect in the case of the RG31.

⁸ Franz, J. Gayl, "Mine Resistant Ambush Protected Vehicle (MRAP)," 22 January 2008, p. 9. This was a study intended to show that the Marines took too long to purchase MRAP. The chronology of the Casspir purchase is not entirely clear.

⁹ Total production was about 2,500, of which about 460 were upgraded (sometimes rendered as remanufactured). The largest export customer was India, which received 165 remanufactured vehicles in 1998-1999 for counterinsurgency use.

¹⁰ By 2004, the Army had 14 Buffalos in Iraq and Afghanistan. It bought another 21 in May 2004 (order completed by December 2004), and another 15 in November 2004. Force Protection Industries announced an order for another 19 and up to 27 more on 7 February 2006. FPI announced delivery of the 200th Buffalo to the U.S. military in June 2008.

The Ground Standoff Mine Detection System was an offshoot of an earlier South African-developed Integral Vehicle Mine Mounted Detector (IVMMD), ten of which were bought in 1998. The Interim Vehicle-Mounted Mine Detection (IVMMD) system, South Africa's "Chubby" system, was intended to detect buried mines, detonating them harmlessly using heavy rollers. The emphasis was on reduced tire pressure, to avoid detonating the mines under the manned components of the system, then using heavy rollers to detonate them. The device was unable to deal with command-detonated buried mines, although in theory it could detect them. The vehicles involved used the South African mine-resistant technology. Each IVMMD employs a single-occupant four-wheel drive vehicle (Meerkat, the Mine Detection Vehicle [MDV]) that can detect mines. Meerkat has a 3-m wide metal-detection array (two induction coils) between its axles. A marking system sprays the estimated center of a mine with ink. It is followed by a full-width mine-proof tow truck (Husky, the T/MDV), which has the same detection and marking elements and a more powerful engine. Husky tows a string of three mine-detonation trailers intended to explode pressure-activated mines. A complete system consists of one MDV, one towing/mine detection vehicle (T/MVD, the prime mover), three mine-detonation trailers, and a support package. This combination was marketed in the United States by CSI (Critical Solutions International). It was made in South Africa by RSD, a division of Dobryl Ltd. The vehicles are the relatively simple ones originally developed for the South African army. An improved Mk II version uses two Husky Mk II vehicles, one as lead (instead of Meerkat) and the other towing the three mine detonation trailers. GSTAMIDS was an upgraded IVMMD using the same Meerkat vehicle and a ground-penetrating radar to supplement the induction coils, so that it could detect mines with little metal content. The mine clearance element is tele-operated from a mine-protected control vehicle. The Army bought Buffalo remote control vehicles for its Meerkats, using its Common Robotics Kit. GSTAMIDS became part of the Army's Future Combat Systems program. GSTAMIDS Block 0, using Meerkats and Buffaloes, was deployed successfully to Iraq in December 2003. The Army ended up buying VMMMD in quantity, each unit consisting of

two Huskies plus the detonation trailer. By 2010, as many as 500 Huskies had been bought. By the spring of 2013, the Army had folded its special anti-mine vehicles into its MRAP program, and they included the Huskies. The master-slave combination of Buffalo and Meerkat was apparently dropped.

¹¹ Buffalo was the only CAT III vehicle. At 84,000 pounds, Buffalo 1 was by far the heaviest of the mine-resistant vehicles. The MRAP program bought the slightly lighter (80,000 pounds), wider (102.5 rather than 97 inches), and higher (156 vs. 144 inches) Buffalo 1A. Both versions had arm capable of 30-foot extension. A mid-2007 program summary showed an acquisition objective of 62 Buffaloes for the Marines and 286 for the Army, plus one for JIEDDO at Yuma, AZ. Of these, 19 had already been delivered to the Marines and 92 to the Army. It is not clear whether these figures included the earlier Buffalo contracts.

¹² According to the DoD IG report, the Army bought 36 Buffaloes in 2004 under two contracts (for 21 and then for 15). The Army bought another 35 in 2005 to satisfy an Urgent Operational Needs Statement for route clearance. In September 2005 the Marines let a contract for 4 vehicles, followed by another in November 2006 for up to 80 more, plus JERRVs. As of 5 December 2006, 44 Buffaloes had been ordered under this contract to satisfy a CENTCOM UONS.

¹³ Cougar in turn was derived from the earlier (2002) Tempest, eight of which were sold to the UK as EOD vehicles.

¹⁴ The UUNS and similar types of requests from forward commanders, such as the JUONS, were introduced as part of an effort to move more procurement authority to forward commanders in the wake of the Goldwater-Nichols reforms of 1986 (they were intended mainly to increase the authority of forward joint commanders). The idea was to overcome the long-range mindset of the Pentagon procurement perspective, particularly in wartime. This process is part of a continuing competition between central staffs and regional commanders for authority over what is bought, as the regional commanders have a much more immediate perspective than the central defense staff. MRAP was very much about immediate vs. longer-term perspectives.

¹⁵ The UUNS for the HEVs was submitted in December 2003. It called for 27 vehicles, and 28 (early Cougars) were produced, the first being delivered in October 2004. Many interviewees for this history recalled a figure of 26 Cougars, which has been used in the text. The DoD Inspector General later found that the award of a sole source contract for these vehicles was inappropriate. See DoD IG report No. D-2007

¹⁶ In May 2006 there was a supplemental CENTCOM JUONS/UUNS/CMNS for 1185 up-armored Humvees. The Marine Requirements Oversight Council validated the requirement in August 2006 for submission as part of the FY2007 Bridge Supplemental. That November, the Army and the Marines validated a requirement for 4,066 vehicles, and the Army (which was in charge of the program) authorized release to the Marines. The Marines completed fielding 2,392 UAHs in December 2006 with Frag Kit No. 5 for additional side protection. [Data provided by John Young.] Note that the figure of 1,185 vehicles was also used for the initial number of MRAP desired, split among three services. As outlined in the JUONS dated 26 October 2007, that amounted to 750 Marine Corps vehicles, 335 Army, and 100 Navy. Of these, the Marines wanted 445 CAT I, 270 CAT II, and 35 CAT III vehicles. The Army wanted 270 CAT I, 55 CAT II, and 10 CAT III. The Navy (mainly Seabees) wanted 30 CAT I, 60 CAT II, and 10 CAT III vehicles. Edie Williams, *Mine Resistant Ambush Protected Vehicle Program*, *op.cit.*

In addition to the small contracts mentioned here, there were two significant contracts for these vehicles. The first was an April 2004 award to FPI for 28 HEVs. The second was a May 2005 award to FPI for 122 JERRVs. The second of these buys was funded, at least in part, by JIEDDO. Note, also, that the PM for Engineer Systems managed these vehicles for the Marine Corps, and the Project Manager for Force Protection did the same for the Army.

¹⁷ In May 2005 Marine Corps Systems Command was appointed joint agent for procurement of 122 Force Protection Industries JERRVs for the different services, funded by the Joint IED Defeat Office. This action probably explains claims that JIEDDO funded the initial MRAPs. The requirements and funding letter was submitted on 7 April 2005, signed by the JIEDDO Integrated Product Team (IPT) Chairman, Major General Robinson USA, and was approved by the Deputy Secretary of Defense on 21 April. The 122 JERRVs included 38 for the Marines. Unlike the HEV Cougars, the JERRVs had no gun ports and a simple 360-degree gun ring on the roof. The allocation of JERRVs was: 13 4x4 vehicles for EOD for the Marines, plus 25 of the 6x6 Engineer version. The Army received 80 (60 for Iraq, 20 for Afghanistan), and Navy received four (Iraq, the 6x6 Engineer version). By this time the first 13 Cougar HEVs had already been fielded to Iraq. In addition to Cougars, the Marines began buying Buffaloes directly in August 2005. The first Buffalo order was ten for the Army (1 September 2002), followed by 21 (21 April 2004), and then by 15 (10 November 2004).

¹⁸ The Inspector General, U.S. Department of Defense (D-2007-107), reviewing the sole-source contracts let to Force Protection, gives some of the history of the Cougar program in a 27 June 2007 report. The report was prepared for Representative Louise M. Slaughter, who specifically questioned awards to Force Protection Industries and to Armor Holdings. At this time Armor Holdings was producing up-arming kits for Humvees and for trucks. The initial Marine Corps contract, awarded in April 2004, was for 28 Cougars. The Marines' UONS for JERRVs was initiated in December 2003 for 27 vehicles.

On 26 April 2004, Force Protection Industries announced that its TSG arm had developed a new mine-protected Typhoon vehicle for this purpose, which would be ready in the third quarter of the year. The name suggests a relationship to the Tempest developed for the British. On 26 April 2004, FPI announced a sole-source order for up to 27 Typhoon. The first 14 were shipped in September 2004. By early 2005 this vehicle was being called Cougar; it was included in the FY2005 Department of Defense Supplemental. Force Protection had advertised Typhoon as having better protection than Cougar, but the vehicles ordered in 2004 were all Cougars. On 21 April 2005 the Deputy Secretary of Defense designated the Marines joint agent to procure 122 Cougars via the Joint Rapid Acquisition Cell. Of these, 38 were assigned to the Marines and the rest to the Army. This contract was signed on 13 May 2005, for a maximum of 122 vehicles, of which 71 were immediately ordered. The remainder of the vehicles was ordered in two batches, the second being ordered on 23 June 2005. A follow-on contract for 79 JERRVs was let in May 2006. Deliveries included at least 50 for Seabees (first delivered April 2007). According to the DoD IG report, a third contract (announced 9 November 2006) was let for 200 JERRVs as part of the MRAP program; this contract included 80 Buffaloes. The pre-MRAP orders were for the Joint IED Defeat Task Force and were designated JERRVs. The report indicates that Force Protection Industries delivered many of its vehicles more than 30 days late; schedules had to be revised to reflect problems. Thus on the original schedule, 24 of the original 28 Cougars were more than 30 days late, and 115 of the first 122 JERRVs. Note that many open sources for Cougar show a very different program history, in terms of early contracts. The DoD report indicates that a report of a 60-vehicle order in December 2004 is incorrect, as is the claim that the initial order was for 88 vehicles. It is possible that larger reported numbers reflect SOCOM purchases outside the Army and Marine systems. Representative Slaughter's 19 April 2006 request for an investigation included purchases of body armor and seems to have been inspired by *New York Times* accounts of an internal DoD memo which stated that 80 percent of Marines killed in Iraq would have survived had they had either sufficient body armor or vehicular protection.

¹⁹ TSG was bought in 2002 by Sonic Jet, the resulting company being named Force Protection Industries. TSG retained a separate identity as a subsidiary or division within FPI until 2005. That accounts for some confusion as to whether particular vehicles were designed by TSG or by FPI. Sonic Jet was a California-based speedboat company founded in 1997. Its business declined badly after September 11, 2001, and a new investor, Fred Kavanaugh, decided to redirect it to anti-terrorism products. In 2002 he bought TSG, which was by then insolvent. At the time TSG was building a few Buffaloes and Tempests and was trying to build the prototype Cougar. After developing Cougar, FPI developed a 6x6 utility vehicle it called Cheetah, but it did not sell.

²⁰ According to a 2007 account of the MRAP program, the British bought a few RG31s in the 1990s and retired them due to mechanical faults, hence their preference for Cougars. The same account describes RG31 as relatively lightly protected, popular with Canadian forces and with the U.S. Army for its mobility, but not as survivable as the heavier Cougar.

²¹ The initial contract for Mastiffs was awarded via the U.S. Defense Department on 10 August 2006 (86 vehicles), for delivery through May 2007; at this time the total British requirement was 100. Initial vehicles were delivered by November 2006. Another 22 were ordered in March 2007, and in October 2007 it was announced that another 140 were being ordered for British troops in Iraq. Mastiff was a 6x6 Cougar integrated in the UK with British electronics and armor. Mastiff 2 was the "Protected Eyes" version supporting the Talisman anti-IED program, with a micro-air vehicle capability (screen displaying the UAV picture), a camera, a mine plow, and a remotely operated gun. Ridgeback was a 4x4 Cougar Protected Patrol Vehicle. Wolfhound was a Cougar 6x6 used as a gun tractor and truck (first delivered in Afghanistan in October 2010). The first Mastiff orders predated the MRAP program, but later vehicles were treated as MRAP Foreign Military Sales (FMS).

²² About March 2006 someone in the U.S. administration in Iraq asked for armored patrol vehicles to stand up an Iraqi security force. The formal request was made in April 2006. It went to the U.S. organization buying equipment, including vehicles, for the new Iraqi government. That organization quickly put together a simple performance specification and issued it. The contract was awarded in May. The main criterion was how quickly vehicles could be provided to the theater. BAE/FPI was somewhat slow initially but soon made up time, airlifting vehicles at its own cost so as to make up the needed numbers. There were numerous competitors, but most did not have vehicles they could provide quickly enough in sufficient quantity. There could be no new tests, and the project had to be low risk with quick deliveries. New designs had to be rejected. Under body protection, as well as protection against small arms fire, was a "hard" requirement. These vehicles had to be protected underneath because they would operate by themselves, without any route clearance or precursor mine countermeasures. It mattered that Cougar had already been tested, hence was a known quantity with good protection; the idea was that BAE would provide the necessary production muscle. BAE managed to build vehicles in many places, including its factory at York, Pennsylvania. The U.S. purchasing organization that bought the Badgers also bought everything else the new Iraqi government needed, and it discovered that requirements were often broadly put. For example, Iraqi officials who needed trucks were asked what capacity they wanted. They had no sense of alternatives, so the purchasing office made up pictures of generic trucks in different categories and gave them different colors. The officials nonetheless had a good idea of what they wanted, but that often meant buying the "green" or "red" truck rather than a 2 ½-ton or a 5-ton truck. David Krawchuk interview.

²³ BAE Land and Armament Systems of York, Pennsylvania won the Iraqi contract with a version of FPI's Cougar, despite having its own RG31 to offer. The contract was let in May 2006, and the first Badgers were delivered at the end of August. Badger is usually described as a lighter version of Cougar. Including all options, the 2006 contract was for 1050 Badgers. Actual deliveries apparently amounted to 865 vehicles through the end of 2010. There were follow-ons. In December 2009 BAE received a contract for 109 second-generation Badgers and 10 Mine Roller kits. In August 2011 BAE received a contract for six ILAV troop carriers and three Route Clearance ILAVs with robotic arms to examine possible mines. In October 2012 BAE received an FMS contract for vehicles for Iraq, Yemen, and Burundi. There was apparently a separate contract for 16 ILAVs for Yemen, ordered some time before 2011.

²⁴ James Thigpen, a retired Marine Colonel and the Navy's Space and Naval Warfare Systems Command (SPAWAR) contractor partner at Charleston, remembered hearing early in 2006 that Marines in Buffaloes were surviving under-body hits. Those in up-armored Humvees (UAH) more often than not survived, but their vehicles suffered catastrophic damage. At the outset the Marines were also using their standard amphibious assault vehicles (AAVs), but they abandoned them after one was completely destroyed by an under-body IED. Edie Williams, *Mine Resistant Ambush Protected Vehicle Program*, *op.cit.* Thigpin interview.

²⁵ This seems to be a reasonable interpretation of the history of the UUNS recounted by Gayl, "Mine Resistant Ambush Protected Vehicle (MRAP)," *op.cit.* Gayl admits in passing that the higher authority that signed the UUNS was probably uninterested in details such as what sort of vehicles were needed and exactly what threats were involved; he was concerned mainly with improving his troops' protection against a growing threat. Gayl quotes three "prophets" of the MRAP program. The first was Lt. Colonel Wayne Sinclair USMC, a Combat Engineer who (as a captain) published an award-winning article, "Answering the Landmine," on counters to mine warfare, particularly the special Rhodesian and South African vehicles, in the *Marine Corps Gazette* in July 1996. His article is unlikely to have been widely remembered seven years later.

Major Roy McGriff USMC, a logistics officer, wrote a paper on "Mine-Resistant Armor Protected Vehicles" at the School of Advanced Warfighting (SAW), highlighting the need for mine-resistant vehicles. (Sinclair, then a major, was one of his classmates.) At this time the Marines were developing expeditionary capabilities that required personnel-carrying vehicles be transportable by helicopter (Osprey MV-22 tilt-rotor aircraft and a future heavy-lift follow-on for the Sea Stallion CH-53 helicopter). The South African style vehicles were far too heavy for that (as indeed were MRAP and M-ATV), so the vehicle solution to mines (the heavy mine-resistant vehicles) that McGriff advocated was not considered attractive. At this time the Marines were more interested in a Humvee follow-on called RST-V (Reconnaissance, Surveillance, and Targeting Vehicle), which was defined by expeditionary requirements: helicopter transportability and a small logistics footprint achieved by adopting a hybrid power plant. Later RST-V would lead to a project for a Combat Tactical Vehicle (CTV) and the current JLTV. The major threats then envisaged were side attack, and the hope was that the RST-V could target enemy forces from a safe distance. Under-body protection entered this series of concepts with the JLTV, which was clearly influenced by the MRAP program and by experience in Iraq. In 2002, the Marines were interested in counter-insurgency, but mainly in the context of urban warfare (the so-called "three-block war"), in which IEDs had not yet become a major factor.

Upon graduation from SAW, McGriff was assigned to Marine Corps Forces Pacific (MARFORPAC), where he met Major Gert DeWet USMC, who had grown up in South Africa and was well aware of the success of mine-protected vehicles there. According to Gayle (p. 10), these two majors helped write the UUNS. The interpretation that Brigadier General Hajlik was much more concerned with the protection of his Marines than with the method advocated in the UUNS is consistent with Hajlik's later statements that he considered the up-armored Humvee good enough for the moment, and with the fact that in the spring of 2005 under-body mines were a very minor part of the overall threat faced by the Marines in Anbar Province. Gayle recounts twists and turns by McGriff and DeWet in their attempts to sell the under-body protected vehicle idea, which suggest that senior officers were not always clear about exactly what they were endorsing; at one stage it involved creation of a special tactical vehicle operator who would be trained like an aviator to operate an armored truck like a tactical airplane.

²⁶ DoD's first attempt to force this degree of reflection, a regulation called A-109, was imposed in the 1980s. Not only did it prohibit anyone from simply asking for a particular item, it prohibited anyone asking for a particular category of items, such as, say, a surface to air missile. Instead, all requirements were to be framed in terms of what the desired item was supposed to do, such as "neutralize enemy air attacks," on the theory that the range of possibilities should be as wide as possible—say, jamming and decoying as well as shooting down enemy aircraft or missiles, with all trade-offs to be taken into account. Many believed at the time that this was no more than a way of stalling programs to death before they could gain momentum, but the idea that a commander's literal request for a particular vehicle should be the essence of a requirement (like a UUNS) was generally rejected. The MRAP program avoided this problem because it began as a Rapid Acquisition Capability Program, in which the program manager can specify what he needs without conducting a full-dress assessment of alternatives (AoA). The issue was not raised when the MRAP program transitioned into a more conventional program. Those in the program argue that in effect JIEDDO provided the AoA by investigating all non-vehicle counters to under-bottom IEDs, and the strategy of parallel contracting might also be seen as an alternative to the usual AoA conducted on paper.

²⁷ A report quoted by Gayle, *op.cit.*, p. 59, gives data: between January and September 2005 there were only about ten under-belly attacks. After September, there were ten attacks *per month* for the rest of the year, an average that continued through 2006 (there were 16 such attacks in January 2006). Most of the under-belly attacks occurred in Anbar Province, where the Marines were operating. These data explain why the Marines' outlook on the type of protection needed changed radically early in 2006.

²⁸ The M1114 HMMWV includes an armored crew compartment, ballistic-resistant glass windows, and floor armor designed to withstand a 12-pound TNT explosion under the front portion of the vehicle, and a 4-pound TNT explosion under the rear. While superior to the unarmored HMMWV, this protection was inadequate for the much larger IEDs used in large numbers later in the Iraq war.

²⁹ Gayle, *op.cit.*, (p. 17) provides a slide listing potential MRAP vehicles, briefed to a 2005 Marine Corps Safety Board by MRAP advocates. The vehicles credited with bottom protection *and* ballistic protection against small-arms fire (the essential MRAP attributes) were the South African Casspir and RG31, the U.S. Cougar (in both 4x4 and 6x6 configurations), the German Dingo 2, and the U.S. Lion. Of these, the United States was already buying and using Casspir, RG31, and Cougar, none of which was instantly available in large numbers. Dingo 2 was a German (Krauss-Maffei Wegmann) armored personnel carrier adopted by the German army in 2004 and placed in small-scale production (the thousandth vehicle was delivered in 2013). It introduced an "integrated under-floor protection system. A description of the earlier Dingo 1 suggests that it had a mine blast deflector (i.e., vee-bottom) under its crew compartment. Dingo was apparently never tested in the United States and was not involved in any way in the MRAP program. It was bought by Austria and Belgium. Protection seems to have been keyed to anti-tank mines, which might have been expected in a NATO war in Europe. The FPI Cougar was marketed at one time as Lion (and also as Typhoon). It is probably the vehicle in the 2005 list, mistakenly distinguished from Cougar.

³⁰ Gayle, *op.cit.* p. 18, provides an example of the questions raised, apparently without appreciating their significance. It might also be significant that his tables of vehicle data presented in 2005 omitted any indication of reliability or maintainability, only resistance to particular kinds of damage. When the MRAP JPO tested vehicles, it demanded both survivability *and* a minimum degree of automotive performance. Casspir, at least in the examples in Iraq in 2004 or 2005, seems to have exemplified the problem of automotive capability. The DoD Installations and Logistics staff, those who had responsibility for maintaining the vehicles in theater, raised the issues. The logic of staff review at this stage was that the warfighter generally does not consider such issues, but will find them haunting him once what he wants is deployed.

³¹ DoD IG report D-2009-030, 8 December 2008, analyzing the Marine response to the February 2005 UUNS. The report was prepared in response to a request by the Assistant Commandant, clearly in response to the Franz Gayl paper. It sidesteps the key issue that in 2005 the threat was side-attack IEDs, not under-body ones, hence that the request for MRAP was more likely generic than specific to an under-body IED, which was not the current threat.

³² Paul Mann pointed out that in effect JIEDDO was demanding that he hold off until he had a perfect solution to the IEDs, which was much the idea behind many programs. In Mann's view, that would never happen in time to do anything useful. He found a valuable ally in Admiral Edmund P. Giambastiani, Vice Chairman of the Joint Chiefs of Staff (JCS). Giambastiani and the Defense Department allowed him to progress from one problem to another in spiral fashion. Thus he was allowed to concentrate at the outset on the under-belly problem, even though the enemy was already using some EFPs. At that point he knew that there was a solution to the under-belly problem (as demonstrated by the South Africans), but the EFP solution was evolving. Once there was an EFP solution, he could incorporate it in production vehicles ordered late in 2007 (LRIP 10). Appendix C lists all LRIP contracts. It took considerable courage for Giambastiani to resist the arguments that his lead anti-IED organization was making, that the enemy could always up its game to overwhelm MRAP protection. Giambastiani also helped beat off attempts to take the program away from the Marines, once it had grown. Mann recalled a meeting, probably in the summer of 2007 to consider the possibility that MRAP vehicles would be neutralized by the enemy's ability to adapt. During this meeting the Army Vice Chief of Staff said that it was incredible that the Navy should be in charge of a vehicle program. Assistant Commandant LGEN Magnus was in the room: "Hey, we do know something about armor!" Giambastiani backed him up. Overall, Mann found JIEDDO thoughtful and helpful, although he considered its view of the potential offered by jamming unrealistic. After all, the enemy could adapt its way around them, too. Mann saw it as his task to keep JIEDDO from slowing his program and thus denying troops the very considerable protection that even the earliest MRAP vehicles offered. Paul Mann interviews.

³³ This point came up publicly in a controversy over the value of the MRAP program. Two economists, Chris Rohlfs (a professor at Syracuse University) and Ryan Sullivan (professor of economics at the Naval Postgraduate School), published an article, "The MRAP Boondoggle," in *Foreign Affairs* (July 2012), questioning the return on the \$45 billion MRAP investment. They were answered by, among others, Christopher J. Lamb and Sally Scudder, "Why the MRAP is Worth the Money," *Foreign Affairs* (August 2012). At this time the Defense Department was claiming that MRAP vehicles had saved 40,000 lives. The two critics argued that MRAP vehicles did not save more lives than armored vehicles that cost a third as much. To get to that conclusion, they looked at a period in the insurgency in which the use of IEDs had already declined considerably, because the insurgents had learned that they did not work against MRAP vehicles. The critics also ignored injuries, which MRAP vehicles prevented. Lamb and Scudder pointed out that by 2008 the casualty rate (killed

plus injured) in MRAP vehicles was 6 percent, compared to 15 in Abrams tanks and 22 percent in up-armored Humvees; in short, an MRAP truck was about four times as safe as an up-armored Humvee. To Lamb and Scudder, choosing to evaluate MRAP vehicles during a period of low IED use was “similar to assessing the World War II Battle of Iwo Jima after the first week and concluding that the United States could have saved a lot of money on amphibious assault vehicles.” Lamb and Scudder also made the points about the importance of protection to the troops being protected; MRAP trucks made it possible to fight these wars. They also noted that in Afghanistan IEDs, which were countered by MRAP vehicles and M-ATVs, were responsible for 70 percent of U.S. casualties in 2009.





CHAPTER 5

THE MARINES' PROGRAM

By the middle of 2006, it was clear to Marine Corps leaders that there was an urgent need for a significant number of MRAP vehicles. IEDs had become a major threat, and Up-Armored Humvees (UAH) and other armoring solutions were not adequate. Multiple urgent statements of need had been received from operational commanders for MRAP vehicles, including two from Commander, Multi-National Force West for a total of 1,185 MRAP vehicles.¹ In June 2006 the Marine Corps Inspector General (IG) highlighted a need for vehicles that could resist underbody mines. The following month the Commandant of the Marine Corps (CMC) approved a MARCENT (Marine Force Central Command) recommendation to field as many MRAP vehicles as quickly as possible. MARCENT Commander Brigadier General Anthony L. Jackson considered the normal joint requirements process too slow. He proposed a separate Marine UUNS covering only the 805 vehicles of the

joint urgent operational need statement (JUONS), which CENTCOM had already issued for MRAP vehicles and the Army's MMPV (Medium Mine Protected Vehicle). This separate document was issued as a UUNS on 28 September 2006, but clearly the Marines were already working the problem.

In November the three-star Army Marine Corps Board (AMCB) recommended that the Marines buy 1,022 vehicles. In addition, the Army expected to buy 2,506, and the Navy 538, for a total of 4,066 MRAP vehicles.²

Many within the Marine Corps felt that it was crucial that the Marines take the lead in the MRAP program, contrasting their lean management and no-nonsense style with a perceived overly deliberate Army style. The Marines had already managed a successful procurement of mine-resistant Cougars for themselves and the Army, and felt that they were the natural lead for a joint program. The Marines' procurement style was partly the consequence of their practice of buying new equipment off the shelf. Thus, "I see it, I want it, I buy it—and it had better be delivered now!" made excellent sense, the unspoken part being that the Corps would adapt as necessary whatever it bought off the shelf. The Army, on the other hand, developed anew most of what it used, which made for a much slower and more deliberate process; this might seem to Marines far too slow and a search for perfection rather than for what was good enough. The Army's answer was that any program buying thousands of new vehicles of any one type had better be careful to avoid a procurement disaster, and that it takes time to be sure that anything is sustainable. At the end of the day, the Army's understanding of what "sustainable" meant turned out to be vital to the program.

In early 2006, the Marine Corps Systems Command began preparations for a potential Marine Corps program to support MRAP vehicle procurement. In July of that year, the MCSC conducted a market survey formally asking industry for information about mine-resistant vehicles and the capacity to produce them. The market survey results showed that the FPI Cougar, already in service in small numbers with the Marine Corps, was a good candidate for immediate production, but there were many valid alternatives worth investigating as part of a longer-term program.

The first Marine officers involved in the MRAP vehicle program were General Robert Magnus (Assistant CMC) and Lieutenant General Emerson "Emo" N. Gardner, Deputy Commandant for Programming and Resourcing (P&R). They took risks to get the initial key funding. Gardner proclaimed that the Marines would replace all of their

Humvees with MRAP vehicles.³ Then-MRAP Program Manager Paul Mann thought Gardener had the skill to get the necessary money from Congress and to encourage the acquisition system to deliver.

Initially the Army leadership was not particularly interested in the program, although it did create a corresponding program office at its Tank Automotive and Armaments Command (TACOM).⁴ In the fall of 2006 and early in 2007, the MRAP vehicle program was clearly a Marine Corps program managed by the Marine Corps Systems Command (MCSC) at Quantico, the Army having almost an observer status despite efforts by Paul Mann to bring it on board in a big way.⁵ Thus, he always emphasized the Army portion of the JUONS requirement in contract and production planning.

Jump-Starting MRAP Vehicle Production

One key element of later success was the approach to contracting and source selection taken at the outset by Barry Dillon. In the fall of 2006 he was MCSC Executive Director, the senior MCSC civilian.⁶

When he first came on board in August 2006, Dillon began exploring options for procuring MRAP vehicles, initially conducting a market survey. He found that there were already many supposedly mine-resistance vehicles. However, there was little test data to back up claims and for most, limited production capacity.

The contract strategy developed by Dillon and others on his staff was to first award a sole-source “bridge” contract to FPI, the vehicle manufacturer that had supported previous Marine Corps and Army MRAP vehicle requirements, for up to 280 vehicles. This bridge contract, awarded in early November 2006, would support immediate MRAP vehicle requirements while a much larger contract was put in place to support the remainder of the requirement.

At about the same time that the sole-source bridge contract was put in place, a Request for Proposals (RFP) was released requesting industry proposals to produce up to 4,000 MRAP vehicles. This contract had two parts: an initial award for test vehicles⁷ that would be used to evaluate vendor vehicle survivability and mission capability, and an Indefinite Delivery, Indefinite Quantity (IDIQ) award⁸ that would allow the program office to place multiple production orders at a time and quantity to be determined by the program office without the need to award a new contract. The cost of the individual

vehicles ordered under the IDIQ was fixed.⁹ Barry Dillon was the Source Selection Authority (SSA) for this contract, the final decision maker for award.

The usual process for buying vehicles or other military systems is to circulate an RFP and invite proposals, and then select a small number from those that bid as winners. If more than one vendor is selected, the usual acquisition approach would call for extensive and competitive testing of those selected, followed by a follow-on down select to a single vendor who would receive the total production award. This process usually took years to complete—which would not satisfy growing urgent needs.

Ten vendors responded to the RFP. The Source Selection Evaluation Board, staffed with both Army and Marine Corps personnel, met on 10 December 2006 to evaluate proposals, just 30 days after release of the RFP. Less than a month later, they provided a recommendation to Dillon, the SSA, to award to a small sub-set of the vendors proposing.

Dillon chose not to directly follow the recommendations of his SSEB. Instead, he awarded contracts for test vehicles, along with IDIQ production contracts, to every manufacturer who was judged to have the capability of meeting technical requirements—nine of the ten manufacturers proposing.

This decision was controversial. Normally, the source selection process operates on the assumption that the most cost-effective solution is to minimize costs by awarding large quantities to a small number of manufacturers. This avoids the cost of procuring and testing multiple test vehicles and can result in lower unit cost due to economies of scale. Dillon recognized, in this case, that the traditional approach incurred very high risk. Speed of delivery was clearly the preponderant criteria for MRAP vehicles. Using the standard approach, one or two vendors would have been chosen, leading to an immediate risk of protests that could have delayed award. If the chosen vendor vehicles did not meet survivability and mission requirements, extensive modifications, new test vehicles, and retesting could have been required. If the vendors were competing for a winner-take-all award, there was, again, the potential for protest and more schedule delays. Under this approach, the production of large quantities of MRAP vehicles could have been delayed for many months. Finally, since only one or two manufacturers would have remained in the game, they would have been required to individually stand-up a production capability that would support the entire requirement. Depending on the manufacturer(s) chosen, this could have been an expensive and lengthy process.

Dillon's decision practically removed the risk of such an outcome. By awarding to every vendor that was technically capable, the risk of protest was nil, even though there was no requirement to award production contracts to every vendor that received an IDIQ contract. By accepting a solution that included multiple vehicle vendors, the risk of major delays due to technical failures was minimized. Finally the potential for award to multiple vendors resulted in an unprecedented expansion of the industrial base, which generated multiple, parallel production lines and a industry production rate far beyond that which was thought possible at the start of the program.

There were trades, of course. Award of fixed price, IDIQ contracts based on technical capability alone resulted in a wide range of vehicle prices. These prices were a factor in later production award decisions, but because speed of production and vehicle capability were predominant, they did not have the weight usually seen. Probably more importantly, this approach resulted in a large number of manufacturers that had to be managed, less economies of scale, and considerable difficulties in sustainment. (See Chapter 12 for the MRAP program office response to these challenges.)¹⁰

One important strength of the program was that it was buying military trucks. Major truck manufacturers—such as International Military and Government (IMG), the military/government arm of International Truck, later renamed Navistar Defense—could become involved. They already had pipelines to supply engines, transmissions, and the like. IMG/Navistar and later Oshkosh became the dominant producers of MRAP vehicles because they were commercial firms used to large-scale production (and because, as will be seen, they both adopted a production-friendly technology). In the case of IMG/Navistar, it seems to have helped considerably that it was an outsider firm unused to the quirks of military contracting. The experience recalls that of World War II, when automobile firms produced so many of the tanks for the Army and Marine Corps.

Dillon realized that some vehicles would fail and some would deliver late. Still, his approach was brilliant. Each bidder had to provide prototypes. As soon as they were delivered, they would begin tests at Aberdeen Proving Ground. And, as soon as they demonstrated that they met minimum requirements, firms would receive an order. The two-stage process would begin at once. Anyone who made the “cut” would receive a production order for a yet-to-be-determined number of production vehicles.¹¹

This was much faster than the business-as-usual process. Prototypes were ordered immediately and then tested. Each contractor was asked initially for two vehicles.

One was blown up at Aberdeen (by a specified bomb) to gauge survivability. The other was driven to demonstrate minimum automotive capability. Then each contractor that survived the first test was asked for four vehicles, so that two of them could be blown up and the other two focused on truck-vehicular operations.

Dillon's approach to contracting was novel, and at first the potential contractors did not believe it would be carried through.¹² When the program office did exactly what he promised, the contractors realized that they could trust him and the program. That trust made the program possible, because so much had to be done virtually on a handshake basis. Dillon's approach also sparked interest because it showed that this was a real program, not just another prototyping or technology development project. Dillon and program manager Paul Mann made it obvious from the outset that the program would run, and run fast. It would not suffer the sort of delay and postponement common in other large vehicle programs.

The leadership example rubbed off on industry, making the contractors willing to keep the momentum going. In one business veteran's view, the program leaders inspired business executives to take decisions they would not otherwise take, because they trusted the government side and because so much attention went into excellent communication between the MRAP program and the manufacturers. The companies were willing to spend their own money, because they did not want to be the ones holding the program back. This went to the highest levels, with CEOs taking calls from the Secretaries of the Navy and then the Secretary of Defense, which got them personally involved. It also mattered that the message sent was consistent at all levels of the program.

MRAP program manager Paul Mann focused on rapid production of vehicles for the near term, and for the longer term building the production base. His objective was to give each manufacturer whose vehicle passed initial testing a quick delivery order to jump-start production and to develop production capacity. A manufacturer had to pass the initial test to get orders. If he failed, he could fix his problems on the fly and try again.

In a sense, this "build-a-little, test-a-little, build-a-little-more...learn a lot!" approach emulated the dramatic success of the Navy's Aegis guided-missile cruiser and destroyer programs, which Mann supported immediately before coming to the MRAP program. However, only three or four trucks could be tested at one time, so after a short time

there was competition to be on time. Manufacturers that could not deliver found that after a time the requirement for numbers was being filled. They might still hope to get orders, because the number of vehicles required rose every 60 to 90 days, so that there was space for new orders. It quickly overwhelmed the capacity of any one manufacturer, providing incentives to all of them to increase their capacities.

Survivability, mission performance and speed of delivery were the primary factors in deciding which companies received production orders. However, secondary factors could still keep vendors from getting an award. For example, there were at least two vehicles where troop egress was a key factor in deciding if they got an award. As trucks were fielded, user feedback and combat performance became very important for later production decisions.

Building a JPO

As proposals were being evaluated and contracts awarded, the organization that would manage the program was being developed.

Initially the MRAP vehicle program was seen as another wartime emergency program; in January 2007 the MRAP vehicle was tentatively designated a rapid deployment capability (RDC) program. The Navy's RDC directive gave relatively small programs that supported urgent requirements additional flexibility and leeway to respond to user needs. Initially, with only 4,000 vehicles envisioned, the RDC was appropriate for the new MRAP vehicle program. However, the RDC designation was never signed, because the program grew so rapidly that it became obvious that it would exceed RDC limits.

Marine Corps procurement was managed within the Department of the Navy acquisition process. In 2006, the Navy's senior acquisition official was Dr. Delores Etter, Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN RDA, 2005-2007). She became the Milestone Decision Authority (MDA) for the MRAP vehicle program. In February of 2007, the Navy was also appointed as the Department of Defense Executive Agent (EA) for MRAP vehicles.

Those involved in the early stages of the MRAP program consider Dr. Etter's personal involvement and enthusiasm to be key to its success. For example, she and her aide flew down to see the first contractor, FPI, taking with her the Secretary of the Navy, Dr. Donald C. Winter, and Brigadier General Brogan (Commander MCSC, which

was buying the vehicles).¹³ From the first, she was ready to support the program's acceleration of standard acquisition methods, beginning with the decision to award nine parallel initial contracts (included \$40 million for test vehicles). Dr. Etter was willing to take chances, and she was well aware of the flexibility inherent in acquisition statutes and regulations.¹⁴

The program always complied with the letter of the law for acquisition regulations and directives. However, the program also took full advantage of allowed waivers and options, and often sought and received useful interpretations of requirements that supported acceleration. These included the Navy and DoD Rapid Acquisition Program directives that provided a good deal of leeway for programs so designated, in compliance with existing directives.

Dr. Etter's support was essential in managing the program as the requirement escalated. Initially, the program was an ACAT III (less than major) acquisition program. Programs of this size have considerable flexibility and less stringent documentation and oversight requirements. By the end of January 2007, it was clear that the MRAP vehicle program's requirements would soon require moving to the next level, ACAT II (over \$365 million in RDT&E).¹⁵ With more than \$2 billion in procurement involved, Dr. Etter notified the Office of the Secretary of Defense (OSD). They said that she should press on. As the Navy's Milestone Decision Authority, she formally designated the MRAP program an ACAT II program on 31 January 2007. She also decided that it would enter the procurement process at Milestone C. Normally that would occur after an engineering manufacturing development (EMD) phase, which included developmental testing. The post EMD decision, Milestone C, allowed the program to begin production.

Dr. Etter's staff initially questioned the requested Milestone C award, largely due to the lack of documentation required for an ACAT II program. Milestone C documentation requirements are extensive. Normally, producing the documentation would have taken weeks or more. In response, Paul Mann and his small team spent Thursday through Sunday in January 2007 putting together a formal document management plan that was sufficient to support the initial production decision.¹⁶ This kind of hard overtime made it possible to meet the standard documentation requirements much more rapidly than anyone outside the program imagined was possible. Dr. Etter's staff was also concerned about the very small size of the program office, which was never as much as 50 percent the size of a conventional office during this period.¹⁷ At this point, the program office

was about 15 people, government and contractor. A program of this size in the other Services, even at this initial stage, would have had well more than 50.

Given a detailed documentation plan, Dr. Etter was willing to risk approving the program. At this stage only the Marines were formally interested, but some in the Army were clearly also intrigued. Mann therefore thought from the outset in joint terms. In his view elements of the Army saw the Marines as a path to get vehicles they needed. Kevin Fahey, an Army acquisition executive, saw a requirement for 2,000 to 2,500 Army vehicles, but believed that the existing USMC program could provide them more quickly. Given his experience, Mann believed that only the Marines could have moved the program as fast as it did.

Etter's willingness to embrace risk mattered, because at the outset few senior officials were willing to do so. Moreover, she recognized that it was vital that she avoid any temptation to micro-manage the program. Given a few months of protection at her level, the MRAP program office was able to establish the capability to manage the program.

Synchronized Approach

Etter had a technical background and understood from the first that computers would make it possible to track the MRAP program in a new way, which would make it possible for decision-makers to focus on bottlenecks and on the sorts of problems that had to be solved outside the MRAP program office. The MRAP program seems to have made unusual use of computer tracking across all its elements, and that achievement may be an important example for the future. Computer tracking made it worthwhile for high-level management committees, first those who came together in Dr. Etter's "synchronization meetings" and later the OSD MRAP Task Force, to operate quickly and effectively. In effect, they reduced the usual inertia inherent in large programs, where decisions take a long time to affect the course of the program because it is so difficult to track their impact.

The Department of the Navy, which was responsible for all Marine Corps ground system procurement, was made executive agent (Department of Defense lead) in February 2007. In May of 2007, Dr. Etter designated the program as Joint in recognition of the multi-Service requirement. Dr. Etter maintained oversight of the program through weekly synchronization meetings with Brogan, her staff, the other Services,

and the many agencies supporting the program. These meetings were a way of reaching necessary decisions quickly by bringing the various parties together. Normally the interested parties would have negotiated with each other at length via staff papers. Observers emphasize the importance of these meetings. Dr. Etter used them to identify and immediately solve problems, gain consensus, and by-pass the bureaucracy to get immediate action. They were essential to the speed of the program.

The synchronization meetings in effect drastically compressed the usual staffing process. They gave staffs much less time to develop changes in the program, and they also gave each concerned party only a limited number of opportunities to register such changes.¹⁸ The meetings, or rather their consequences, required the attention of a dedicated member of Dr. Etter's staff. Dr. Etter took the unusual step of placing an SES-level MRAP Program Coordinator on her staff, Ms. Elaine McCusker. Ms. McCusker served as the key point of contact between the Joint Program Manager (JPM) and MCSC below and OSD above. She was very important to the program's success. As a senior executive service (SES) manager, she was able to get attention quickly when needed, and fix problems without lengthy staffing involvement.

While Secretary Etter and her staff were the senior managers for the MRAP vehicle program at the Department of the Navy level, it was the Marine Corps Systems Command that provided the day-to-day management of the program. The major players there were Brigadier General Mike Brogan, the Marine Corps Systems Command Commander who would become the Joint Program Executive Officer; Barry Dillon, the MCSC Executive Director; and Paul Mann, the program's first Program Manager.

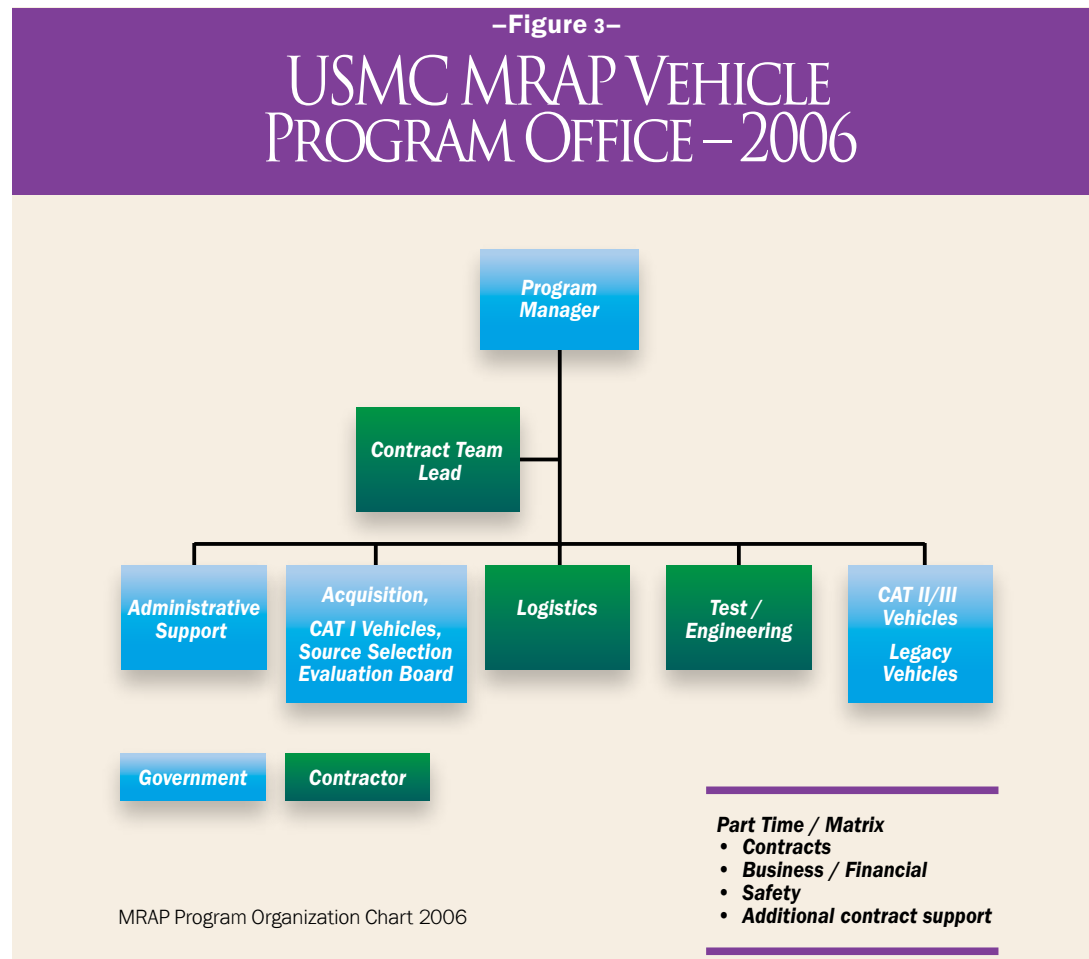
Dillon had had a Navy background before coming to MCSC. Although he had generally worked in aircraft, he was also involved in the Navy's Cooperative Engagement Capability (CEC) air defense program and in several Navy Space and Naval Warfare Systems Command (SPAWAR) programs. As such he was well aware that anti-air warfare, particularly Aegis, was a major Navy development and procurement success story. Dillon had done many risky, challenging things, and had a taste for high-risk, high-payoff programs. He also understood how to pull together a like-minded team.

Dillon chose a program manager with no previous Marine or land vehicle experience—hence with no “baggage”—Paul Mann. Dillon interviewed Mann in late August 2006, and when he arrived in Quantico to meet Dillon, he had already turned in his

notice to the Navy. Mann had just been named Engineer of the Year at the Naval Sea Systems Command for having overseen the team which integrated and certified the combat systems of the aircraft carrier and its Strike Group as it was readied for its first deployment. He also had extensive experience within the Navy's Aegis cruiser/destroyer air-defense program office.

When Mann arrived on 30 October 2006, there were only seven people in the MRAP Program Office. (See Figure 3.) Less than two weeks later, the sole-source MRAP vehicle bridge contract was awarded, and the IDIQ competitive production RFP was released. Both of these contracting actions had been working for months. There could be no delay in their execution.

In 2006 the Navy's Aegis program had recently solved a particularly difficult problem represented by CEC, a means of coordinating Aegis systems that offered benefits both



to the fleet and to the rapidly growing ballistic missile defense program. Mann had been team leader of a group that solved the problem for the aircraft carrier *Ronald Reagan*. It was ironic that in 2009, for his work as the Joint Program Manager of JPO MRAP, he would be selected by the Department of the Navy as the first recipient of the Department's Acquisition Excellence award, named for Rear Admiral Wayne E. Meyer Jr., who was famous as the "father of Aegis." Mann himself was well known as Meyer's protégé; he had embraced Meyer's ideas of how to run a high-technology program. After heading the CEC solution and readying the *Ronald Reagan* for deployment, Mann was, in Dillon's view, capable of dealing with a very chaotic situation on many levels, from flag and general officer down to tester and troops in the field.

Mann had no truck experience whatever, but he had all the other qualities needed to make the MRAP program successful. In fact, lack of experience could be a virtue, since Mann would question everything in his quest to solve the IED problem. Once he understood, he would absolutely support vital decisions.

Having enjoyed great success in the Aegis program and then in the carrier program, Mann was looking for something new. Dillon chose him as the program's chief civilian executive. It did not matter to anyone in charge that he was relatively junior, but that encouraged Mann to develop a small and relatively junior team willing to take risks in order to move the program as rapidly as possible. Not everyone chosen found the atmosphere inviting, and Mann made it easy for them to leave without personal cost. That allowed him to recruit a dedicated team happy to work extraordinary hours to get vehicles built and into Iraq and, later, Afghanistan. A typical description of the experience of Mann's program was: "It was a hoot, the best years of my life, and the worst, in terms of overtime and lost weekends. I'll never experience anything as good again."¹⁹

It was striking that so many of the key personnel in the MRAP program came out of the Navy and particularly from Aegis. They shared a particular style of procurement, which favored 80 percent initial solutions followed by spiral development to improve them. Aegis relied heavily on testing, with the "Father of Aegis" motto, "build-a-little, test-a-little, build-a-little-more...learn a lot!" The program also favored an unusual approach to contractor relations: it sought to build a stable government-contractor team built on trust.²⁰ That was a necessary part of spiral development. The contractors had to be confident that they would be allowed to apply what was learned from the tests. The MRAP program was unusual in the extent to which it shared test data with the

contractors. Spiral development also required considerable engineering depth on the part of the government side, since it had to be able to evaluate alternative proposals to improve what it had. Moreover, given a stable government-contractor team, the MRAP program could be confident that contractors would not resist innovations brought in from outside, since they would not be seen as threats to individual contractors' programs.

These practices were very different from those followed in typical concurrent-development programs, in which the government carefully guards test data it uses as the basis for selecting one prime contractor. Once the contractor has been selected, there is limited interest in further testing to improve his product, although testing could be used to see whether that product is ready for production. It is tacitly assumed that once the product passes its tests, it need not be further modified unless conditions change.

In February 2007 the two Armed Services Committees heard program manager Paul Mann explain that the Marines intended to use the mine-resistant vehicles for something more than EOD support.²¹ They had found that IEDs did not stop the vehicles and that their crews generally walked away after encountering an IED. That suggested that the EOD trucks should become troop carriers. That opened a door for Congress. The Marines knew they needed a lot of vehicles—when the committees asked, they thought 2,400—and money to match, if they were to get them.

The congressional committees were enthusiastic: finally there was a solid solution to the IED horror. They told Mann that they would support any reasonable budget request without question. But they asked, "So where was the Army?" It could offer only its own Joint Light Tactical Vehicle (JLTV), whose requirements were something like those for MRAP, but the JLTV was only in the development phase. Much larger numbers were involved, but they could not be obtained at all quickly. This led the committees into direct involvement with what became the MRAP joint program.

Throughout the program, everyone was painfully aware that delays would cost lives. About March 2007 Barry Dillon passed around a picture of an early MRAP truck that had been totally destroyed by an IED. Everyone was crushed...until Dillon added that every person inside the MRAP had walked away. The program was largely driven by the emotional attachment of those involved. Everyone saw pieces of destroyed MRAP vehicles signed by those they had saved: "This truck saved my life!" This kind of personal involvement was extremely unusual in defense.

The small size of the program reflected an inability to get program personnel, first from within the MCSC and later from the other Services. It was a major frustration throughout the first year, at least, of the program's life. It began with only five or six government personnel and five or six contractors, and it took months to reach the 20 to 30 range. Early on, Paul Mann's greatest fear was that outsiders would find out how thin his resources were; for example, when he briefed the Joint Requirements Oversight Council (JROC), he had less than 25 people. He realized that the JROC was used to far larger numbers, so to protect the program he produced an organization team that seemed to include everyone involved in even the most peripheral way. No one experienced in the DoD acquisition process would have believed that Mann's thin team could have managed a viable program. Mann's view was the opposite: the thin team made individual responsibility obvious, and those who could not do their jobs quickly realized they had to go. To make the program run, Mann used metrics more thoroughly than in other programs. He held weekly meetings, looking at seven measures of success. His well structured and disciplined use of metrics made it clear what the trends were and what had to be done.

A Multi-Service Framework

It turned out to be very important that the MRAP program was a multi-Service program, drawing on both Marine and Army resources. The Marines contributed a lean procurement organization that could make rapid decisions. The Army contributed its vast vehicle engineering resources: most of the engineers in the program came from the Army's Tank Automotive and Armaments Command in Warren, MI. The MRAP JPO generally had a larger footprint at TACOM than at its home in Stafford, Virginia, near Quantico.

The Marine and Army Service cultures were radically different. In the spring of 2007 the Army replaced its team in Warren due to an inability to bridge the gap between Service cultures. It abandoned its original organization and carefully selected new individuals who were considered flexible enough to work with the Marines.

That began with Kevin Fahey, the Program Executive Officer (PEO) responsible for the Army MRAP vehicle program, who selected his managers. They had to work in an environment radically different from what they were used to. The JMVP was never a conventional "program of record" (POR) with a well-arranged logistical tail and a series of the developmental and acquisition milestones. It seemed immune to the infinite

number of problems normal programs faced. Those who worked in it and survived evince a mixture of nostalgia and resentment that no more conventional program can move at “MRAP speed.” For example, no normal POR, at least for a truck, would have been allowed to spend so much on testing.²²

Perhaps it is fairer to say that different organizations interpreted regulations, as they applied to test results in very different ways. The JMVP emphasized the difference between guidance and directive regulations. In typical programs, guidance is treated as though it was directive; some call this the “chilling effect” of regulations. Test organizations typically find numerous flaws in any vehicle.

The JMVP approach was to get something into service quickly, despite its non-fatal imperfections, because a quick solution with minor flaws would save more lives than a perfect solution delivered later—the best is always the enemy of good enough. A more typical approach is not to take chances in a bureaucratic sense; better to get it just right than to get it into service. This tension was palpable in some interviews for this history.

The MRAP vehicle program Acquisition Program Baseline (APB) is a good example. The APB defines the non-tradable performance requirements that the Program Manager must meet. In many programs, these requirements are numerous, very specific, and often include design constraints, as well as performance requirements. The MRAP vehicle program APB requirements were intentionally few and written to minimize constraints in meeting the essential survivability and mission performance user needs. This allowed the PM maximum flexibility for vehicle design trades and adjustments as the program progressed. An Army participant used to more conventional programs described it as “building an airplane while flying it.”

End Notes

¹ The estimated cost of the 1,185 vehicles was \$1.29 billion in FY 2000 dollars. That did not include the maintenance package the JPO bought for each vehicle, which cost about as much as the vehicle, and it may not have included the massive government-furnished equipment (GFE), which turned out to be necessary.

² This was the basis for the 4,000-vehicle procurement ceiling for the MRAP vehicle production contracts that were awarded in January of 2007.

³ Gardner interview.

⁴ Gardner spoke to his Army equivalent, the chief of the G-8 division. In the summer and fall of 2006 he kept asking the Army to get on

board, proposing a united front to start the program with sufficient resources. Gardner found the Army extremely reluctant. Eventually he told them that the Marines would carry out the program with or without them. The program was made joint in the belief that eventually the Army would have to become involved. Gardner considers his Commandant, General James T. Conway, key to gaining congressional support, particularly through a key March 2007 meeting with Senator Joseph Biden, who was an ardent advocate of the MRAP Program. (As the multi-Service MRAP program was wrapping up in mid-2013, Vice President Biden was guest of honor at a program-recognition ceremony.) He considered Dr. Gates more important in his ability to move the defense bureaucracy, and also for his ability to bring the Army on board. Gardner interview.

⁵ By November 2006 the Army did have its own program office, and was participating in the writing of the RFP. It was also involved in source selection. At the TACOM level, the Army was involved, but its leadership did not want to buy MRAP vehicles on a large scale.

⁶ At this time Dillon had unusually broad authority, because the previous Commander of the MCSC, Brigadier General William Catto, left about early 2006, and his successor, General Michael Brogan, did not arrive until October 2006. During this period Dillon was acting Deputy Commander, later Executive Director; he ran the MCSC between July and September 2006. By that time Product Group 15 (heavier vehicles, including Humvees) was well aware of the vee-hull EOD vehicles. Kelley interview.

⁷ This was a radical departure from the usual practice of inviting formal paper responses. The Neuberger Draft comments that this practice in itself caused firms to invest time in improving their designs rather than paper responses, and helped eliminate firms that could not actually produce vehicles. Almost all the manufacturers told Neuberger that a long-term acquisition figure would have been the change in the program they most desired. The history of the program suggests that no such figure could have been given.

⁸ As noted above, each IDIQ contract had a ceiling of 4,000 vehicles, which was expected to be the total requirement. The original intent was to support a possible, if unlikely, award to one vendor for all vehicles. However, each contract had four options, and legal evaluation of the contract determined that these options allowed the purchase of 4,000 vehicles on each option from each vendor. As the requirement increased, this gave the program office access to, in theory, huge numbers of vehicles. This was pure serendipity, but the nascent MRAP program office took advantage of it to avoid having to renegotiate contracts, which would have been a major issue. This is also, by the way, one of the reasons for the multiple awards that few have recognized.

⁹ The vehicle prices were fixed within bands, called stair-step pricing. The highest price was for initial awards, with steadily falling prices as quantities increased. The intent was to incentivize and provide funding to support manufacturers investment in production capacity early on, leading to increased capacity throughout the industry. This strategy was highly effective, and led to a greatly expanded industrial base within months.

¹⁰ The draft Neuberger report (document provided by Richard Owen) commented that the program suffered somewhat from its mix of start-ups and large established companies (like BAE and IMG/Navistar). At least one start-up—probably Protected Vehicles Inc. (PVI)—simply ran out of money and had to leave the program. Larger firms with financial and technical resources typically found it difficult to work under the flexible conditions of the MRAP program. Smaller firms, which were nimbler, lacked working capital needed to grow their production base (the initial sole-source order to FPI was an attempt to solve this problem). Two of the smaller firms told Neuberger that they would have preferred to license production in order to grow it, because they found it difficult to obtain what they needed from the supplier bases they were developing. Larger firms with more mature supplier bases did not have this problem. One large firm that decided not to participate told Neuberger that it would have been interested had the project been structured as a full-cycle “factory to foxhole” logistics program. However, initially that is exactly what the MRAP Program Office had in mind: it included integrated logistical support in the contract package. What it did not do was attempt to forecast the ultimate size of the program. Several successful manufacturers, such as IMG, commented to the present author that they sensed early on that the MRAP vehicle program was going to be huge, and that they were willing to take risks on that basis.

¹¹ The first contracts were for only two vehicles per category each, with an incentive of \$100,000 per vehicle for early delivery of the test vehicles. The contract guaranteed a minimum of two vehicles per manufacturer, so the government was not obligated to buy any more if the first two failed their tests. Each contractor was asked for a vehicle in each of two categories (I and II). Each vendor had to propose a delivery schedule for the maximum number of vehicles expected for that category (initially 1,500 CAT I and 2,600 CAT II). Each contract had a ceiling of 4,000 vehicles per year to provide for the possibility that one contractor might be asked to build all of the required vehicles, then estimated at 4,060.

¹² Dillon interview.

¹³ Kelley interview. He was impressed by the personal engagement of the Secretary of the Navy, which could be traced to Dr. Etter. The party was surprised by how primitive the FPI plant was. It had no automation whatever. Kelley gave Dr. Etter much of the credit for the sense of urgency the program developed. He considered her very courageous, in her willingness to navigate the shoals of the Pentagon. She

was also unusual in avoiding the typical trap of becoming too involved in program details. Instead she held quick meetings, and she was always willing to assume risk, providing cover for Dillon and Brogan to run the program.

¹⁴ Dr. Etter interview. She had the view, attributed to Nelson Rockefeller, that the role of lawyers was to tell her how to do something, not to tell her she could not. She had her legal team at every meeting to keep her aware of potential waivers and to allow her to sign at once if a step was legally possible—what was not forbidden was allowed, a very different attitude from the conventional wisdom. That is not to suggest that Dr. Etter would ever take a step that was forbidden. Her attitude made it possible for her to move rapidly from step to step, however, producing or receiving documentation in parallel with actions. Although she never said so, having the legal team present dramatically reduced the time usually required to obtain formal legal opinions and thus made it possible to get full value from the innovative contracting and management practices developed by the MRAP program.

¹⁵ On February 8, 2007, Kenneth Krieg, the Under Secretary of Defense, issued a memorandum stating that, given the likelihood that the MRAP Vehicle Program would soon exceed ACAT I thresholds, he planned to designate the program as ACAT ID program with the Navy as Executive Agent (DoD coordination authority) and the Commander, Marine Corps Systems Command as the Joint Program Executive Officer (JPEO). He also requested a joint acquisition approach to be provided by March 15, 2007. Subsequently, Dr. Etter designated the program as Joint program on 11 May 2007. The program was designated as an ACAT ID program on 6 September 2007, at which time the Commander MCSC was also designated as the JPEO.

¹⁶ Richard Owen interviews.

¹⁷ At one point, the MRAP JPO inflated its apparent size by presenting an organization that included everyone that was actively involved in supporting the program, regardless of whether they were formally a part of the PMO. The concern was that if the small size of the actual MRAP Vehicle PMO was shown, senior decision makers might not believe that they could effectively manage a program of the scope and size of the program office. Richard Owen interview.

A November 2006 organization chart shows four government and three contractor full-time and unspecified part-time and “matrix” personnel. (This is the source for Figure 3.) By January 2007 there were 13 government and 44 contractor personnel. By February 2008 there were 230 government and 210 contractor billets. By 2012 there were more than 700 people directly involved in the JPO, and more than 4,000 reported to the program office.

¹⁸ The idea of speeding a program by limiting the number of reviews by each participant was not new. For example, a participant in the battleship reactivation of the 1980s commented at the time that the program had run very fast because everyone got only one “chop.”

¹⁹ Kim Yarboro interview. She found MRAP the best program of her 31-year career in acquisition. She thought it was crucial that those running the program had been brought in from outside, not contaminated by routine practices. She particularly emphasized leadership, which kept everyone in the program working together rather than competing, as might be more usual. There was no fight over who was in charge, because the team was so lean that everyone had more than enough work. So much was going on that Program Manager Mann had to rely heavily on his own managers. He could not micro-manage whether or not he wanted to. He retained just enough oversight. Mann controlled the process by controlling the flow of money.

²⁰ Mann contrasted his approach to contractors with the typical Defense Department one represented by the Army’s Tank and Automotive Command at Warren, MI. In Mann’s view, trust was essential; he could not nitpick endlessly, because if he did nothing would be done. The matter came to a head for him during a plant visit (Navistar in West Point, MS). The visit was a readiness review. He found his Army quality control people “confrontational” on every point. The Government team acted as though the contractor knew nothing, and that made him uncomfortable. He rejected the Army’s standard view of contractors as “very problematic” for the teaming agreements he had in mind. Instead of nitpicking, he wanted his JPO to offer constructive criticism that would move the program ahead. Over time, his industry teams became highly responsive and candid as they realized they would not be pounded for what they said, including admission of errors. Mann treated all the contractors on the basis that they were trying to solve the same problems he was facing; together they could produce the right vehicles quickly enough. At the outset, all of them—government and contractors—were in over their heads. Mann interview.

²¹ Sean Stackley (ASN RDA) interview. Stackley is a retired Navy captain who, upon retirement, was a professional staff member on the Senate Armed Services Committee staff in 2006-2007 before becoming ASN RDA.

²² Comment by Kevin Fahey, as he described the non-standard characteristics of the MRAP vehicle program. In the end he characterized it as survivable but ultimately not sustainable, because it was not a Program of Record, hence did not have the requisite logistical backup. Fahey interview.





CHAPTER 6

THE MRAP VEHICLE COMPETITION

The MRAP vehicle program began by buying 244 vehicles of an existing explosive ordnance disposal (EOD) type (described as “MRAP lite”) in 2006, on sole-source contract with Force Protection Industries (FPI). They were based on FPI’s “Hardened EOD (or Engineer) Vehicles,” a version of its Cougar.¹ Some of these vehicles were close to early MRAP vehicles, but none quite met requirements. For example, the alternator in a pre-MRAP Cougar was too small for the electronic outfit later required. Concurrent with the sole-source award to FPI was a Request for Proposals (RFP) issued on 9 November 2006.

The contract with FPI was a key element of the overall risk-management strategy of the program. It provided the bridge to support an initial MRAP vehicle capability, albeit not perfect, while the “full-up-round” MRAP vehicles were built, tested, and, if successful, produced.

The nine companies that received contracts for vehicles to be tested were BAE Systems, General Dynamics Land Systems Canada (GDLS-C), IMG (International Military and Government, which became Navistar, one of the two largest producers), FPI, Armor Holdings, General Purpose Vehicles (GPV), Protected Vehicles Inc. (PVI), Oshkosh Truck Company (OTC) (the other largest producer), and Textron Marine and Land. Almost all entries represented some degree of teaming; a veteran of one of the companies called them “competimates,” observing that there was a great deal of incestuous teaming because everyone involved expected this to be a large program. Nine ID/IQ (indefinite delivery, indefinite quantity) were awarded on 26 January 2007. Each contractor was to deliver two vehicles in each of Categories I and II for initial testing. The first test vehicles appeared at the Aberdeen Test Center (ATC) in February 2007.

The Source Selection Acquisition Committee (SSAC) of eight was half Marine and half Army. Technical evaluation was firewalled from a Price Evaluation Team. Inside the Technical Evaluation Team were three sub-teams: technical evaluation; past performance/risk assessment; and delivery/produceability schedule evaluation. The technical team was concerned with four questions.

- The first was survivability against direct fire by AK-47s and 0.50 caliber guns, mine blast under a wheel, and mine blast under the center of the vehicle. Each bidder had to provide armor “coupons” (samples of the armor used in the vehicle) to be tested against direct fire, plus a vehicle to be attacked by under-body mines. Because different parts of the vehicle were differently armored (the plates were called “stacks”), each manufacturer had to provide samples of the different plating. It was also necessary to test seams between different strakes of armor. Ballistic glass was also an important part of protection, and it, too, had to be tested.
- The second issue was mobility: if a vehicle could not be driven, it could not stay in the fight.
- The third was production readiness: each prospective contractor had to submit a production plan for up to 4,100 vehicles. As of January 2007, the JPO planned for 1,500 CAT I and 2,600 CAT II vehicles.
- The fourth issue was the company’s technical management: can they (and will they) effectively manage a program such as this?

For each issue there was a technical team. The Army was particularly helpful on mobility. The Marines had survivability and production readiness. Each team had four personnel, and there was a supervising team of four more. The past performance team was a single person using a survey/questionnaire, asking for past performance data over the last two years. Barry Dillon's overall directions were to "keep it small, keep it short."

Dillon, the Executive Director of Marine Corps Systems Command (MCSC), was key to what happened. The Army view was that the program should go for the top four producers, and the Marines' Project Management Officer (PMO) thought that it was impossible to go for the top six or seven; the top four should be the winners. Dillon wanted as many winners as possible as a guarantee that as many vehicles as possible would end up in theater. He directed his testers and evaluators to show the bottom companies how to fix their deficiencies and get well. He argued that if one contract was awarded to the top company, that would give 1,500 vehicles in 16 months. The top two companies might provide 1,500 in 10 1/2 months. The top three could provide 1,500 in nine months. The top six or seven might provide the 1,500 in 7 1/2 months. These figures were based on data from a paper survey. Some members of the evaluation team were furious because it seemed obvious that Dillon was merely creating extra work. In retrospect, they were lucky. On paper the top four were BAE (RG-33), GDLS-C (RG31), Oshkosh, and PVI. BAE was the only one of the top four to be entirely successful initially. Even BAE, which had a proven design, turned out to have serious problems.²

The selection of the broadest possible range of vendors was also motivated by the critical need to rapidly broaden the industry production base. The MRAP program manager, Paul Mann, was able to award contracts to multiple and incentivize facilitization for multiple vendors, resulting in a more rapid expansion of the industry base than would otherwise have been possible. The program manager used an innovative process of awarding based on first to qualify, *not necessarily the best design*. The size of the award was based on the vendor production capability, and designed to incentivize them to increase capacity for the next award. As each vendor was qualified, they received an award if there were sufficient remaining requirements to support such an award. This resulted in very rapid production, but also multiple vehicles that had to be supported. All of this was the result of explicit trade decisions made by Mann and Dillon, aimed at providing both rapid production and increasing industry base, while practically removing the risk of program failure as a result of the failure of any one vendor or vehicle.

Finally, an unanticipated benefit of this decision was the ability to respond to dramatic changes in real-world operational employment of the vehicles. Without this diverse range of vehicle capabilities and manufacturers, it would have been difficult, and taken much longer, to come up with MRAP vehicle variants such as the BAE U.S. Special Operations Command (SOCOM) vehicles, Navistar's MaxxPro Dash, and Oshkosh's M-ATV. The fact was that the Services and SOCOM approach to employment of MRAP vehicles changed as they were used, and this led to changes in the types of vehicles desired. They learned over time, and the vehicles were able to evolve rapidly in response because of the many options available.

Vendors and Vehicles

BAE-GSD: RG-33

BAE Ground Systems Division (GSD) (York, PA) offered the RG-33 in both CAT I (4x4) and CAT II (6x6: RG-33L) versions. As the market for mine-resistant vehicles expanded dramatically after the invasion of Iraq, BAE found itself restricted by the marketing agreement BAE Olifant Motor Company had already concluded with GDLS-C (see below).³ It went to OMC for a new design, which made for some similarity between the RG31 (marketed by GDLS-C) and BAE-GSD's RG-33, but they were distinct designs. BAE took the protective capsule (hull) from OMC, but it added its own content, and it built the vehicles at its York plant. The RG-33 was considerably heavier than the RG31, although it was apparently based on the same type of truck chassis. It is not clear to what extent the RG-33 was conceived specifically for the MRAP vehicle program, but it was built only for that program. It benefitted from U.S. production technology. OMC gang-built (single building station) its vehicles rather than use a production line with vehicles moving between component stations.⁴ One peculiarity of the line-up of companies was that BAE tended not to integrate the companies it acquired, so that the BAE operation at York was not closely aligned with BAE OMC in South Africa.⁵

The RG-33 CAT I vehicle was bought largely by SOCOM in its basic form and as an Armored Utility Vehicle (AUV). There was also an RG-33 Armored Recovery Vehicle (ARV), which was never successful and did not go beyond basic testing. The CAT II

vehicle was the RG-33L, which was produced both in its basic version and as an ambulance. Both versions of RG-33 were upgraded, as RG-33 Plus and as RG-33L Plus.⁶

The basic SOCOM CAT I vehicle weighed 46,000 pounds (combat weight) and could make 65 mph using a 400 HP Cummins 1SL 8.9 liter diesel. This version accounted for the first 262 vehicles, of which three were test articles. Beginning in May of 2008, an upgraded A1 model was produced with the more powerful 450 HP version of the Cummins diesel used in CAT II Plus vehicles and a TAK-4 independent suspension. The A1 model did not include heavy explosively formed penetrator (EFP) armor, so combat weight increased only to 51,340 pounds, and speed increased to 68 mph. SOCOM also bought the AUV version, which was essentially a protected pickup truck with an open back. It also provided a towing capability. Combat weight was 57,890 pounds, and maximum speed was 65.2 mph. As a measure of maneuverability, turning diameter was given as 96.1 ft. That compared to 64.6 feet for the CAT I vehicle.

RG-33L CAT II vehicle weighs 52,000 pounds (combat weight 50,835 pounds) and has a maximum speed of 66.9 mph. The engine is a 400 HP Cummins 1SL 8.9-liter diesel. As a measure of maneuverability, turning diameter is 80.2 ft.

BAE's production ramp-up was described as challenging: it was promising 56 percent of its production in a single month (January 2008). A program veteran later remembered that at peak BAE could barely produce 200 to 300 vehicles per month, and that the Joint MRAP Vehicle Program (JMVP) just could not get them underway. By August 2007 BAE was moving its hull fabrication from York to Lansing, MI.⁷ There was a proposal to substitute a version of RG31 for the CAT I RG-33. Production amounted to 2,384 vehicles, most of them CAT II.⁸ This was a real problem related to issues with the technical production package that resulted from the failure to capture vehicle changes that occurred when re-designing the vehicle on the fly during testing. BAE was one of the group of vendors originally recommended for down select. Had BAE been one of only two or three vendors, production for the entire program could have been dramatically slowed when this happened.

SOCOM's RG-33s were the only trucks integrated by the contractor and not by the Navy's Space and Naval Warfare Systems Command (SPAWAR) Charleston, SC, facility.

GDLS-C: RG31

General Dynamics Land Systems Canada (GDLS-C) had the license to market OMC's RG31 in North America.⁹ The company already made LAVs (Light Armored Vehicles) for the Marines and Strykers for the U.S. Army. It saw RG31 as a useful addition to its portfolio. Its vehicles were exported from Canada to the United States by the Canadian Commercial Corp (CCC), a Crown Corporation (i.e., governmental) that acted as prime contractor to the U.S. Defense Department, much as the U.S. Defense Department acts as contracting agent and guarantor of U.S. Foreign Military Sales. CCC had been involved in other U.S. programs and therefore was familiar with U.S. requirements. RG31 was a development of OMC's earlier Mamba armored personnel carrier, announced in 1996 and first completed in 1998. It was the vehicle the U.S. Army had ordered in 1996 as its first mine-protected vehicle.¹⁰

GDLS-C imported vehicles made by BAE OMC in South Africa, but it also handled sales of RG31s made by BAE at its U.S. facilities. OMC was never a U.S.-style mass production operation. It could not provide very large numbers of vehicles. Mixed production may have made configuration management difficult. However, GDLS-C was used to maintaining configuration control and also to providing satisfactory support such as manuals. It was considered better at the production process than BAE, but contracting was somewhat complicated by the need to deal with both CCC and the South Africans building the vehicles. Vehicles built in South Africa were outfitted, not at Charleston, but in Kuwait by a SPAWAR team set up there. This operation accounted for the bulk of RG31s used in Afghanistan. These RG31s moved by ship to Kuwait and then were airlifted into land-locked Afghanistan. Overall, the Canadian/South African connection required unique, but entirely successful, arrangements.

All pre-MRAP program RG31s were made by OMC. The capsules of the first 24 MRAP vehicles were made in South Africa and sent to York, PA (BAE) for final assembly. That was for LRIPs 1 and 2, which were executed in advance of testing. (Appendix C lists all MRAP vehicle LRIP contracts.)

The initial award for RG31s was driven by the program's objective of 4,060 total vehicles (not just RG31s) fielded by December 2007.¹¹ A production award to GDLS-C would open a production line with the potential to be one of the most productive and it would reduce risk by adding an additional high-capacity line to mitigate the survivability and

production capability risks of the other initial award vendors. The risk was minimal, given the small number of vehicles involved (20), the proven and currently operational BAE production lines in York, and the mature RG31 vehicle.

GDLS-C's next award was in August of 2007. Production for this order was split between OMC (305) and Demmer Corp. in Lansing, MI (295). For following awards, all were built at OMC and Demmer, with final assembly in Anniston, AL. At the outset GDLS-C offered a capacity of about 120 to 140 vehicles per month, based on what they thought they could achieve given a big order. OMC was comfortable with 50 to 60 per month, but could double that if need be. GDLS-C eventually produced a little over 1,600 MRAP vehicles. After the MRAP vehicle program began ordering vehicles, GDLS-C continued some dedicated production for the Army.

The versions offered in 2007 were the 4x4 RG31 Mk 5 (CAT I) and Mk 5E (CAT II). Mk 5 was deemed survivable but unacceptable from a human-factors point of view, and Mk 5E (RG31A2) was deemed too small for the ten-passenger CAT II requirement. GDLS-C reconfigured it as a six-passenger (CAT I) vehicle, and it was subsequently ordered. By the time the MRAP program was buying these vehicles, U.S. forces already had considerable numbers of earlier versions.¹²

The MRAP vehicle program designated different versions of RG31 by letter: A1, A2, A3, etc., of which A3 was an enhanced-mobility version. Most Army RG31s were the A2 solid-axle version, and that is the version the Army later wanted for Route Clearance purposes. A3 was also identified as the Mk 5EM version of the vehicle. In 2010 the versions in service were the CAT I (A2), the A2M1 CAT I RTR (Reduced Turning Radius), and RG31A3.

RG31A2 (formerly Mk 5E) was an extended-hull version of RG31, 95 percent common with the Mk 5 being fielded under the Operational Needs Statement (ONS) to the Army Engineers. Improvements over A1 included an extended cab (5 feet longer), a 570-amp (vs. 280 amp) alternator, and thicker ballistic windows. The suspension used leaf springs with dampers. The power plant was a 275 HP Cummins Diesel. This vehicle weighed 37,485 pounds and had a top speed of 65 mph on level ground. Turning diameter was 58.2 feet, which made RG31 the nimblest of MRAPs. The RTR version had enhanced payload (12,800 vs. 4,452 pounds) and weighed 46,300 pounds. Turning circle was 50 feet, and maximum speed was 55 mph. It was built under LRIP 13 (105 vehicles, 5 for test).

RG31A3 (Mk 5EM) was a short cab derivative of Mk 5/A2 with a reduced turning radius (50 vs. 62 feet), a Robust Suspension Upgrade (parabolic leaf springs with dampers), and increased payload (12,800 vs. 4452 pounds). It had a more powerful engine (300 HP Cummins), and weighed 46,300 pounds. As of December 2008, GDLS-C' subcontractor BAE OMC had made 440 RG31 Mk 5E in South Africa. Another 333 were made in the United States. All were sold to the JPO by GDLS-C. These were in addition to many vehicles bought prior to the MRAP program.¹³ Total MRAP production of RG31s amounted to 1565. Many RG31s were bought outside the MRAP program.

In 2008, all RG31 MRAP trucks were deployed in Afghanistan.¹⁴ At that time, they were the lightest of the MRAP vehicles, hence were favored for an area of particularly bad terrain and few roads.

IMG/Navistar Defense: MaxxPro

IMG/Navistar produced the MaxxPro.¹⁵ It differed from the other MRAP vehicles in that its protective capsule was not integrated with its chassis; it was placed on top of the chassis. That made for easier production. In this sense MaxxPro seems to have been the only major production MRAP vehicle that did not incorporate the South African designs, which integrated monocoque body and chassis. More MaxxPro MRAP vehicles were produced than any other variant. When the first MaxxPro spectacularly failed its first explosive test, the lack of integration with the chassis made it possible for IMG to produce a new prototype within days, by putting a new capsule on top of an existing chassis. No other manufacturer could have done that, and the testers certainly did not expect anything so quick.

MaxxPro was the CAT I vehicle. The CAT II (MaxxPro XL) was an expanded version using the same engine. As might be imagined of a major truck manufacturer that made its own engines, the power plant was a MaxxForceD/D8.7 International DT430 engine. (Like other MRAP trucks, this one used an Allison 5-speed transmission, the industry standard.) MaxxPro weighed 43,500 pounds and was relatively fast at 69.2 mph. The big panels of MRAP expedient armor protection (MEAP) armor added 4,500 pounds. MaxxPro Plus, introduced in 2008, offered improved protection against EFPs plus an improved drive train, an increased capacity suspension, dual steering gear, and a 570-amp alternator. It weighed 53,000 pounds. Navistar also produced an ambulance

version. Finally, it produced a lighter-weight version of MaxxPro called MaxxPro Dash, 4,000 pounds lighter with a 145-inch wheelbase (operational length 254 vs. 260 inches), yet still EFP-protection capable. It had the same engine and transmission, and was credited with a speed of 67.9 mph.

Navistar's great strength, it turned out, was that it was not a defense contractor and therefore had no idea of what it could not or should not do. As a company, it was used to making large bets on the market. Its attitude towards the MRAP vehicle program was similar: the Navistar management thought that it would be a huge program, so it risked considerable company money on it.

The key figure was the company's president, Archie Massicotte, who had been assigned by International Truck to find new markets at a time when the commercial truck market was rapidly declining. He argued that the company should leverage its considerable civilian technology to enter the defense business. To that end he was placed at the head of a new International Military and Government division (IMG), which was later renamed Navistar Defense. Massicotte recruited his staff from the automotive world.¹⁶ Crucially, he retained his pre-defense mind-set, which was very different from that of the other successful bidders. Prior to bidding for MRAP vehicles, IMG bid on a technology demonstrator, the Future Tactical Truck System (FTTS), a forerunner of the Joint Light Tactical Vehicle (JLTV), which gave it some insight into what an MRAP vehicle would entail.¹⁷

Massicotte decided to bid on the MRAP vehicles. Initially he planned to offer a South African-based design using the welded armored hull typical of those vehicles. At this time the Israeli armor house Plasan Sasa, which was responsible for much of the armor being mounted on Humvees, was IMG's armor partner in the abortive FTTS technology demonstrator. That came about as the result of a cold call. At the first meeting, the IMG engineer responsible for FTTS laid out what he needed, including protection against small IEDs. The two Plasan representatives showed how their armor would be put together and gave examples of protected trucks they had helped build. At this time IMG was already working on its MRAP vehicle bid. The FTTS engineer who had received the Plasan call was aware of the MRAP vehicle project; at that time IMG was very small, with only 30 employees. He passed the Plasan information to the MRAP vehicle team. With the deadline for bids perhaps 72 hours away, the IMG team decided to adopt Plasan's "kittable" armor. Plasan had explained that their armor

eliminated the need to weld a vehicle's hull. The Plasan armor was bolted and sealed into place.¹⁸ Vehicles could be built ten times as fast as the welded alternative. Welding required specialized trained personnel, but bolting armor into a frame required far less training. Thus this one innovation changed the market.

It turned out that bolting armor together could produce just as survivable a system as welding. Welding required not only much more skill, but also a process of certification and inspection. A welder had to pour energy onto his joint before it fused properly, and that inevitably took much longer than bolting a plate into place.

At the point at which IMG/Navistar changed designs, 52 days before they were due to deliver four test articles, jokes were circulating that they had only a “paper truck.” Those betting on the outcome thought Navistar was dead last in its chance of receiving a contract. The company's secret was its enormous commercial strength: it was big enough to bring 700 engineers to bear on the problem, but not so big that senior management did not get involved. It could afford to invest \$40 million in steel because its CEO believed that it would get an MRAP vehicle order. The test articles were delivered ten days early. The company was, moreover, very “hungry,” hence willing to take real risks. Given its size, it could absorb a large order, in this case 1,200 vehicles, more than the number ordered from any other vendor. That was nothing much compared with its capacity of 150,000 commercial trucks per year. IMG/Navistar also had an advantage in that the dynamics of an MRAP vehicle were not too different from those of the trucks with which it was familiar, for example, a cement mixer. IMG could therefore adapt elements of vehicles it was already making, a very different situation from that of the other MRAP manufacturers. IMG/Navistar's MaxxPro used a frame that had been designed for school buses, with some cement mixer components. IMG/Navistar built its trucks (except for their vee-bottoms) on its commercial truck line at Garland, TX; it bolted the vee-bottoms together at West Point, MS.

Plasan was a key player. When Navistar stood up production, it obtained all its armor from Israel, and deliveries of that armor consumed half the commercial airfreight capacity from Tel Aviv. Given the bolt-on armor design, it was relatively easy to construct a new industrial base, because the labor did not have to be so very skilled. Navistar found a Sara Lee hog butchering plant that had recently closed in West Point, MS, a town of 20,000. Its unemployed workers were soon trained to use torque wrenches and to bolt together vehicles. IMG/Navistar hired most of them. This training was

an order of magnitude easier than training for welding. The design of the vehicle and its armor made the program possible. IMG/Navistar used its existing production lines to make the chassis on which the bolted-armor body was placed. Bolting also made upgrades simpler. Plasan had been designing bolted-armor systems for 20 years, but its technology had never been leveraged on this scale before.

When IMG/Navistar decided to switch to Plasan's kittable armor, Plasan brought a team to its plant to meet its chief engineer. He did not yet know that the standard for armor was welding. He did know, from his wide experience of the commercial world, that bolting was much easier, and that welding, particularly of special armor steel, could be tricky.

The requirement was simply to bring a truck to the Army's Aberdeen Test Center (ATC), where it would be blown up. IMG/Navistar brought their truck. They were an unknown company teamed with Israelis who had not been involved in the program. The truck failed on the blast pad. One of the dummies inside caught fire, and the truck fireballed. The test director, Colonel John Rooney, USA, told them to "get their piece of garbage off the test pad," the implication being that it would be a long time—if ever—before they returned.

The surprise was the way the program worked. Company president Massicotte asked whether they would retest if he brought a truck back within days. Rooney said that he would, if they could come back that quickly. IMG/Navistar did not have another complete truck, but it did have another frame. In 48 hours IMG and Plasan mechanics made, shipped, and installed a new suit of armor. Given the experience of the first test, they were able to solve the problems. It turned out that hot gas from the blast had penetrated the hull when some joints came apart. The solution was simple. Once they knew what the problem was, they overlapped the joint with a simple 90-degree angle iron, right at the firewall. This time the IMG/Navistar truck survived.¹⁹ No one could understand how Navistar had moved so fast. The key was that its protective capsule was not tightly integrated with its chassis, so only a new capsule had to be built. For the automotive test, Navistar rebuilt its unsuccessful CAT II truck as the CAT I automotive test truck.

Key to IMG's success was Massicotte's attitude. He was familiar with "hand-shake" agreements in the commercial world. He once said that the company could get more

done with a handshake than in four years of contract negotiations. Massicotte was used to taking large commercial risks. To the JPO, he was the 'lean-ahead' contractor who had the resources to absorb costs and execute large contracts. Accepting large risks was a major part of the company's corporate culture, because the commercial truck business always involved huge gambles. Massicotte often ordered material for more trucks than had been requested, because he thought that larger orders were likely to come, and he wanted to be able to keep the JPO's business by being able to fulfill them. Massicotte's senior MRAP vehicle engineer commented that IMG/Navistar was alone in its commercial-oriented culture—it was another outsider, which made the MRAP vehicle program move the way it did.

IMG/Navistar was small enough for the MRAP program to be personal. Early on, the executives went to the West Point armor assembly plant and worked on the trucks themselves. The work force noticed. Executives were working there several weeks each month for eight months. The workers at the plant saw the executives' presence as evidence of unvarnished commitment.

The other contractors had considerable military experience. They knew that programs usually penalized contractors for taking risks. IMG/Navistar did not think that way—at least not at the time.

Ultimately Plasan could not keep up with the sheer number of vehicles ordered from Navistar.²⁰ It could barely meet the initial 1,200-truck schedule, but while that work was proceeding, John Young, who at the time was leading the OSD MRAP Task Force, called the company's president to the Pentagon. Young wanted to know how many more vehicles Navistar could produce in the same time frame. Armor was the limiting factor; Navistar had to—and did—find a substitute for Plasan's material, without having to modify its overall vehicle design. Plasan was unwilling to provide more than the contracted amount, and the two companies fought over the issue. They reached agreement at the last moment, and Navistar president Massicotte had to go back to the Defense Contract Management Agency (DCMA), which accepted vehicles for the Government, and to Brigadier General Michael Brogan, Commander of the MCSC, and Paul Mann, the MRAP Vehicle Program Joint Program Manager, to explain that his company would overcome the supplier base problem if the new armor passed its tests. Aberdeen was "spun up" to test the modified vehicle as quickly as possible, and it passed. The extra production that John Young promised amounted to 755 vehicles.

Bolt-on armor made not only for rapid production, but also for design flexibility. So did the company's huge truck business. It could intersperse MRAP chassis with commercial truck chassis on its assembly line in Garland, shipping those chassis to West Point to be armored. When the focus shifted away from the super-heavy MRAP II, Navistar management realized that the emphasis was moving to Afghanistan, with its rough terrain and its dearth of roads. It took them only a few days to turn around to a lightweight derivative of their MaxxPro Dash. They were able to present the relevant data within a week. The company also managed to anticipate other requirements, such as the ambulance and the wrecker, the second the MRAP Recovery Vehicle (MRV).

IMG/Navistar received its first big contract because it was willing to lean forward, and because it offered so huge a production capacity. It demonstrated its willingness by delivering test vehicles in advance of most other manufacturers, and they worked. There were minor automotive deficiencies, but IMG/Navistar had a credible corrective action plan. The DCMA confirmed the company's production capacity, subject to the same bottlenecks that affected all the MRAP vehicle manufacturers. The MRAP JPO was impressed by the way IMG aggressively addressed issues identified during the test phase. Its solutions were soon validated and would be implemented in production vehicles. When the production contract was awarded, IMG was ramping up to a capacity of 240 vehicles per month, and if it could solve supplier and raw material issues it was clearly capable of producing more than 300 vehicles per month.²¹

The JPO was also impressed that IMG/Navistar was already aggressively pursuing spiral options for enhanced survivability against EFPs and blast, a more powerful alternator (600 amps single or dual, under development), and increased payload (increased suspension travel and larger tire load capacity).

In May of 2007, The JPO decided to order 1,200 CAT I vehicles, the largest of the early awards, to support a production ramp-up to 250/month, to be completed by February 2008. That was the quickest way to get many more MRAP vehicles, and it offered the largest possible price break, using the JPO's volume discount-pricing procedure. Against that, the order would exceed the projected FY2007 Full Supplemental Marine Corps funding; it required funding from and allocation of IMG/Navistar vehicles to another user, the reluctant Army. The required funding was still within the limits of the approved ACAT II program.²² To stay within the projected FY 2007 Supplemental, the program would have to hold the order to 650 vehicles, which would support a ramp-up

to 185 vehicles/month, with production completed in December 2007. There would be a smaller price break. Total procurement cost would be held down to \$602 million rather than the \$1.103 billion of the 1,200-vehicle purchase. The JPO decided in favor of the 1,200-vehicle purchase, and it was approved; Dr. Etter issued the Acquisition Decision Memorandum (ADM) on 25 May 2007. IMG was aware that payment for the 1,200 vehicles would require further action, and that there was no guarantee that the money would be forthcoming. Massicotte trusted the JPO, and in effect he bet half a billion dollars of his company's money on the outcome. He was not disappointed.²³

All versions were CAT I: the original MaxxPro; the MaxxPro Plus; the CAT I MEAP; the MaxxPro Dash with EFP protection; the MaxxPro Dash with ISS; the MRV (wrecker); and the MaxxPro Dash ambulance. It weighed 43,500 pounds and could make 72 mph. Turning diameter was 59.2 feet, close to what RG31 achieved. Total production of the original version was 5202 vehicles.

As of August 2007, plans called for 1,958 vehicles by March 2008; 77 had been delivered in August. Given parts shortages, it seemed unlikely that the target would be met. Navistar solved its problems, and by December 2008 there were 4,867 trucks in Iraq and another 134 in Afghanistan, and 25 trucks had been lost in battle in Iraq. A total of 5,542 had been produced.²⁴ Total production amounted to 7,899 vehicles, including 250 wreckers. The IMG CAT II (16 test vehicles) was deemed survivable, but it was not procured in quantity because it offered an insufficient payload. Of the total production run, the base version accounted for 2405 operational and 6 test vehicles.²⁵

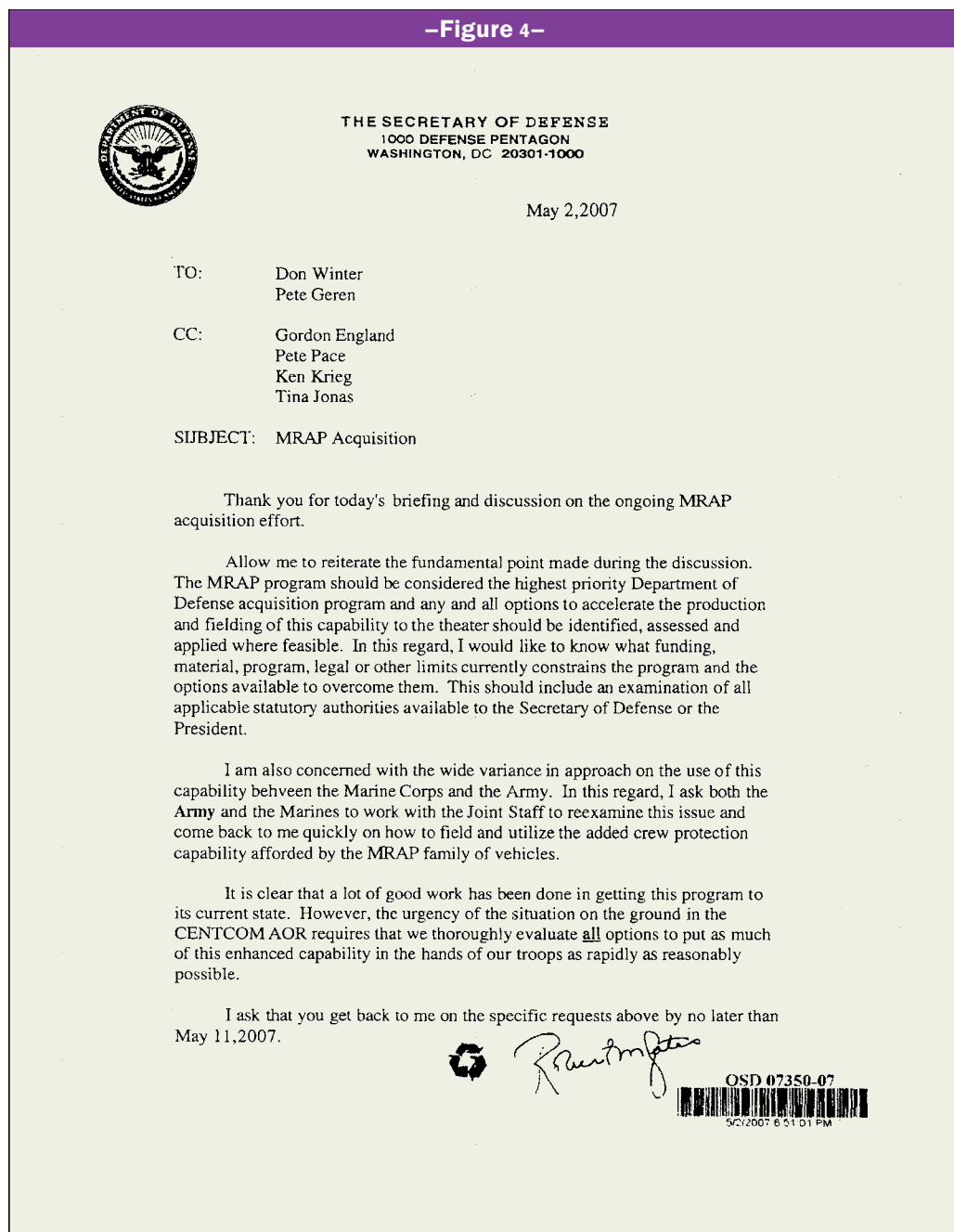
Navistar was particularly proud of its work on the MRV, the MRAP wrecker. It knew that trucks were being disabled, and that they were so heavy that only a tank recovery vehicle (the Army's M88) could handle them. The only other wrecker had no armor. Particularly in Afghanistan, the enemy found that they could stop convoys by attacking recovery vehicles, and then mount complex attacks. An armored wrecker was a different proposition. Navistar anticipated that a wrecker would be needed, and it worked independently on the project for a year and a half. It displayed its wrecker at shows, but for a long time there was no response. The company was told that the wrecker was underpowered, that it could not recover all types of vehicles. In the end, almost the only thing it could not recover was an Abrams tank.

Navistar was ready when OSD realized that the wrecker was needed. It used a COTS chassis and wrecker body but used parts of a Dash for the front end. The technical key

was the main bearing at the base of the crane, which Navistar's commercial operation made every day. By this time Secretary of Defense Gates had granted the entire MRAP vehicle program a DX industrial rating—a statement that it was the most important of his programs, and hence had absolute priority over others in getting material. (Figure 4 is the SECDEF's 2007 DX memo.)

On that basis private companies in the United States were compelled to give MRAP vehicle components priority, and it was easy to divert the necessary bearings to the

—Figure 4—



program and the MRV project. In September 2010 the JPO asked for two or three wreckers so that they could be tested in December. CEO Archie Massicotte told his team to build ten of them, which he was sure could be sold one way or another. Work began on Thanksgiving Day 2010, initially to produce ten test vehicles. On the following Wednesday it was 100 (Massicotte told them to build 150). On the following Monday it was 250, with two to be delivered in December for initial tests. The contract called for delivery within 90 days, with the first within 14 days and the entire first batch within four months. Undersecretary of Defense Ashton Carter could not believe how fast the company was able to move.

That Navistar thought like a commercial truck company rather than a military supplier had some unusual advantages. The company set up dealerships wherever in the world it sold trucks, and it did not see Iraq and Afghanistan as exceptions. Its dealers could provide supplies outside the military logistics chain.²⁶ Fire suppression was a case in point. Early in 2008 the bottles involved initially were not licensed for military transportation by the Department of Transportation. As vehicles ran out of bottle life, they were sidelined. Commanders in the field complained bitterly. The dealerships managed to get enough bottles quickly enough to keep the vehicles running.²⁷

Ultimately Navistar was one of the two largest producers of MRAP vehicles (Oshkosh was the other, with the M-ATV).

FPI: Cougar and Buffalo

Force Protection Industries Inc. (FPI) of Charleston, SC, produced Cougar (CAT I and CAT II) and Buffalo (CAT III) vehicles, of which Buffalo was a legacy of the earlier mine clearance program transferred to MRAP vehicle program management.²⁸ Cougar was produced in both 4x4 and 6x6 forms to meet the Category I and II requirements.

The 6x6 Buffalo was by far the heaviest MRAP vehicle, at 78,500 pounds in its pre-LRIP 10 version. Its most characteristic feature was a 30-foot extendable boom with an attached rake/probe. The latter was combined with a video camera, and the combination was used to find or uncover IEDs with sufficient standoff to protect vehicle and operator. Given the sheer weight of the vehicle, maximum speed was lower than that of CAT I/II MRAPs at 55 mph. Buffalo Mk II was also designated A1. The later A2 or Mk III version (Delivery Order 13) offered towing and recovery capability, a

more powerful engine (440 HP Caterpillar C13) with a Caterpillar transmission, and an automatic fire extinguishing system. Its boom added an Air Digger System in which high-pressure air was blown over a suspected IED to remove debris so that the IED could be seen.

Cougar was built in numerous versions, none of which had a standard M-series designation, although all did have National Stock Numbers applied to them.²⁹ The basic CAT I vehicle was built in A1 and A2 versions and it was modified with ISS (as A1). There was also a CAT I/Saber/tube-launched optically guided weapon/improved target acquisition system (TOW/ITAS) version. The CAT II version was built in A1 and A2 versions and also with MEAP protection against EFPs. The A1 and A2 versions were also modified with ISS. In addition, there were 4x4 and 6x6 Hardened Engineer Vehicles (HEVs) and 4x4 and 6x6 JERRVs, plus an ambulance version. All of this variety is aside from minor individual variations due to the nature of the FPI production process, which meant, for example, that a rear door from one vehicle generally could not fit another.

The CAT I (A1) version was powered by a Caterpillar C-7 7.2 liter engine (330 HP, 860 foot-pound of torque). It weighed 34,000 pounds and could make 62 mph. Turning diameter was 58.9 feet, making it one of the more nimble MRAP vehicles. This vehicle seats six: driver, co-driver, and up to four crew. The A2 version had the same engine, but weight increased to 38,000 pounds. This version had its roof raised seven inches to provide more space for seats to move under the effect of blast, an early consequence of the extensive testing program. Weight in this version increased to 41,500 pounds. The Saber version, which fires the TOW anti-tank missile, seems to have initially been a specific development for the Army to support their Combined Anti-Armor Team with ITAS. Although the Army faced no tanks in Iraq, TOW offered units built around MRAP vehicles heavy firepower, for example against buildings and bunkers.

A Cougar CAT I Enhanced Mobility (EM) version bought under LRIP 13 was tested in August-September 2009; testing was suspended in September, when it was decided that these vehicles would not be fielded.

FPI teamed with GDLS (for production) as Force Dynamics.³⁰ FPI received an initial sole-source ID/IQ contract for 288 vehicles (Cougars and Buffaloes) to jump-start

production with a known proven vehicle until other contractors could be selected, qualified, and could produce vehicles. The 244 Cougars bought under this contract were later called “MRAP Lite.” FPI’s vehicles were the first to complete developmental testing, and the company was awarded a contract for 1,000 vehicles. The company completed Cougar production in October 2008.³¹ FPI appears to have offered its Cheetah, a next-generation Cougar, as a CAT I candidate for the MRAP vehicle program. The program preferred to continue production of the existing Cougar.

For many of those in the program, FPI epitomized small-scale production.³² It farmed out its automotive business, mainly to the Spartan Motors Company in Michigan, and it concentrated on building the armored parts of its trucks. The vee bottoms of the hulls were generally welded at one plant and then mated to the flat sides and tops of the crew compartment. This assembly was done by hand, and no two Cougars were quite the same.³³ That made outfitting difficult, and in theory irregularities in the production process should have caused problems in combat. They would surely have disqualified FPI in a more conventional program. In fact Cougars were successful in combat, and they were well liked. They had a reputation for roominess.

FPI was well aware that it had limited production capacity, but it did not want to invest heavily in more because it knew that at some point, probably sooner rather than later, the program would end, and it could not afford to carry enormous overhead. It therefore opted for a coalition approach to production, signing deals with Armor Holdings; Textron; the Marine Corps Logistics Center (MCLC) in Albany, GA; and Spartan Motors in Michigan. Because orders were smaller than expected, not all of this was needed; Armor Holdings built about 50 Cougars and the MCLC built about three. Toward the end of the program, GDLS bought FPI.

The MRAP program bought a total of 3,153 CAT I and CAT II Cougars, in addition to earlier, pre-program production.³⁴

Armor Holdings (BAE-TVS): Caiman

Armor Holdings of Sealey, TX (which became BAE-TVS on 31 July 2007) offered the 6x6 Caiman in both Category I and Category II versions.³⁵ The company had been interested in under-body protection since about 2005 in connection with the Army’s Future Family of Tactical Vehicles program, a kind of predecessor to the JLTV. The

requirement was to provide reasonable protection for six men in a very maneuverable vehicle, roughly comparable to the later M-ATV. Armor Holdings tracked Marine Corps interest in a protected vehicle carrying a squad, with a level of protection somewhat higher than that of the usual armored truck. Protection had to be all-around, including moderate under-body protection. Armor Holdings offered some shaping for that purpose, and that experience led it into the MRAP vehicle competition. Armor Holdings acquired Stewart & Stevenson, which made the Army's standard truck, the Family of Medium Tactical Vehicles (FMTV). In 2006 it was producing an armored-cab version, ramping up to 45 vehicles per day. Armor Holdings' company in Fairfield, OH was producing armored Humvees (M1114s and then M1152s) in large numbers. That made it possible for Armor Holdings to combine its armor expertise with its automotive capacity in its MRAP vehicle bid. It also had connections with OMC in South Africa, which had the necessary under-body protection expertise. In its view it was offering the reliability already demonstrated in the trucks combined with MRAP protection.

Caiman was built on the same assembly line as FMTV, and its commonality with the trucks was considered desirable from a maintenance point of view. On the other hand, buying Caimans cut into FMTV production. There was some feeling within the JPO that Armor Holdings rejected criticism instead of accepting it and solving problems, but Caiman survived in production because the Army liked it, presumably because of the commonality with FMTV.

The CAT I version of Caiman was rejected, but the 6x6 CAT II vehicle which was accepted was reclassified as CAT I. Thus, virtually all Caimans were CAT I vehicles. By August 2009 Caiman had been provisionally designated XM1220 in the U.S. military vehicle system, indicating that it was en route to standardization by the Army, and was ultimately designated M1220. This 50,620-pound vehicle was powered by a Caterpillar C7 engine with an automatic transmission, and it could make 64.4 mph on level ground. Turning diameter was 62 feet.³⁶

Armor Holdings received a contract (LRIP 7) on 13 July 2007 for 1,170 vehicles (1154 CAT I, 16 in CAT II configuration for tests), all of which were to be delivered between August 2007 and February 2008, a performance the MRAP vehicle program described as a resounding success. After Armor Holdings was bought by BAE, the new BAE-TVS company produced an additional 1,695 vehicles, for a total of 2,871 Caimans by the end of MRAP program production.

The Others

PVI (Protected Vehicles Inc.) and Oshkosh were both awarded contracts based entirely on their technical proposals and not on test vehicles, in much the same spirit as the pre-test sole-source award to FPI. (PVI was founded by retired Army colonel Garth Barnett, who had co-founded FPI). At this time Oshkosh, which received an award at the same time for its Alpha, was considered the highest-capacity producer with the lowest vehicle cost and a low survivability risk. The proposals were deemed low-risk, but neither was successful.

PVI offered the Golan as its Category II truck.³⁷ Its name indicated that it was an Israeli design (in fact by Rafael). The Golan achieved the necessary rigidity by eliminating all side doors rather than by accepting the greater height involved in a vee-hull. It was adapted to use reactive armor, and in February 2007 it was assessed as offering a major advance in survivability. In retrospect the Golan is interesting as an example of a mine-resistant vehicle that did not use the South African-type vee hull. Access was out the top or the back. That arrangement was considered poor; in a complex ambush there might be no way out of the vehicle. It was a relatively small (36,000 pounds) agile vehicle described as adapted particularly to urban and confined areas. The program ordered 60 for the Marines based on their design potential, before receipt of test vehicles. There were no further orders despite some congressional pressure. The Golan was attractive from a production point of view, because Oshkosh, a huge truck manufacturer, would be performing automotive integration and vehicle assembly. In February 2007 the production process was being tested with 14 vehicles that had either been produced or were in process.

Ultimately the vehicle never passed a test. The company was a start-up with limited resources, which it spent on engineering support for testing. It went out of business, and the program office terminated PVI's 60-vehicle contract.

Oshkosh (in partnership with PVI) offered the Israeli-designed Alpha as its CAT I truck, the lightest of the lot, at 26,000 pounds.³⁸ PVI provided the welded hull, and vehicles were assembled by Oshkosh. The JPO ordered 100 as a risk-reduction measure, based on the technical proposal. Like the Golan, it achieved rigidity by eliminating all side doors. It too was described as suited to urban and confined areas. Troops hated the door-less design (it failed to provide the required egress points), so none was

ordered after the first 100. The Oshkosh order was significant for later development. Oshkosh learned enough from its rejections to become the successful bidder for the M-ATV intended for Afghanistan. That was possible because the program emphasized transparency: it wanted all potential bidders to learn as much as possible from the test program. All of the Alphas went to the U.S. Border Patrol in the Department of Homeland Security. Having lost in the MRAP “sweepstakes,” Oshkosh learned a lot, and it came back later as producer of the M-ATV for Afghanistan.

In the original competition, Oshkosh asked for additional time in order to produce the lightest-weight vehicle it could. Its Army vehicle experience convinced it that weight would be a critical factor, even though the Marine program office explicitly said otherwise. For the Alpha project it used a special lightweight ShieldAll armor developed by Batelle. Oshkosh made the standard Army tactical trucks, and conducted their up-armoring program, which was probably informed by and affected its MRAP vehicle experience.

The Oshkosh CAT II entry was the Australian Bushmaster, made in Australia by Thales.³⁹ It was developed from CAT earlier South African vehicles by the Australians to support their operations in Namibia in the 1990s. It was considerably larger than the program wanted. It failed the underbody protection test. The judgment seems to have been that mitigation was possible, but not acceptable given time constraints (the problem would have had to go back to Australia for modification, and a new vehicle built). At least the vehicle tested also had automotive problems.⁴⁰ Bushmaster embodied a different operational concept from the U.S. one, but no potential U.S. customer wanted it.

Like Navistar, Oshkosh was a large commercial truck builder, although unlike that company it had extensive military truck experience. Also unlike Navistar, it did not see the MRAP vehicle program as an enormous opportunity, so it chose to partner with other companies rather than develop a new vehicle internally. In the M-ATV competition that it won, it leveraged its existing experience with the Marines’ largely off-road MTRV truck (see below).

Textron offered a version of its M1117 Armored Security Vehicle (ASV) for both CAT I and CAT II.⁴¹ ASV was an armored car widely used by U.S. Military Police, and it offered better ballistic protection than the up-armored Humvee. However, it offered

no under-body protection at all. It was low-slung, and its occupants rode between its wheels. It had a flat bottom. The vehicle did not survive test explosions. Even so, there was some congressional support for buying the vehicle, because it offered better ballistic protection than the up-armored Humvee.

GPV (General Purpose Vehicles), located near Detroit, offered two candidates out of its modular series of wheeled armored vehicles (the 4x4 Sergeant and the 6x6 Commander). The company claimed mine protection due to their vee-shaped hull. GPV received an IDIQ contract but never delivered any vehicles.

End Notes

¹ Dr. Gary Coleman interview. He joined the program at the end of January 2007. The FPI contract was for up to 280 vehicles (200 CAT I and 80 Cat II). This sole-source contract was awarded on 9 November, paralleling the Request for Proposals for the ID/IQ contracts (issued 2 November, with proposals due 18 December).

² Descriptions of prototype vehicles are from the Joint MRAP Vehicle Program Review, 30 August 2007 and from the 2010 Master Plan for Test and Evaluation, which gives data of all prototypes tested by the MRAP vehicle program up to that time (it does not list the M-ATV competitors, however).

Given test results, BAE had to make significant design changes on the fly. That changed their parts requirement and parts availability, hence ability to produce. It turned out that they also had poor configuration maintenance, and did not produce mature vehicle drawings quickly enough.

According to a summary of interviews with Gallagher and Randolph (courtesy of Richard Owen interview), Blackwater was told that their armor coupon had to represent the armor that was going to be on their vehicle, at a specified location. They felt they did not have to install armor, which weighed 500 pounds per square foot, on their vehicle; they delivered only coupons. Aberdeen set it up on the test stand and asked Blackwater to verify the set-up, but the company told them that it was not the real armor, only representative. When Aberdeen asked whether they wanted to shoot real armor or withdraw, Blackwater promised (but did not provide) real armor. One round went through the “representative” armor, but another was stopped. Aberdeen told them they had failed, but offered to keep them in if they upgraded, after which they could undergo the blast test. On the blast test, their vehicle was blown up, and everyone inside would have been “seriously messed up.” Blackwater protested; the perception was that they wanted to get into the vehicle business. The program offered not to render a failure rating, and Blackwater never sued. This was in the MRAP II competition, not the original MRAP competition. The account also refers to failure by FPIL, which cannot apply to the original competition.

³ Ross Boelke interview.

⁴ That is, a vehicle sat in one place on the factory floor while it was built up, instead of progressing down a production line while pieces were added in a steady stream. That much reduced production tempo.

⁵ Reportedly RG-33, like RG31, is based on the German Unimog series of chassis, which was also the basis for the German Dingo. Unlike Dingo, RG-33 integrated body and chassis to minimize space in which the gas from an explosion would be trapped. This vehicle seems to have been developed specifically for the United States MRAP vehicle program, as no other users are listed. The only engine associated with it was the 400 HP Cummins 400 Turbo Diesel. A 2007 MRAP program slide gave maximum weight of the 4x4 CAT I version as 40,340 pounds, which made this RG-33 about a third heavier than RG31 Mk 5. Maximum weight of the 6x6 CAT II version was 61,340 pounds, with a commensurately heavier payload (11,704 pounds vs. 10,014 pounds).

⁶ These versions later had M designations applied, not necessarily in any order corresponding to the order in which the vehicles were developed. The base version of RG-33L was designated M1232; the Plus version is M1237, and the corresponding ambulance is M1233 (but the Plus ambulance is M1237A1). The SOCOM base CAT I vehicle is M1238. There is an undesignated version with ISS (Independent Suspension), but the Plus version with ISS is M1238A1, and the SOCOM AUV is M1239.

⁷ The version bought for CAT II was RG-33L, for the Army. The first LRIP order was for 75 vehicles; as of December 2008, the total was 1722, and Army CAT I vehicles were being converted to CAT II. By June 2008, 731 had been delivered. All were in Iraq, and four had been damaged in combat. Of the fielded vehicles, 14 were supporting tests, three were at “MRAP U” for training, 38 were de-processing, and another five were waiting de-processing.

⁸ SOCOM was the only user of BAE CAT I vehicles, beginning with 259 of them under LRIPs 6 and 9 in 2007, followed by three in 2008 (LRIP 11). These were called Base CAT Is; the SOCOM Plus CAT I had an upgraded 450 HP Cummins engine, TAK-4 independent suspension, and additional payload capacity. Production: 44 in 2008 (LRIP 12 and 13), 58 in LRIP 17 (January 2010), and 26 in LRIP 18 (July 2010). CAT II production was 731 vehicles under LRIPs 1, 6, and 9 in 2007. CAT II Plus had an upgraded 450 HP Cummins engine, upgraded Axle Tech 5000 5G axles, and additional payload capacity. Production amounted to 600 under LRIP 10 (2007) and then 395 under LRIPs 11 and 12 in 2008 (March and July). SOCOM had its own upgraded CAT II AUV version, with a 600 HP Cummins engine, a tow capacity of 36,000 pounds, and a cargo payload. SOCOM received 38 under LRIP 11 in March 2008 and another 32 under LRIP 18 in July 2010. There was also a CAT II HAGA (Heavy Armored Ground Ambulance), first bought under LRIP 6 and 9 in 2007 (128 vehicles). The initial requirement was an Immediate Warfighter Need (IWN) statement submitted by the Director of the Joint Rapid Acquisition Cell (JRAC), and approved by the Under Secretary of Defense on 18 April 2007. It called for eight vehicles. JRAC had designated HAGA an urgent need on 27 February, citing the use of vee-hull ambulances already being used by the Australians and the Dutch. HAGA was upgraded with a 450 HP Cummins diesel, Axle Tech 5000 5G axles, and a longer folding ramp as the HAGA Plus Ambulance. Production amounted to 53 vehicles under LRIPs 11 and 12 in 2008. Of the total of 2,384 vehicles, 785 went to the Army, 457 to SOCOM, 6 to the Marines, 1,071 to S/C, 34 to GVIC/Test, and 14 to BL. 17 were CAT I test articles.

⁹ The initial North American marketing agreement between GDLS-C and OMC was signed in 1996, presumably just after the initial sale for Bosnia. A follow-on signed in 2005 extends to 2017.

¹⁰ A BAE OMC presentation shows how RG31 has grown. The initial versions were Mk I and II, produced in very small numbers. The version of Mk 3 produced for the UN weighed 9 metric tons; the version for the United States and Canada weighed 9.5 metric tons. The Mk 5 version for the UAE weighed 11 metric tons, and the ONS II version for the United States weighed 13. RG 31 Mk 5E (MRAP) weighed 15.4 metric tons, and the follow-on Mk 6 A/B weighed 17. All were 4 x 4 vehicles. Payload increased from 1.5 tons in Mk 3 to 3.8 tons in Mk 5E and to 6.5 tons in Mk 6E. Over the same versions the crew capacity increased from 7 (plus the driver) to 9 and then to 10 (plus the driver). The BAE presentation shows no sales of Mk 6. Mk 3 MPA was sold to the U.S. Army (TACOM), to the Canadian Army, and to Rwanda. Mk 5A was sold to SOCOM and to TACOM in the United States and also to the UAE and to Italy. Mk 5E was sold to SOCOM, to the MRAP JPO, and to Spain. Mk 5EM and Mk 5EHM went only to the MRAP JPO. Major sales of Mk I and 2 were 70 to the UN (1996-2004), 33 to Rwanda (1997), 4 to Colombia (1996), 7 to Swaziland (2001), and 5 to Mali (2002). Sales of Mk 3 were 20 to Rwanda (2006), 75 to Canada (2006), and 153 to TACOM (2004/5, before the MRAP vehicle program was created). Mk 5A went to TACOM (259 in 2005-7), to SOCOM (50 in 2007), to the U.S. Marines (12 in 2007), and to the UAE (76 in 2006). Mk 5E went to TACOM (111 in 2008), to the U.S. Marines (1382 in 2007/8), and to Spain (110 in 2009). The U.S. sales were via the JPO. Mk 5EHM sales were 250 to the U.S. Marines in 2010 (JPO), and Mk 5EM sales were 27 to the U.S. Marines in 2010. These figures do not include 2 to Italy and 2 more to the UN, of unidentified types. Total production was 2,619, of which 2,219 went to the United States. The OMC presentation shows a sketch of Mk 4, which was produced only as a prototype.

The predecessor vehicle, Mamba, was a very rudimentary version of the South African short-cab mine-resistant vehicle, with big tires, mud flaps, etc. It is externally similar to RG31. Mamba was manufactured between 1993 and 1997, a total of 653 being made (of which 67 were exported). Most were Mk 2s (4x4 instead of 4x2). The chassis (and also the chassis of RG31) is the German Mercedes-Benz Unimog 4x4 cross-country type. The power plant is a 123 HP Mercedes-Benz diesel. Loaded weight given by *Jane's Armour and Artillery* is 6,800 kg (about 15,000 pounds). Mamba Mk 3 is an upgraded version with a better ride and stability, and with additional ballistic protection. Mk 3A may have indicated a remanufactured Mamba. Nyala was a development by OMC; it might be considered RG31A0. Charger may have been another trade name (although reported for the U.S. Army, it was never official).

The original four Mk I Nyalas of 1996-1997 (2355-20-001-9926) had Mercedes engines and 100 amp alternators. Armor protection was below current Mk III production. Ballistic glass protection was also below current protection. There was a small commander's hatch with an auxiliary weapon pintle. Tires and wheels were of lesser capacity than the current version, and the vehicle was automotively different from the current one. It had eight small roof hatches and inboard-facing seats, which meant that the occupants could not shoot from their seats.

After Mamba, the next version bought for the United States was the 9 Mk I RG31s of 2003/4 (NSN 2355-20-001-9926). They were automotively similar to the current vehicles, but still had the Mercedes engine and the 100-amp alternator. The 2005 series consisted of 6 Mk I (2355-20-001-9926) followed by 30 Mk II (hulls 7-36: 2355-20-001-9922). Mk II had applique armor to improve its protection, a tire/wheel upgrade, two large rear roof hatches instead of the former eight small ones, and it was later retrofitted with a Platt weapon station on top. When the slide was made a 280-amp alternator kit upgrade was pending. Mk III was Hulls 37-148 of 2005, the Baseline ONS I Configuration (2355-20-001-9932). Compared to Mk II, it had an upgraded hull with better protection, a Platt weapon mount, an upgraded suspension (2 shocks), and tire/wheel upgrades. Data on early U.S. RG31s from an undated slide (prepared by the MRAP vehicle program) showing different U.S. versions of RG31. Other sources state that Mk III (or Mk 3) has a Detroit Diesel engine. No Mk IV was listed in the

MRAP slide (and none was marketed by GDLS-C). Mk V (later Mk 5) was the Baseline ONS 2 Configuration, the initial order for which was 265 vehicles (at the time of the slide, another 183 were pending). They were 2355-20-003-0065. This version introduced a Cummins engine and a 280 amp alternator, it had a new transmission/T-case, driveline, and axles; it offered increased payload; it had upgraded ballistic glass (without firing ports), it had half doors for driver and commander, it had an Objective Gunner Protective Kit (OGPK) weapon station on top, and it had the two large roof hatches. The final image on the U.S. slide was the MRAP version bought in 2007, offering fleet commonality with RG31A1 as the baseline truck. Assessed commonality between RG31A1 and RG31 was about 15 percent. RG31A1 had 90 to 95 percent commonality with the RG31A1 SOCOM version, with MRAP CAT I RG31 Mk 5A, and with MRAP CAT II RG31 Mk 5E. The numbers given above in parentheses are National Stock Numbers. Mk 5E is an extended Mk 5 with a larger passenger/cargo compartment.

By way of comparison, the curb weight of an RG31 Mk 5 is 29,840 pounds (from a 2007 MRAP program presentation). *Jane's* gave the combat weight as 8,500 kg (about 18,600 pounds), which suggests that Mk 5 had been considerably up-armored, presumably to overcome its earlier reputation as lightly protected. There is also a Mk 6 version, not in U.S. service. GDLS-C counted its vehicles by Delivery Order (DO) rather than by LRIP; it listed eight Delivery Orders (DO 1 through 5 and DO 7 and 9). DO 1 was the four test articles, Mk 5A and Mk 5E (LRIP 4/20); DO 2 (contract awarded 23 February 2007) was 20 more, delivered in August and September 2007, for the same two types. These were the troop test vehicles, the stage at which Oshkosh and PVI dropped out of the MRAP vehicle program. GDLS-C production ramped up with DO 3 (Mk 5E: 600 vehicles, contract award 23 February 2007). DO 4 (17 July 2008) was another 673 vehicles, the largest award to GDLS-C. It was soon followed by a supplemental DO 4 contract (100 vehicles, also 17 July 2008). DO 5 (4 September 2008) covered another five vehicles, presumably for further tests. DO 7 (12 February 2010) was 250 vehicles for Afghanistan. Finally, DO 9 (28 July 2010) was for 27 vehicles. MRAP production thus totaled 1,679 vehicles. Of these, DO 4 was a Mk 5E with ECPs and with narrower turning diameter so that it could better negotiate narrow roads. The DO 4 supplemental and DO 5 were both for Mk 5EM vehicles. DO 7 was for Mk 5EHM. This version had a 300 HP engine with 900 ft-lb of torque, compared to the earlier 275 HP and 600 ft-lb; most DO 3 and DO 4 vehicles were upgraded to this standard. DO 9 was for Mk 5EM and Mk 5EHM with the TAK 4 independent suspension. That was added as a kit in theater, but the modification had to be tested first to ensure that it did not reduce survivability. In November 2010 GDLS-C received an order for 691 upgrade kits to bring DO3/DO4 Mk 5Es up to DO 7 configuration; an additional contract for 425 more kits was awarded in November 2011. This effort was called Block Upgrade 3 (BU 3); 436 conversions were completed by MSF in Kuwait by January 2013, before the effort shifted to Letterkenny Army Depot in the United States. This is a continuing program, because remaining RG 31s became the standard Army medium mine-protection vehicles (MMPVs). In addition to the suspension, Block upgrade features included a powerpack, spall liner protection, new protective seats, new armor-glass windows, new steps and fuel tank, door assist; Skydexs floor matting; and automatic fire-extinguishing system (AFES); and new ammunition stowage. Data on Delivery Orders and GDLS-C vehicles from GDLS-C.

¹¹ Briefing for Dr. Etter dated 16 February 2007. Production risk was assessed by one-day visits to each vendor's site conducted between 2 and 6 February 2006. Presumably the visit that Brigadier General Kelley remembers to FPI was conducted at this time. Visits were usually lower level, but FPI was particularly important because of its lead sole-source contract. The February briefing rated Armor Holdings, BAE, FPI, GDLS, GPV, IMG, Oshkosh, PVI, and Textron. In view of later events, it is ironic that IMG was the only company whose capacity was rated as high risk. GDLS-C and BAE were the only ones green-lighted in every category. Armor Holdings was rated high risk in production engineering and moderate risk in tooling/equipment and in manpower/personnel.

¹² The relevant "pedigree" chart prepared by the MRAP JPO shows two categories of RG31s procured by other organizations: route-clearance vehicles (PM-AMS, the Army's program for Assured Mobility Systems) and SOCOM. Route clearance procurement, according to this chart, amounted to 157 RG31 A0 (Mks 1, 2, and 3); 260 RG31A1 (Mk 5); 8 RG31A1 (for DOD JCOE: Mk 5s); and 111 RG31A2 (Mk 5E). SOCOM had 50 RG31A1S (Mk 5 and legacy types).

¹³ A chart in the December 2008 Program Review showed 510 RG31A2 Mk 5E produced under LRIPs 1-9 plus 673 with ECPs (LRIP 12 [July 2008], of which 350 had reduced turning radius) plus 105 RG31A3 Mk 5EM (LRIP 12-13). The A3s (100 under LRIP 12, five under LRIP 13) were for SOCOM. They had upgraded 300 HP Cummins diesels, enhanced maneuverability, M-ATV-style independent suspension (TAK-4), and increased payload capability. Purchases resumed with LRIP 17 in 2010: 250 RG31A2 with independent suspension. The final purchases were under LRIP 18 in 2010: six A2 and 21 A3. The total fleet of 2,247 was divided into 1,538 for the Marines, 150 for SOCOM, and 536 for the Army (for route clearance). These figures included the "other organization" figures cited above. "Legacy" RG31s amounted to 157 RG 31A0 route clearance vehicles (Mks 1, 2, and 3), 260 RG31A1 route clearance vehicles (Mk 5), 8 RG31A1 DOD JCOE (Mk 5), 50 RG31A1 SOCOM (Mk 5), and 111 RG31A2 route clearance Mk 5E (MRAP configuration) trucks. This list gives some idea of the configuration management problem the MRAP vehicle program faced. These were mainly Army vehicles, but SOCOM had 50 legacy RG31A1-S. The Army had 1,388 RG31A2 MRAP trucks and 105 RG31A3 MRAP trucks.

¹⁴ As described in December 2008, the program began with DO #3 for 588 MRAP RG31A2s deployed to Afghanistan; 22 non-deployable DO #2 and #3 trucks remained in the United States for tests, for training, and for integration development. DO #4 covered another 773 trucks, the first of which were accepted in November 2008. DO #5 was for 5 trucks, for delivery in January 2009. The DO lists in the

program were not the same as the LRIPs. Thus DO#2 and the PVI produced 24 RG31 (12 Mk 5A and 12 Mk 5E). LRIP 9 (DO #3) was for 600 RG 31A2. LRIP 12 was DO #4, including the 350 trucks with reduced turning radius. LRIP 13 (DO #5) was for five RG 31 Mk 5EM test trucks. LRIP 12 had been split into 440 trucks built in South Africa and 333 built in Anniston, AL. All of the LRIP 13 test trucks were built in South Africa. By this time at least 12 trucks had been lost in combat. Of trucks made in the United States, hulls were fabricated in Lansing, MI, but the trucks were assembled (integrated) in Anniston, at a new site, before they were shipped to Charleston for outfitting. Those produced in South Africa were outfitted by SPAWAR in Kuwait.

¹⁵ Navistar was the parent company; IMG became Navistar Defense. The company was originally International Harvester, which renamed itself Navistar in 1986. It retained the “International” name for its trucks, and its new defense arm was International Military and Government (IMG). Inside the MRAP vehicle program, IMG became simply Navistar.

¹⁶ John Major interview. Major came from Ford and was the 45th employee at Navistar Defense. Massicotte began with sales of COTS trucks, but the MRAP vehicle program was his first big specialized defense project.

¹⁷ Wolverton interview. He began as a body designer, designing a cab for an International Harvester truck. He left International Harvester and returned to Navistar to work on the FTTS technology demonstrator. It was intended as a pre-feasibility study of JLTV, to vet requirements. This project was conducted in 2005-2006. At this time the under-body attack problem was just beginning, so protection was mostly against side attack. The vehicle had to combine integrated armor, a remote weapon station, night vision equipment, and a hybrid diesel-electric power plant, the latter desirable as a way of reducing the footprint of an expeditionary force. Expeditionary considerations also explain a demand that the vehicle be C-130- and helicopter-capable. This combination of requirements gives a fair idea of priorities in 2005, when it seemed that the Iraq war would be short and that the Army should be thinking in terms of what would happen after Iraq. Protection was mainly against small-arms fire, but the design also featured an add-on vee-bottom kit. There was considerable emphasis on the hybrid drive, because fuel was so large a part of the logistics footprint of any expeditionary force (as early as 1999 the big Army exhibition in Washington made this point very forcibly). Perhaps the most important thing about IMG's FTTS program was that Plasan was the armor partner. IMG's FTTS program culminated in a display in the Pentagon. Everyone who saw IMG's FTTS wanted to know whether that was what the company was offering as its MRAP vehicle bid. In fact, Wolverton was not part of the company's MRAP vehicle effort, but he soon joined it. He began to study the physics of under-body explosions, and he became familiar with Casspir and with other South African vehicles. They were far too heavy to qualify as FTTS candidates. By way of contrast, he learned that the emerging MRAP vehicle program had no concern with weight; it could tolerate 40,000 to 60,000-pound vehicles. He left FTTS to join the MaxxPro program.

¹⁸ Often it is said to have been glued into place, but that was not the case. They used a leak-proof and waterproof sealing agent called Sycaflex.

¹⁹ Only Navistar officials witnessed the test, because the Plasan engineers were not U.S. citizens.

²⁰ Plasan's armor production capacity was limited because it produced its armor in an autoclave. Navistar became convinced that armor could be produced instead in a press, which offered much greater productivity. That became urgent when the company ramped up production. Navistar invested to replicate process and material, and got the result certified. It almost came to legal blows with Plasan, but the two companies worked out a solution in which Plasan provided half of Navistar's armor and accepted that the other half would be Navistar's outside purchases using its (Plasan's) capsule design. This was not just armor for the vee-bottom, but all of the armor in a truck. In Navistar's view, much of Plasan's later success—for example with the M-ATV—came out of its success with MaxxPro. For its part, Plasan was glad to design a protective capsule and supply its boltable armor, but it would not transfer its technology, including its design techniques. In effect, Navistar licensed production but nothing more. That is why it changed direction when it competed for M-ATV. Massicotte interview. Because the Israeli government was involved in the business end of Plasan, the U.S. government asked whether it could accelerate production. It could not do so sufficiently to meet Navistar's schedule. Navistar had to find an alternative supplier, which Plasan willingly certified, although it did not have to.

²¹ Slides to support decisions on IMG MRAP LRIP CAT I and FPI Sole Source CAT III, undated but internal dating of the PowerPoint file shows it was created on 20 March 2007 and modified on 23 May 2007.

²² The threshold was \$2.493 billion, of which \$1.323 billion had been spent. The LRIP 4 CAT I cost of the 1,200 vehicles was \$1.03 billion.

²³ As Archie Massicotte remembers it, he was willing to go on a handshake for the 1,200 vehicles because he knew whom he was dealing with, he knew that it would be all right, and that the funds would eventually catch up. He had to tell his Board to trust him, and the funds took longer than expected. However, he was right: the situation was resolved properly. Kevin Fahey, the Army's PEO, once told Massicotte that he liked him because he was not a typical defense contractor. A typical contractor would negotiate first, produce second. Navistar would go for an undefinitized contract, build its vehicles, and clean up the contract later on. Massicotte found that painful, because it tied up the company's money for a long time. It might not have been possible in a program he found less vital.

²⁴ By this time there were three versions: MaxxPro, MaxxPro Plus, and Dash. All were CAT I. The original MaxxPro weighed 43,500 pounds, the Plus version 53,000, and Dash 49,000, with a slightly lower center of gravity and a reduced turning radius (54 vice 62 feet). Dash had been conceived as a high-mobility version for Afghanistan. As of December 2008, a total of 5181 MaxxPros was scheduled for delivery to theater, but the ultimate total planned for all versions in theater was 6024. The first order for 1200 vehicles was awarded on 31 May 2007, followed by one for 755 on 20 July 2007 and the LRIP 9 order for 1000 on 18 October 2007 and by the LRIP 10 order for 1,500 on 18 December 2007. The 2008 orders were LRIP 11 (743, 14 March), LRIP 12 (four CAT I test vehicles), and LRIP 13 (822 Army Dash, 4 September 2008). Another chart showed 2955 MaxxPro, 2247 MaxxPro Plus, 822 MaxxPro Dash, and 16 CAT II test vehicles (LRIP 5). Of these, nearly all were for the Army (200 MaxxPro and 211 MaxxPro Plus were for the Air Force). There were six test vehicles for each of MaxxPro and MaxxPro Plus, and seven for Dash. MaxxPro Plus included 507 ambulances.

²⁵ The next version was MaxxPro MEAP. While MEAP was being developed, a better means was found to improve MaxxPro protection, so production shifted immediately (in LRIP 10) to MaxxPro Plus (1,736 vehicles and four test vehicles). There was also an ambulance version (505 vehicles and 2 test vehicles). The requirement for greater agility led to a weight reduction program and also improved maneuverability. The payload increased, too. The result was MaxxPro Dash (1215 vehicles, 7 test vehicles). The final production version was MaxxPro Dash with independent suspension system (ISS) (1,225 vehicles). Production ended with LRIP 19 (March 2008). After that LRIP 20 bought 240 MaxxPro Recovery Vehicles and ten test vehicles. Of the total of 7,899 vehicles (excluding the 16 CAT II test vehicles), the bulk went to the Army (7,217), which lent 20 to the Marines; the Air Force operated the remaining 412.

²⁶ Massicotte interview.

²⁷ Massicotte interview.

²⁸ Buffalo was the only CAT III truck, and by far the heaviest at 84,000 pounds (the 1A version bought as CAT III weighed 80,000 pounds). As of August 2007, acquisition objectives were 286 Army, 62 Marine, and 1 JIEDDO vehicle, of which the Army had received 92, the Marines 19, and JIEDDO none. The truck had an extendable arm with an attached rake/probe, which could be manipulated using a television camera on the arm. A status sheet indicated changes such as a spall liner (to protect those inside from an external blast), relocation of the Chameleon jammer to the outside of the vehicle (to keep it from blowing around inside after an explosion), and a tow bar retrofit. The Army was developing a package to protect against explosively formed projectiles, and an up-armoring kit was needed. The MRAP program continued the ongoing Buffalo program with an initial sole-source contract plus an LRIP 4 contract in 2007, and then LRIPs 11, 12, and 13 in 2008. The sole-source award closed out Mk 1 production with four vehicles designated HST, followed by 58 Mk 2 A1. LRIPs 11 and 12 (March and July 2008) bought another 13 Mk 2 A1 and then LRIP 13 bought 8 Mk 3 A2. Buffalo was built on the chassis of the Mack Granite truck, which by 2007 was out of production, with stocks declining. Buffalo production was pursued urgently so as to make sure that enough vehicles could be built.

²⁹ Thus the CAT I (A1) vehicle is 2355-01-552-5565; CAT I (A2) is 2355-01-554-3420.

³⁰ The production contract was with FPI.

³¹ A chart in the December 2008 Program Review reports a ceremony to mark the completion of production; another chart shows 2,016 vehicles, including 5 LRIP 13 test assets to be made in CY09. Another chart shows 1841 in theater, of which 3 were battle losses. The 2,016 figure appears not to include legacy vehicles. At this point there were 1037 CAT I and 814 CAT II vehicles in Iraq, 458 CAT I and 20 CAT II vehicles in Afghanistan, and 55 CAT I and 11 CAT II vehicles in Kuwait (these totals presumably include legacy vehicles, since they considerably exceed the production figure). There were also 141 CAT I and 57 CAT II MRAPs, JERRVs, in U.S. Northern Command and 15 CAT I and 6 CAT II MRAP vehicles and JERRVs in U.S. Pacific Command. The Northern Command figure presumably includes test articles and vehicles awaiting shipment.

³² FPI tried very hard to outgrow the perception that they were a “mom-and-pop” organization. Reportedly Garth Barrett left the company (to found PVI) over exactly this issue; he did not want the company to grow, and preferred licensing production. Some perceptions did not change: long after FPI had upgraded its accounting system, some people still lamented that it did its accounting with “QuickBooks.”

³³ Although it developed an elaborate quality control plan, FPI often had no quality manager, and it would have been disqualified from any more deliberate program. Vee-bottoms and upper body parts were made separately, and typically they did not quite match. Putting chains around the combination of vee and upper body solved the problem, and squeezing the vee until it met the flat sides of the upper part of the body. The combination was spot-welded, the chains were removed, and the body was fully welded together. This seemed horrifying, and it seemed obvious that so much stress had been locked into the body that it would spring apart if the vehicle were subjected to an under-body attack. In fact nothing of the sort happened; Cougars survived as well as other MRAP vehicles. Their main drawback was the lack of standardization: no rear door from one Cougar could be relied upon to fit another. There were cracking problems in 2008-9, but other more conventional designs also had them. Cougars did suffer from substantial cracks around brackets used to mount jammers and also around

windshields, because the latter were rigid and therefore caused concentrations of stress. When Cougars were in Detroit, a fixture was built to replace the chains, but the vee bottoms were still too wide, and they still had to be forced to fit the upper body parts. Livingston interview.

³⁴ An MRAP vehicle program chart of “MRAP pedigrees” produced in 2011 divided Cougar production by Service, category, and version (A1 and A2). These numbers appear not to include the initial sole-source contract. The change from A1 to A2 entailed: raising the roof 7 inches to allow for greater seat movement in a blast; AFES; cantilevered seats; T-Case restraint; and a modified floor plate. The CAT II version added provision for CASEVAC. LRIP 1–10 bought 1,812 CAT I A1, 186 CAT I A2, 829 CAT II A1, and 191 CAT IIA2 vehicles. That amounted to the great bulk of Cougar production under the MRAP program. In 2010, 53 CAT II A2 were converted into ambulances.

³⁵ Armor Holdings received its first MRAP vehicle production award the day that BAE bought the company. As with the other BAE operations, this one did not change once it was acquired; it retained its personnel and its corporate culture. The former Armor Holdings organization at Sealey, TX produced manuals far better than those produced at York for RG-33, and late in the program the MRAP JPO tried to contract with them and with a new facility near Detroit for the relevant manuals. By then the Caimans were being retired, so the effort was dropped.

The company began as Stewart & Stevenson (S&S), which became a major supplier of electric generators. In 1991 it created a Tactical Vehicle Systems (TVS) division to obtain an initial award for the Army’s Family of Medium Tactical Vehicles; it received an 11,000-vehicle contract that October. To build trucks (which the company had not previously done), S&S bought its Sealey, TX, manufacturing facility, where it later made Caimans. FMTV is a series of 2 1/2 and 5-ton trucks in about 15 versions with considerable commonality. Armor Holdings bought TVS and other parts of S&S in 2005; the company was acquired by BAE in August 2007.

³⁶ As per the fact sheet in the MRAP Program 2011 “Smart Book.”

³⁷ Garth Barrett founded PVI when he left FPI. It was based near SPAWAR in Charleston. Golan had a combination of reactive armor blocks on the sides and cage armor (to resist RPGs) over the windows. Golan weighed 36,000 pounds and had a Cummins QSB8.9 diesel engine with automatic transmission and a 400-amp alternator. It could accommodate 8: two in the forward seats and six passengers.

³⁸ It had a Cummins QSB6.7 diesel engine and a 400-amp alternator. Seating was provided for 6: 2 forward, 4 in the main compartment.

³⁹ Bushmaster weighed 33,950 pounds and was powered by a Caterpillar C-7 6-cylinder diesel (330 HP); it had a 300-amp alternator. It could seat 10: a driver, co-driver, and 8 passengers. It is not clear what the complaint about size meant, since at 282 inches in length Bushmaster was somewhat shorter than a CAT II Cougar.

⁴⁰ The rapid test technique had a weakness, in that the single vehicle sent for such tests could be a lemon. One of the testers said as much, but then pointed out that in a program like this all the vehicles delivered had to work as delivered. If there was one lemon, there could be many more.

⁴¹ Like many wheeled armored vehicles, the Textron armored car had sharply angled sides, which increased the effectiveness of its armor. This angling may have suggested to some that it had the anti-mine efficacy of a vee-hull, but that was not at all the case. As submitted to the MRAP competition, the Textron vehicle weighed 34,160 pounds. It was powered by a 260 HP Cummins 6CTA8.3 diesel. Seating was provided for 4: 2 forward and 2 passengers, which meant that it lacked the space in other CAT 1 competitors, which typically seated 6.





CHAPTER 7

MRAP PRODUCTION

The MRAP vehicle program office decided to buy a thousand vehicles (\$1 billion) at the outset, not the least to energize industry. Initially Dr. Etter, the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN RDA), opposed so large a purchase, on the grounds that smaller proof-of-concept purchases should be made. Lieutenant General Gardner USMC favored the large buy and was able to convince Dr. Etter to proceed. He was then Principal Deputy Director, Cost Assessment and Program Evaluation, Office of the Secretary of Defense (OSD), and he had been an early proponent of MRAP vehicles.

Five Vendors

Ultimately only five vendors provided trucks that satisfied survivability/mobility and quick delivery criteria from the initial RFP: BAE Ground Systems Division (GSD); General Dynamics Land Systems-Canada (GDLS-C) (to build vehicles designed by BAE OMC in South Africa); Force Protection Industries Inc. (FPI) (also licensed to General Dynamics); IMG (which became Navistar Defense); and Armor Holdings (bought by BAE on 31 July 2007, which would become BAE Tactical Vehicle Systems (TVS)). The last three built the bulk of the vehicles. IMG, which began as the defense arm of Navistar (owner of International Trucks), developed a new plant capable of producing 1,200 to 1,500 vehicles per month. In August 2007 the program office estimated that maximum monthly production from all five companies was 1,300: 500 to 600 from IMG; 300 from BAE GDS; 300 to 400 from FPI; 400 from Armor Holdings; and 300 from GDLS-C. The initial IDIQ allowed multiple production orders per vendor for up to 4,060 cumulative MRAP vehicles. By the end of 2007, three more low-rate initial-production (LRIP) contracts had been awarded (LRIPs 9-11). At this time the overall target was 1,200 vehicles per month. The first MRAP vehicles contracted by the JPO were fielded in Iraq in April 2007. By August, a total of more than 6,000 were on order, and scheduled deliveries ramped up from nearly 1,200 in December 2007 to more than 1,500 in January 2008. (Appendix C provides more details of the various MRAP LRIP buys.)

A sixth vendor, Oshkosh, failed to win follow-on MRAP vehicle orders in the initial competition but built all of the M-ATVs described in a later chapter.

LRIP 1 and 2 awards predated completion of testing. They were distinct from the 244 vehicles ordered from FPI on a sole-source basis (200 CAT I and 44 CAT III); the sole-source contract later supported purchase of 14 more CAT IIIs. LRIP 1 (27 January 2007) amounted to another 65 CAT I and 60 CAT II from FPI, and 15 CAT I and 75 CAT II from BAE.¹ LRIP 2 (21 February 2007) amounted to 60 CAT II from PVI, 100 CAT I from Oshkosh, and ten CAT I and 10 CAT II from GDLS-C, a total of 395 vehicles.

Most of these contracts were let for more or less established vehicles that might be expected to be more or less satisfactory, the object being to promote production facility expansion. In the remaining case, PVI (which had reactive armor), the object was

to support a vehicle expected to be able to defeat more advanced IEDs. Neither the Oshkosh nor the PVI vehicles progressed any further. As noted in the previous chapter, both the Oshkosh and PVI vehicles were not as established as those offered by FPI, BAE and GDLS-C. PVI went bankrupt trying to solve problems revealed by tests, and the Oshkosh vehicle had performance issues that made it less competitive. Exclusion of these vehicles reduced the LRIP 1/2 purchase effectively to 245 vehicles from FPI, BAE, and GDLS-C. Note that although it was a new design, BAE's RG-33, tested at APG, was considered an established vehicle because it had been designed by OMC, the successful designer of the established RG31 offered by GDLS-C.

The first post-test award was LRIP 3: 1,000 vehicles (772 CAT I and 228 CAT II) from FPI (20 April 2007). This quantity was approved specifically to enable the program to maintain the build-up of production rate (and capacity), and to justify long-lead purchases that might be available from limited sources. That presumably applied to the chief bottlenecks encountered later: armor; special run-flat tires; and heavy-duty axles.²

At this point the Army was becoming more interested in the MRAP vehicle program. The Marines were still running the program, but the Joint (rather than Marine) Requirements Oversight Council (JROC) was setting its goals. The program office was aware of potential requirements for more than 4,000 vehicles by the time that the indefinite delivery/indefinite quantity (ID/IQ) contracts were awarded in January. The production "ceilings" for those awards were designed to support a potential award to a single contractor for all 4,000 vehicles. That is not the way it worked out, but that is the context. A 25 May 2007 acquisition decision memorandum, referring to a 10 May 2007 JROC memorandum, set a new requirement for another 1,200 vehicles, bringing the projected total to 2,595, in addition to the earlier sole-source contract for 244 vehicles from FPI. At the same time another 14 FPI vehicles were added to the sole-source contract, so the total of MRAP vehicles under contract since November 2006 would be 2,853. As before, the increase was needed to maintain the ramp-up of production: ultimately a lot more MRAP vehicles would be needed. This LRIP bought the first 1,200 vehicles from IMG (later Navistar), which turned out to be one of the single largest MRAP vehicle producers, along with Oshkosh.

LRIP 5 (approved 12 June 2007) was for 455 more vehicles from FPI (395 CAT I and 60 CAT II) and 16 CAT II (for tests) from IMG (12 June 2007).

LRIP 6 (approved 26 June 2007) was 441 from BAE (425 CAT I, 16 CAT II). LRIP 7 (11 July 2007) was initially 1,162 CAT I and eight CAT II from Armor Holdings and 755 from IMG. Shortly after the LRIP 7 quantities had been set (13 July) they were revised, because the Joint Allocation Distribution Board allocated the LRIP 6 vehicles to the Army and SOCOM. The Army asked that all 255 of its CAT I vehicles be delivered instead as CAT II. To ensure that there would be enough test assets, the JPO asked (and Dr. Etter approved) reallocation of the Armor Holdings vehicles under LRIP 7 as 1,154 CAT I and 16 CAT II. The LRIP 6 award to BAE was changed to 170 CAT I and 271 CAT II. All of this was easy to do using ID/IQ contracts. With normal contracts specifying particular quantities, the simple action taken on 13 July would have likely entailed protracted contract renegotiation.

LRIP 8 (6 August 2007) was 600 CAT I from GDLS-C and 25 CAT I and 100 CAT II from FPI—a total of 6,415 vehicles was then under contract. As a measure of the economics of the Joint MRAP Vehicle Program (JMVP), which had come into being at this point, the vehicles were expected to cost \$1.208 billion apart from GFE, which would account for another \$688 million. Logistics support would cost another \$551 million. The ratio of GFE to basic vehicle cost suggests how sophisticated these vehicles were: GFE was the electronics and other equipment added at outfitting time. At this point the object was to field as many adequate vehicles as possible and also to grow the industrial base; orders were based on monthly production capacity (to keep production lines hot), on the date when the next-phase test results would become available, and on manufacturers' lead times.

LRIP 9, the first FY2008 order (18 October 2007), cut the original five manufacturers to three: IMG (later IMG/Navistar); FPI; and BAE. This called for 1,000 CAT I from IMG, 800 from FPI (553 CAT I and 247 CAT II), and 600 from BAE (89 CAT I, 399 CAT II, and 112 CAT II ambulances). This sufficed for the desired 1,200 per month, with another order due in December (LRIP 10, 18 December 2007). It left BAE-TVS (ex Armor Holdings) with planned deliveries of 300 per month in January and February 2008, but none afterward, so the JPO added that company back into the mix in LRIP 10 (668 CAT II vehicles). The other three builders received repeat orders: 1,500 CAT I from IMG, 358 from FPI (178 CAT I, 180 CAT II), and 600 CAT II from BAE. LRIP 9 and 10 sufficed to maintain deliveries of 1,200 vehicles per month through April 2008. By this time GDLS-C was in trouble meeting orders. The challenge with GDLS-C was

that they would not consider any change from their standard way of doing business in order to meet the accelerated schedules and vehicle evolution. Overall, LRIP 10 was the largest order to date; it was intended to cover deliveries from May through July 2008. During the drafting of LRIP 10, however, the Marines and the Air Force reduced their MRAP vehicle requirements.

MRAP 1.5

Meanwhile the perceived threat changed. Once the Army was a major participant in the program, its experience with the explosively formed penetrator (EFP) threat changed the program. The Army Research Laboratory (ARL) had already developed a new armor to deal with EFPs. It had already been applied to Humvees, but they could not readily accept the weight involved. Indeed, the Army's experience that Humvees could accept some EFP protection may have shaped its early attitude towards the MRAP vehicle program, which at the outset concentrated on the under-belly threat the Marines faced.

By late 2007 the JMVP could envisage vehicles protected against both under-body IEDs and EFP IEDs. EFP protection was heavy, so vehicles were redesigned so that they could mount slabs of standoff protective material described as the MEAP (MRAP Expedient Armor Protection) suite, in which a massive box of special protective material is held at a short distance from the vehicle body. The standoff protection was called an "A-Kit"; all vehicles beginning with LRIP 10 had provision for it. There were plans to provide each vehicle with either vendor-produced or GFE armor kits. Because the EFP armor was not integral with the vehicle, vehicles were delivered fitted to accept it but generally not with it already installed. Anti-EFP armor was heavy, because it had to absorb the very considerable energy with which a penetrator struck. Initially that meant 250 pounds per square foot, and many square feet of vehicle had to be covered. This was the sort of weight that tanks carried, and even then only over limited areas.³ The goal was to find materials which could absorb energy so much more efficiently that they might weigh as little as 100 pounds per square feet, but that did not prove possible.

Initially vehicles were given small patches of the new armor. It was soon clear that they could not easily handle the additional weight, and axles began to fail. LRIP 10 incorporated numerous ECPs to improve performance despite the increase in weight,

mainly in the form of improved suspension and power train. Other improvements included increased alternator power and an automatic fire extinguishing systems (AFES).

It was not enough simply to provide a slab of anti-EFP protection outboard of the troop compartment. The enemy became aware that this material stood away from the side of the vehicle, and that there were gaps in protection. It is not clear to what extent successful attacks reflect the enemy's own ability to analyze evolving protection, or were simply (un)lucky hits. However, it does seem clear that in some cases the enemy shot high to get over the side protection. The unattainable ideal was 360-degree top-to-bottom protection.

The initial MEAP version of the MaxxPro weighed 53,000 pounds but had no major suspension upgrade, so the extra armor consumed the vehicle's payload. Navistar developed a lighter form of EFP protection, which was quickly incorporated in a new version of its vehicle, MaxxPro Plus. Like MaxxPro, MaxxPro Plus weighed 53,000 pounds (64 mph, 67.2-foot turning circle), but its protective kit was reduced to 8,000 lbs, leaving it with more payload. To support the extra weight, it had an upgraded DT 570 engine and heavier-duty axles (23,000 pounds front and 30,000 pounds rear instead of the earlier 19,500 pound type). MaxxPro Plus went to 30,000-pound axles (and to 4x4 drive) as its total weight increased to 80,000 pounds. MaxxPro Plus was the main MRAP vehicle delivered with MEAP, but all of the others were modified by engineering change proposals (ECPs) to accept it.

Once the Plus had been designed, Navistar looked at its available internal volume and designed an ambulance version, which the program office did not yet want. Navistar talked to them and to the medical people and fitted out a Plus as an ambulance at its own expense. They won an award for 505 MaxxPro Plus Ambulances.

Like MaxxPro Plus, RG-33L Plus had 23,000-pound axles instead of the earlier 19,500-pound type. The CAT II Plus version of RG-33 has EFP armor on its side, which increases its combat weight from 50,835 to 71,095 pounds. Width increased from 113 to 134 inches, since the EFP armor was in boxes spaced away from the side of the vehicle. To accommodate the extra weight, the engine was upgraded to 450 HP, but speed fell to 65 mph and turning diameter increased to 86.4 feet. These figures explain why adding the EFP threat so seriously overloaded vehicles. Ambulance versions had a motorized litter-lift forward and a folding ramp for loading patients. The Plus version of the

ambulance differed from the Plus version of RG-33L in having new tires and wheels and heavier axles with new shocks. It also had a longer folding ramp than the base version.

Cougar CAT II (A1) was adapted to take EFP armor and AFES. The CAT II (A1) version had the same engine as CAT I, but it weighed 40,000 pounds and speed thus reduced to 55 mph. Turning circle increased to 64.6 feet. With boxes of anti-EFP armor hung outboard of its body, this vehicle weighed 49,540 pounds. As with CAT I, the A2 version had the 7-inch higher roof. These vehicles seat ten: driver, co-driver, and eight crewmembers. The ISS version weighs 51,500 pounds. It has increased capacity springs, improved seats, improved internal ballistic protection, provision for installation of EFP armor, and AFES. The ISS change was one of 19 listed for LRIP 10 Cougar CAT Is and IIs.

The new version of Caiman was Caiman-Plus (M 1230), with increased payload, EFP protection, upgrades to the chassis, a door assist system, and improved crew seats. It had 16 unique modifications (ECPs) including “Mama Bear” EFP protection hung outboard, chassis upgrades to frame, 19,000-pound axles, brake wedges, a door assist system (to make it easier to get out of a rolled-over vehicle), a fuel shut-off valve, rear and side step improvement, fuel tank improvement (self-sealing plus automatic fire suppression [also for the cabin]), improved crew seats, a backup alarm, aluminum wheels and Goodyear run-flat tires, and LED lighting. It had a new 570-amp alternator and a three-piece belly plate. This version was based on the current production (2009) FMTV A1R chassis. The upgraded C7 engine produced 330 HP. Weight increased to 62,000 pounds. Width increased from 96 to 121 inches.

There was no operational anti-EFP version of RG31; all RG31s were deployed to Afghanistan, where EFPs were not encountered.

Vehicles designed to resist both forms of unconventional attack, under-body *and* EFP, can be described as MRAP 1.5, something beyond the original MRAP vehicle concept. EFP protection was introduced in LRIP 10 (18 December 2007). LRIP 10 bought 1500 CAT I vehicles from IMG (modified MaxxPros and then MaxxPro Plus), 358 from FPI (178 CAT I and 180 CAT II Cougars), 600 from BAE (RG-33L Plus), and 668 from Armor Holdings (CAT II Caiman-Plus). Overall, it was the largest order to date, intended to cover deliveries from May through July 2008. During its drafting, the Marines and the Air Force reduced their MRAP vehicle requirements.

The following year's LRIP 11 essentially ended Caiman production with 1024 more CAT II vehicles. LRIP 12 bought a pair of test vehicles for an upgrade program. Improvements included a 450 HP Caterpillar engine, upgraded air conditioning, improved seats, and enhanced underbody survivability. By December 2008, 2815 Caimans had been produced; 1,170 had been delivered by April 2008. A contract for 1,700 Caiman upgrade kits was let in August 2010. One of the two test vehicles became the prototype for a Caiman ambulance, and nine vehicles were converted.

The JPO clearly saw LRIP 10 as an interim step; it envisaged an anti-EFP vehicle designed as such, which it called MRAP II. LRIP 10 included 12 MRAP II test vehicles (six CAT I each from BAE and Oshkosh, the latter teamed with Ideal Innovations) at total costs, respectively, of \$5.2 million and \$17.6 million.

MRAP Improvement Program

ECPs for an MRAP Improvement Program were tested between late 2008 and mid-2009. For Cougar they were: improved lighting (dome lamps); power receptacles and a back-up alarm; AFES; an improved independent suspension system (ISS); blast mitigating floor matting; steering assist; Internal Ballistics Protection Module IBPM (with Kevlar blanket); removal of gun ports and rear gun stowage (done in all MRAP vehicles except some SOCOM variants, when it was realized that troops did not fire their rifles from the vehicles, and that rifle ports were potential weak points in protection (not to mention the toxic fumes generated from weapons fired inside a vehicle); mounting provision for EFP protection; fuel tank fire protection; upgraded seats and seat belts; a 570-amp alternator with APU (auxiliary power unit); the extra seven inches of headroom (roof height extension); a transfer case cover; a floating floor; improved front and rear tow points; and an improved heating, ventilating, and air conditioning (HVAC) system. This list was apparently typical of MRAP vehicles. Cougars in particular were criticized for poor internal arrangement, and presumably there were also rearrangement ECPs.

The corresponding list for MaxxPro at the same time included the beefed-up axles and upgraded springs, a similar upgraded alternator, hydraulic boost on the rear ramp, an enhanced transmission, a new grill configuration, increased engine power, provision for casualty evacuation, front disc brakes, upgraded batteries, dual steering gear, and a dual actuator for the front door assist mechanism. For the 6x6 Caiman, the corresponding

ECPs include: redesigned ladders; rear spring upgrades; improved rear braking (12 degree brake wedges); new lightweight wheels (aluminum instead of steel); improved seats; LED interior lighting, an upgraded front axle (14.7K increased to 19K pounds) with air over hydraulic brakes; the upgraded alternator; door assist; a cabin and engine automatic fire suppression system upgrade (AFSS); and improved fuel tank protection.

For RG-33L, the corresponding ECPs included: the upgraded alternator; a new rear suspension; 5-point seat belts; new ballistic windows; EFP mountings; a ring turret adapter; new 16R20 Michelin XLZ tires; new axles (with belly armor adapted to them); and AFSS).

MRAP II

Like many other programs that in retrospect were clearly spiral-developments, this one tried to graduate from modifying earlier models (a spiral) to developing wholly new ones (what it called MRAP II).⁴ Conceived in 2007, the vehicle was intended particularly to deal with a perceived heavy-EFP threat. At this time the EFPs seen in theater were mostly small and medium, but more numerous and larger ones were predicted. The question was how much of a threat MRAP vehicles should be able to survive. The larger the EFP, the more difficult it was to move and to produce, so it could reasonably (in the end, correctly) argued that there was a practical limit to the problem—any really large EFPs would be few and far between.

Unlike an MRAP vehicle with add-on armor, MRAP II was expected to have much more complete protection against EFPs, though it was recognized that the ideal 360-degree protection was unattainable. As such it had to be much heavier (greater than 80,000 pounds) than an MRAP truck, which was already a very heavy vehicle. The larger the EFP a vehicle had to survive, the more massive the vehicle. MRAP vehicles were useful only to the extent that they could move troops into position; the larger ones were already too big to operate in urban areas. The test process was somewhat different from that for the original MRAP vehicles. Each offerer's armor "coupons" were subject to various attacks, including EFPs. As before, if the coupons passed the tests, then the vehicle was blasted. Costs were compared on the basis of a notional production run of 4,100 vehicles per year, for a total of 20,500.

Competitors were a mixture of earlier MRAP offerors and new ones. The RFP was released on 31 July 2007, with proposals due on 1 October. As before, the offeror had

to have a prototype vehicle. The JPO asked for both CAT I and CAT II versions. The bidders were:

- FPI with its Cheetah (CAT I). This was a new 4x4 design, which the company described as more agile than its predecessors. It carried a slab of standoff material (anti-EFP) covering the lower side of the passenger compartment and the upper part of the rear wheels. Cheetah was the smallest of the entries, with a projected production cost about half that of any other.
- I3/Oshkosh/Ceradyne with its Bull (CAT I and CAT II versions). I3 was Ideal Innovations Inc. and Ceradyne was a consulting firm. Oshkosh would have been the manufacturer. Both versions of Bull were 6x6, the CAT II version being distinguishable by its longer passenger compartment (three rather than two windows on each side). The slab of MEAP stood away from the body of the truck, but the gap between slab and body was covered by angled steel sheets (presumably covering slabs to seal off the gap).
- BAE with both a Caiman variant and RG-33E as its CAT I and CAT II entries. Its Super Caiman was literally wrapped in bar armor, the only vehicle in the competition so protected. RG-33E had the usual standoff layer of MEAP, in its case tall enough that it needed windows at the top.
- PVI with a version of the Golan that had been part of the original MRAP competition. A photograph appears to show a mounting rail for EFP protection running the length of the passenger compartment. As in the original competition, there were no side doors.
- Blackwater with CAT I (4x4) and CAT II (6x6) versions of its Grizzly. Blackwater was a security firm trying to enter the protected vehicle field. Its Grizzly had a distinctive inward- and outward-sloping side, which met what appeared to be vertical slabs of EFP-protection armor over the engine and the lower side of the passenger compartment. Its vehicles had distinctive engine exhausts led over the side of the roof, and what looked like single-seat driving positions centered on the vehicle.
- IMG with its MaxxPro (CAT I). Navistar's bid was rejected before the prototype stage (Navistar doubted that MRAP II would ever be bought in quantity, and the bid may not have been very serious).

- Tahrach-NABI with a new CAT II vehicle, FAMP(V).

Armor coupons were submitted by all bidders but IMG, which did not expect MRAP II ever to materialize. Evaluations showed that I3 was by far the best, with BAE's vehicles distant seconds. Nothing else approached the quality of these two entries. A summary of technical evaluations showed them the only acceptable ones. The two Blackwater vehicles were rejected for lacking important forms of protection.

The JPO decided to buy six CAT I and six CAT II vehicles each from the best two competitors, BAE and I3/Oshkosh/Ceradyne, plus 20 armor coupons each (except that it did not need 20 for the I3 CAT II, because they were the same as those in the CAT I design). Bull was massive, even larger than Buffalo, and very survivable, but also very slow and virtually unmaneuverable.⁵ BAE's Super Caiman resembled a conventional Caiman surrounded by screens of bar armor. On 18 December 2007 the JPO let six-vehicle contracts for only the two CAT I competitors, Bull and Super Caiman. I3 (but not Oshkosh) was new to the JPO, and BAE had had difficulties producing its vehicles, so the JPO seems to have been relieved when the project died.⁶

The JPO also decided to offer to accept updated proposals and coupons from PVI (CAT I), Blackwater (CATs I and II), and FPII. The armor solutions offered by all three failed to defeat the anti-armor threat, presumably the EFP (but possibly an RPG), and they were told that any superior armor solution would have a ripple effect on the vehicles—that is, the vehicles could not carry greater weights. Nothing came of the offer for further discussion, possibly because the entire MRAP II program did not last much longer.

By the time the two prototypes had been built, the forces in the field were more interested in agility and mobility, and the JMVP was developing lighter-weight versions of vehicles such as MaxxPro Dash.⁷ The program had to contend with political “interest” from the district in which one of the MRAP IIs was being built.

Overall, MRAP II was not so much better than a modified MRAP to be worthwhile. Although the smaller vehicles had reduced payloads when given EFP protection, they were expected to be easier to handle and capable of negotiating worse terrain without rolling over. They were also expected to operate more easily in dense urban areas. MRAP II illustrates the extent to which spiral development conflicts with the normal view that only something completely new can be fully satisfactory.

The program was well into source selection before it was realized collectively that MRAP II was not wanted. Attention turned to smaller and lighter vehicles, particularly as emphasis turned from Iraq, with its good roads, to Afghanistan, with almost no roads at all. That was when Navistar produced the MaxxPro Dash, and why RG31 made a comeback. At the beginning of 2008 production had ended, but two months later RG31 was wanted again because it was so well suited to tight places. The Marines and the Engineers took Cougars. This reorientation was the origin of the M-ATV program. The progression from Dash and the existing vehicles to M-ATV reflected the way the program worked: “Give me what you have NOW, then source-select for what is really wanted!” (M-ATV is discussed in a later chapter.)

Further Production

LRIP 11 (14 March 2008) was intended to buy out all Service requirements except the Army’s (stated as 10,433 to 15,884 vehicles, the JROC having approved an “interim” requirement for 12,000). At this time the Marines needed only 11 Buffaloes, the Air Force 89 vehicles, and SOCOM 24. The remaining ballistic test vehicles were ordered, plus replacements for the 30 vehicles previously diverted to tests. As placed on 14 March 2008, LRIP 11 amounted to 2,243 vehicles.⁸ The planned SOCOM vehicles were not ordered because source selection was not yet complete. JROC had just added a requirement for 11 recovery (wrecker) versions of the SOCOM vehicle, and on 2 May an order was placed for 40 SOCOM AUVs: 24 vehicles; three test vehicles; 11 wreckers; and two test wreckers, all from BAE.⁹

LRIP 12 (17 July 2008) bought 801 combatant and 24 ballistic test vehicles, the latter to test ECPs and also protection against EFPs. Most of the combatant vehicles were RG31s from GDLS-C (771 CAT II) and 30 BAE RG-33s for SOCOM. The test vehicles were bought from all five manufacturers: BAE (six SOCOM CAT I, two CAT II, and two ambulances); BAE-TVS/Armor Holdings (two CAT II in CAT I configuration with upgrades and EFP kits); FPI (two CAT I, two CAT II, and two CAT III without EFP kits); GDLS-C (two CAT II); and Navistar (two CAT II and two ambulances).¹⁰ CENTCOM had already expressed a preference for a more mobile variant of the existing production vehicle (rather than the proposed MRAP II, which was decidedly less mobile), and the approval memorandum for LRIP 12 recommended that the JPO conduct a technical evaluation of the existing production vehicle versions to decrease

their turning radius, increase their power-to-weight ratio, and reduce width and height, all without reducing their inherent protection. Contract awards for modified vehicles for ballistic testing were to be ready in time for delivery orders to be placed by 1 September 2008, i.e., in time for LRIP 13.

By this time the earlier requirement for a lighter and more agile MRAP was being met in the form of MaxxPro Dash. Thus LRIP 13 (4 September 2008) consisted mainly of 822 MaxxPro Dash (seven for test), plus five each of the earlier FPI (Cougar) and GDLS-C (RG31) vehicles, presumably also for tests. This LRIP also covered a slightly later purchase of 16 Buffaloes. This latter order was delayed pending a new long-term contract. Meanwhile, SOCOM vehicle requirements changed, so eight of the Buffaloes were replaced by eight BAE SOCOM vehicles (RG-33s), as indicated in a 31 March 2009 memo. The Marines agreed to give up eight of the 16 Buffaloes originally allocated to them. This change was made possible by the system of ID/IQ contracting. It did create major funding issues, though.

LRIP 14 (10 December 2008) consisted of 400 MaxxPro Dash. That was in addition to ECPs to upgrade existing vehicles.

LRIPs 15 and 16 and parts of LRIPs 17 and 18 were devoted to the new M-ATVs described in a later chapter.

Purchases of earlier MRAPs continued, albeit at a slow pace. In addition to M-ATVs, LRIP 17 included 1050 MaxxPro Dash, 58 Caimans and 250 RG31s. LRIP 18 included 32 RG-33s for SOCOM and 70 (later reduced) for the Army.¹¹ LRIP 19 included 175 MaxxPro Dash, with 250 MaxxPro Dash ambulances included in LRIP 19.¹² A final 471 Dash (with independent suspension) were bought under LRIP 21 (1 June 2011). The MRAP wreckers (MRVs) were bought under LRIP 20 (19 November 2010: 250 of them) and under the final LRIP 23 (12 July 2011).¹³

Vehicle deliveries determined what was required of the rest of the pipeline, including vehicle integration at the SPAWAR Charleston facilities and shipment overseas. Deliveries increased from 169 in August to 842 in November and then to 1,187 in December 2007. Experience at that time suggested that 1,200 vehicles per month was not merely a goal but also a practical upper limit for the pipeline, and the JPO had to stretch out some planned deliveries to stay within that limit through early 2008. A projected spike in January (which would have seen 1,370 deliveries) was reduced by

shifting some planned Caiman deliveries so that more Army FMTVs could be produced.

At the outset, then, there were five parallel production lines. That was complicated enough, but each family of vehicles underwent rapid spiral development, so that, say, LRIP 5 of Navistar's MaxxPro was quite different from LRIP 11 or 13. There was little configuration control. As a consequence, even nominally equivalent trucks from the same manufacturer were not identical, because commercial manufacturers considered many components equivalent. There might be 15 different wipers, all of which would meet specifications, but each of which had a slightly different impact when it came to outfitting a vehicle. Manufacturers also did not necessarily design their trucks for easy maintenance; in one instance armor had to be dropped to get at an oil filter.

It helped that the MRAP vehicle program came on stream after the U.S. economy had slowed considerably from the red-hot days of 2003. With the U.S. economy running down beginning in the fall of 2008, manufacturers were hungry. They knew how to produce new trucks, and they jumped in happily. They responded quickly and effectively to continually emerging requirements.

The JDAB decided which vehicles went to which Service. The Army was so large that it had to take vehicles from all five lines, although it much preferred the MaxxPro CAT I. The Marines and the Navy initially filled about 40 percent of their requirements with FPI Cougars and by 2008 favored ramping up FPII production. SOCOM and the Air Force favored BAE's RG-33, but the company was unable to produce enough of them.

In addition to the more or less standard trucks, there were three special types: ambulances, the SOCOM Armored Utility Variant (AUV), and MRAP recovery vehicles (MRV). The first ambulances were RG-33L CAT IIs (eight each for Iraq and Afghanistan) authorized under a separate CENTCOM JUONS. Later there were a Cougar CAT II and ambulance versions of the MaxxPro Plus and the Dash. The special SOCOM variant was based on BAE's RG-33. The first MRV was built by BAE, but was not successful. An order for a version of the Navistar MaxxPro CAT I truck was placed in December 2010 as part of the Navistar ID/IQ contract (LRIP 20 mod). It met an urgent requirement associated with the Afghan surge. The first 250 were produced within four months of contract award (the first MRV was accepted 23 days after award), and fielding began five months after award.

There were also special upgrades of existing types of vehicle for service in Afghanistan, where there were few roads, so almost all driving was off-road. The major improvements were independent suspension and survivability upgrades.¹⁴ (These improvements are described in greater detail in a later chapter.)

AMS Vehicles

Many of the Army's Assured Mobility Systems (AMS) vehicles were related to MRAP vehicles. Late in the program the AMS Product Manager was double-hatted as Assistant Project Manager for RG31, managing that vehicle for the JMVP. He was also managing AMS for Kevin Fahey at PEO Combat Support and Combat Service Support (CS&CSS).¹⁵ Later Army publications linked MRAP and AMS vehicles, so it seems appropriate to mention them briefly here.

The AMS vehicles were used for route clearance and mine clearance. They were: Buffalo/MPCV; Husky/VMMD (Vehicle Mounted Mine Detection System); Cougar/JERRV; Panther/MMPV (Medium Mine Protected Vehicle); and RG31s. They were mainly legacy vehicles from the pre-MRAP vehicle period.¹⁶

Of these, Buffalo/MPCV (Mine Protected Clearance Vehicle) was separate from the Buffalo (H1-13 and H14-25), Buffalo A1 (H85-239), and Buffalo A2 FAT. All had the hydraulic arm. Panther is a modified RG-33, bought outside the MRAP vehicle program.¹⁷ The JERRVs were Cougars converted at Letterkenny Army Depot in Pennsylvania.

End Notes

¹ Dr. Etter approved these purchases in a 9 February 2007 memo. It referenced her separate (and simultaneous) approval for the program to move to Milestone C, low initial-rate production (LRIP). The latter document set the initial LRIP figure at 749 vehicles as 'the minimum quantity necessary to ramp-up and establish an initial production base for the system by accelerating production, support testing, and validating the production capability of MRAP vehicle contractors.' Exit criteria from Milestone C (i.e., to full-rate production) were completion of operational test and evaluation and survivability testing to the approved Test and Evaluation Master Plan (TEMP); completion of all required ACAT II documentation; and briefing Dr. Etter on the process for selection of vendors and allocation of quantities for follow-on full rate production, but in fact the program always remained at the LRIP stage, because no version of MRAP vehicles could be considered final. All ACAT II program documentation should have been completed by 1 August 2007. But, this was overtaken by events due to the transition to an ACAT I program. Dr. Etter approved the LRIP 2 purchases in a 21 February 2007 memo, for the GDLS-C, Oshkosh, and PVI vehicles. The requirement for a Full Rate Production Decision Review (FRPDR) was finally cancelled about mid-September 2008 (program files include a 23 September e-mail advising the program that no such decision review would be needed, but not the basic memo). As of that date, OSD lawyers were "advising."

² The date was that of approval by Dr. Etter; orders were let about a week later. One of the approval documents also referenced increased in-theatre requirements documented by the Marine Requirements Oversight Council (MROC) in a 5 March 2007 paper. Dr. Etter's 20 April memo seems to have been the first to require the MRAP vehicle Program Manager to provide periodic updates on all known and emergent MRAP vehicle requirements, including those originating with the Joint Staff, the Combatant Commanders, and other military departments, to help in acquisition planning.

³ Steel weighs about 40 pounds per inch thickness per square foot, so 250 pounds per square foot weighs more than six inches of solid steel. The problem was always that a vehicle burdened by too much armor weight would become useless in its tactical role, in which case it would not be used and it would not protect anyone.

⁴ Major contemplated changes were listed in the August 2007 project review: added dash speed (asked by users); added fuel tank protection (ballistics and self-sealing); added automatic fire suppression; added compressed air; added power distribution system (for all of the electronics); added 5-point seat belt system and crash-resistant seats; added tactical netting systems such as tactical operations center intercommunications system (TOCNET) and weapons stations such as the objective gunner protective kit (OGPK)); deleted rifle stowage racks for the crew; and deleted gun ports. Of these, the only change requiring a new vehicle would have been the added dash speed. The RFP was to have been released on 1 October 2007.

⁵ I3 was Ideal Innovations Inc. Bull was based on the Marines' medium truck (MTVR), and it had the MTVR drive train (Oshkosh made the MTVR). It featured Autoflug (mine blast absorbing, foldable, and stowable) suspension seals, a TAK-4 independent suspension, and coil springs with hydraulic shock absorbers. The tires were Hutchinson run-flats. It weighed 64,800 pounds, of which 1,800 pounds was payload. The engine was not specified, but Bull could make 65.2 mph. Turning radius was not given. It was 336 inches long, which compared to 323 inches for a Buffalo, but it was considerably lighter (Buffalo weighed 78,500 pounds in its A2 pre-LRIP 10 version). Data for Super Caiman are not available; the data in the Master Test document are for the production Caiman Plus.

⁶ Given its past performance, there was some question as to whether BAE could execute the program. Navistar was particularly well liked because of its "lean-forward" attitude, and its size, which would enable it to absorb costs early on (as it had demonstrated in the MaxxPro program). I3 was a largely unknown quantity (except for its Oshkosh element, which had not succeeded in the past in the MRAP vehicle program) with some political backing.

By this time it was clear that the bulk of MRAP contracts were going to Navistar. Its President Archie Massicotte believed that the MRAP II competition was driven by industry's hopes of restarting competition on an entirely new plane. Oshkosh was the only company that could reasonably hope to rival Navistar's productivity. Massicotte interview.

⁷ The RFP for MRAP II was issued on 31 July 2007. The program was officially abandoned in July 2008, \$25 million having been spent. According to the 19 August 2009 Program Objective Memorandum (POM), MRAP II was abandoned specifically because commanders wanted lighter, more mobile vehicles.

⁸ Orders were given to BAE (393 CAT II, 51 ambulances, 30 SOCOM), to BAE-TVS (formerly Armor Holdings: 1,024 CAT I), to FPI (12 CAT I, six CAT II, six CAT III [Buffalo]), and to IMG (526 CAT I, 217 ambulances).

⁹ LRIP 11 amounted to 743 vehicles from IMG (528 CAT I and 217 ambulances), 29 from FPI (12 CAT I, 6 CAT II, and 11 CAT III), 447 from BAE (393 CAT II, 51 CAT II ambulances, and three SOCOM), and 1024 BAE-TVS (all CAT II). After the original LRIP award had been made on 18 March, the JROC validated a new requirement for 11 SOCOM recovery vehicles (wreckers). A 22 April 2008 Action Memo by Elaine McCusker recommended the additional SOCOM order amounting to 27 AUVs already authorized under LRIP 11 plus 13 recovery vehicles, including two test vehicles. Every new or modified version of an MRAP vehicle had to be explosion-tested before it could be approved.

¹⁰ This breakdown is the author's guess, based on the stated totals of 773 RG31s and 36 RG-33s for SOCOM, and the stated number of 24 test articles. Under this authority EFP kits would be procured, except for GDLS-C vehicles that received attachments for MEAP. EFP kits for CAT III vehicles would be procured separately. The memo approving LRIP 12 recommended procurement of up to 10 more MRAP ballistic test vehicles as recommended by the JROC, and also approval to procure up to 25 more MRAP vehicles in the latest upgraded configuration if approved in advance by the JROC. They would be procured as emerging requirements were validated based on the changing and evolving threat, the contractors to be chosen based on test objectives for both ballistic tests and service.

¹¹ The 26 June 2010 memo laying out quantities noted that on 10 May 2010 the JDAB asked for another 118 MRAPs, and that the Program Office needed another 21 for ballistic and automotive tests, the latter essential given the new suspensions used in Afghanistan. The original LRIP 18 envisaged purchase of 102 vehicles from BAE (32 RG-33 AUVs for SOCOM plus 70 RG-33A1), and 16 from GDLS-C (RG31A3). The extra 21 test vehicles were 11 from GDLS-C (5 RG31A3, 6 RG31A2), six from FPII (3 A2 CAT I and three A2 CAT II) and four M-ATVs from Oshkosh. The supporting MCSC memo (26 July 2010) stated that SOCOM's preferred mobility solution was the BAE AUV (RG-33 variant) and a version of RG31 (the 16 operational RG31s listed above).

¹² LRIP 18 and 19 were modified under a 20 March 2011 memo. The type of ambulance planned was changed from M-ATV to MaxxPro Dash and the number of non-SOCOM RG-33s reduced from 70 to 26. This change was intended to satisfy an urgent need for ambulances due to an increase in operational tempo and to increased attacks against Coalition forces. Later SOCOM asked for more M-ATVs, and the Marines asked for more MRAP vehicles to replenish Forward in Stores, depleted by battle losses. As of 22 October, therefore, LRIP 19 as approved comprised 175 MaxxPro Dash, 250 M-ATV ambulances, and 82 M-ATV for SOCOM.

¹³ CENTCOM issued its request for vee-hull recovery vehicles on 27 August 2010; on 22 October the OSD Task Force called for a small number to be used in a Limited User Evaluation (LUE). This was the 10 originally contemplated. To meet urgent needs in Afghanistan, the first should be produced no later than 15 December 2010 and the balance no later than 21 January 2011. On 16 November, however, the number was raised to 250, on an urgent basis; it was known that operators in the field needed 240 of them at once. The other 10 would support testing and provisioning (analysis of the need for spares). This quick increase was possible because it did not breach the JROC-approved total MRAP vehicle figure. On 17 June 2011 the Joint Staff validated a JUONS for the additional 10 wreckers, and senior leaders in Afghanistan wanted another 130. A 1 July 2011 memorandum from Under Secretary of Defense Ashton Carter, who was then head of the MRAP Task Force, approved the 140 wreckers under LRIP 23.

¹⁴ The main independent suspensions were the TAK-4 on Marine Corps Cougars (first delivered to Afghanistan in August 2009), the DXM independent suspension on 2,717 MaxxPros produced by Navistar, and the independent suspension of the GDLS-C RG31A3. In mid-2012 an underbody upgrade kit for the MaxxPro was tested. Caiman Plus was an EFP upgrade for the Army and the State Department (1,140 kits were required). Given the greater weight of the vehicle, its engine and suspension had to be upgraded. In addition, anti-RPG nets and bar armor were produced for the RG31.

¹⁵ The confusion between the JPO and AMS exemplified the larger problem that many of the same people, in the same office, worked for the Army's JPO and for the AMS office. That was typical of the program. People had to wear both joint and Service hats because they were not part of a true JPO with a formal table of organization like, say, JSF or MDA. JPO program manager David Hansen pointed out that this ambiguity created serious problems, and that it points to a lesson that ad hoc JPOs should be avoided in future. Hansen interview.

¹⁶ These vehicles were included in a draft PowerPoint presentation by David Hansen for the Strategic Execution Conference, 24-25 April 2013. (See Figure 2.) The current AMS summary of vehicles describes them as part of the JMVP. Note, however, that contracts for AMS vehicles were let outside the MRAP vehicle process. This note is included for completeness.

¹⁷ The Army chose RG-33 as its MMPV in December 2007, letting a contract for up to 2500 vehicles through 2015. Nine test vehicles were ordered, for completion between May and August 2008, and in April 2008 the Army let a contract for 179 vehicles. The designation goes further back, to before the MRAP vehicle program. MMPV was conceived for point, route, and area clearance of mines and IEDs. In 2004 the Army's Communications Electronics Command (CECOM) asked manufacturers for informational white papers looking towards procurement of 200 MMPVs. They were to be transportable by C-130s, capable of carrying 8-10 soldiers or 4-6 soldiers and an EOD robot. The vehicle was to operate on- and off-road and to withstand a 15-pound explosion under its centerline (as reported in an open-source publication cited on the Internet by the Global Security organization, which is a private organization). It would also be protected against small-arms fire (7.65 mm ball, with protection against 7.65 mm AP desirable). TARDEC issued a more detailed solicitation in 2005, and again in January 2006. In January 2008 BAE announced that it had won the contract. The name Panther was adopted to differentiate the MMPV from RG-33s built for the JMVP; it was based on RG-33L, the 6 x 6 version of the RG-33. This information is unofficial, from the Global Security website, but it is probably based on official releases. More recently the Army has announced a Mine Protection Vehicle Family (MPVF) consisting of the MMPV, the VMMD, and the MPCV (Buffalo), of which the MMPV is the command and control vehicle. At this time MMPV is split into MMPV Type I (RG-33), to support EOD companies and for rapid response, and MMPV Type II (RG31) to support Engineer Units in route and area clearance operations. Other initiatives are the Area Mine Clearing System (AMCS) and the Interrogation Arm (IA). Of these, AMCS is a classical mine clearance device using a rotating flail to detonate or destroy anti-tank and anti-personnel mines. The IA is a mechanical arm that can be operated from a Husky or an RG31. The only non-MRAP vehicle in the list is Husky, which the Army first bought in the 1990s from South Africa. It was marketed in the United States by CSI (Critical Solutions Inc.), which claimed that over 500 had been deployed in Iraq and in Afghanistan, the latest version being the single-operator Mk III. Originally Husky worked with a separate Meerkat vehicle, but the Mk II Husky could replace Meerkat. As of May 2010 the U.S. Army had ordered over 250 Husky II systems, accounting for the over 500 claimed by CSI. It was the first purchaser, but in 2010 the Marine Corps and the Canadians followed suit, followed in 2013 by the Spanish Army. In the summer of 2013, these vehicles continued to be built in South Africa.





CHAPTER 8

“TEST A LOT!”

The MRAP experience began with tests. From the outset, it was accepted that no one knew enough about under-body explosions to make major program decisions without full-scale testing. The emphasis on testing was no accident. Paul Mann’s Aegis experience made him unusually alive to the value of testing.

No Simple Solutions

The Navy had learned in the Cold-War period before Aegis that its anti-aircraft missiles enjoyed great maximum performance but poor reliability. There was no simple single solution that might be uncovered by smarter analysis. Instead, ships and missiles had to be tested again and again while being minutely monitored. This testing drove a very successful “get well” program established in the early 1960s to cure the Navy’s

air defense missiles. The first commander of the test station was then-Captain Wayne E. Meyer Jr., who set up the successful Aegis program that, in essence, educated Paul Mann. The lesson Meyer learned and taught was that details mattered, and that they could be understood only by constant testing. A subtler lesson was that spiral development worked far better than its alternative, an attempt to jump from one system to a completely new and theoretically better one.¹

Much the same thing—that there was no simple characterization—could be said of a vehicle confronted by an under-body IED. It turned out that not only the overall design of the vehicle, but also details—where objects were inside, how they were (or were not) tied down, and the positions and character of the seats—were all crucial. This understanding was common for ground vehicle testing well before MRAP vehicles. The challenge was not the understanding of the test requirement, generically. It was in developing an MRAP vehicle-specific test that could be supported within the dramatically compressed program schedule. And, in addition to the actual testing, there was a follow on analysis for every test to translate test data into information that would adequately support a decision.

A vast amount of testing was needed to settle such details, as was obvious to a graduate of the “Aegis management school of hard knocks.” To find out what happened in explosions, the testers had to go beyond existing techniques. They had to test not only the vehicle itself but also the effect of an explosion on those inside it. There were already dummies used to test the way cars behaved in crashes, but a car crash happens in tenths of a second, and the effects of an IED are felt in milliseconds, a hundred times shorter. There were already developed blast-test dummies before the MRAP program, but even they had limitations. By the end of the program, the vast experience gained was going into the design of a new generation of explosion-test dummies that could be used to test future vehicles.

Similarly, by 2007 a great deal had been done to learn about the previously dominant threats, projectiles from machine-gun size up, hitting the vertical parts of vehicles. There was no great hope that low-slung combat vehicles such as tanks could be modified to withstand under-body attacks; the usual answer was to try to sweep mines aside. That was possible because the mines to be expected in large-scale combat were usually strewn over the surface of the ground, which was the only way they could be placed quickly in numbers. For example, the main Cold War mine threat was mines

strewn by rocket or by artillery in the path of armored forces. IEDs were a very different proposition, hidden one by one by the enemy. They were difficult to detect and they had to be dealt with one by one.

Innovative MRAP Testing

The need for testing might seem obvious. However, in most programs, calls for more testing, for example for live-fire testing, were anything but welcome to most program managers, because they ramped up the unit cost of whatever was being produced, since the cost of testing had to be spread over the production run. This attitude was natural given the normal development process. The object of the process was an ideal product. Testing was a way of choosing among several candidates. Once one had been selected, that was the end of the process, at least in theory.

The standard process is a series of developmental tests (DT), which often went through a series of down-selects to pick one or more final articles that then went into low-rate initial-production (LRIP). The purpose of DT was to show that the system met the design specifications. The LRIP supported a final operational test (OT) that was intended to show that the system was operationally effective and suitable, without regard to design specifications, per se. In sum, there was considerable testing after a system was selected, usually leading to sometimes minor, sometimes major modifications of the selected system.

In a spiral process like that followed by the MRAP JPO, testing has a very different role. The initial test did not weed out unsuitable candidates initially; the MRAP program winnowed its field from nine vendors that responded to the RFP to eight that sent vehicles for testing. The results were seen as partial solutions, good enough to place in production, but requiring further work as further testing accumulated relevant knowledge. The knowledge was useless unless it was shared between the program and the manufacturers, because the point was to keep improving the vehicles, those already in service and those yet to be built.

As an Aegis veteran, Mann understood how sustained testing could help solve problems. It had taken years of testing to uncover the rather subtle flaw that had stymied the Cooperative Engagement Capability (CEC) program. When Mann took up his post, the Army's Aberdeen Test Center conducted explosive testing of vehicles.

It happened that Mann already knew the Commander of ATC, Colonel John Rooney USA. Instead of trying to minimize tests, Mann supported Colonel Rooney's advice for additional funding.

In 2006 Colonel Rooney was already deeply involved in the IED problem, having attended a Pentagon meeting on the subject as early as July 2003.² The meeting was intended to bring material developers, intelligence, and operational testers together. The Army in Iraq was using mainly unprotected Humvees, although a few had been up-armored. By the end of the day he had been designated lead tester for up-armored vehicles. Between 2003 and 2006 he accumulated considerable knowledge of armor through numerous tests. At this time the Army was buying kits to up-armor Humvees, and his approach was to ask anyone in industry to offer kits for tests. He visited Iraq four times to see the effects of IEDs on vehicles. By that time there was considerable improvisation in-theater, much of it "Hill-Billy" armor. Rooney's experience of the up-armoring program greatly influenced his approach to testing vehicles (and to instrument dummies inside) against IEDs of various kinds.

The anthropomorphic dummies played a growing role in vehicle tests, because they did not figure prominently in tests of side attack. In those attacks, the issue was whether the side of the vehicle was penetrated. If it were penetrated, did the penetrator hit something vital in the vehicle, such as a fuel tank or ammunition? Those inside a vehicle would be killed or injured by the secondary effects of the hit, metal spalling off the inside of the walls or an internal explosion.

An under-body explosion lifts the vehicle, imposing a sudden acceleration. Accelerations would be sudden, and they would affect different parts of the body differently. The acceleration can instantly break bones and that breakage can kill. It can also affect internal organs, but it was enough to see whether bones would be shattered.³ If they were unbroken, the victim of an explosion would generally live.

The anthropomorphic dummies used in the MRAP program were the best available, but it was recognized in the test community that these dummies had limitations. Early in 2011, the test community received authorization to begin a major program to develop an entirely new explosion-test dummy with greater bio-fidelity, the Warrior Injury Assessment Mannequin (WIAMan). Although WIAMan would not be ready until about 2016-2017, it is an important legacy of the MRAP vehicle program. By

2013 the WIAMan program was absorbing a considerable fraction of the overall U.S. government biomechanical engineering effort.

Meanwhile the testers continued to use existing dummies, but labored to ensure they measured what was happening much more precisely. Before MRAP testing, a vehicle survivability shot used only a few anthropomorphic dummies. It was assumed that the testers could guess which positions subjected vehicle occupants to the worst damage, so they could economize on the use of anthropomorphic dummies. Very early in the MRAP program, Aberdeen took the position that effects in each crew position could be and probably would be different, and that the differences were unpredictable. An anthropomorphic dummy had to occupy each crew position. This was a new and controversial idea. The test community did not want to risk so many fully instrumented dummies, which were expensive and difficult to replace. Colonel Rooney personally pressed the point that in order for the testing to be realistic, real dummies had to be in each crew position, despite the risk of loss. The MRAP program tripled the amount of available dummies so that the loss of these assets in testing would not slow the test program.

At the outset, the only fully instrumented dummies were in the driver's seat and one passenger seat. The other seats were occupied by water dummies whose only instrumentation was an accelerometer (one line of data). Soon the best available fully instrumented anthropomorphic dummies (hybrid-3s) occupied every seat in the vehicle. Close observation of events in theater helped the testers see what data were *not* being collected, so that they could improve their tests.

Colonel Rooney also enormously increased the amount of data collected from the dummies in each test. That gave the program sufficient data to understand what was happening not only to the vehicle but to what was inside, particularly seats and floors. Test-inspired improvements in internal components added enormously to crew survivability. Given sufficient test data, it was possible to discern trends and to draw conclusions that could be fed back into the program. None of this would have mattered in a conventional program, in which the design of thousands of vehicles was frozen at the outset. It mattered greatly in a spiral program, in which each short LRIP production run could be improved over its predecessor. Ultimately the MRAP vehicle testers would be running 128 data lines from each crash dummy inside each vehicle, and even that was not enough.

Conversely, as the testers built up their knowledge, they got to the point where they could look at an injury sustained in the field and correlate it better to test results. That understanding made it easier to detect a change in the threat that had to be countered by modifying existing vehicles.

Setting Up the Test Program

Colonel Rooney was first told about the MRAP vehicle program just before Thanksgiving 2006. He did not know how large it was going to be, but he knew it would be critical, so he immediately formed a substantial test team of about 250 experienced people. As he began to plan, he became concerned that ATC's throughput of ballistic testing was insufficient; he had only enough equipment to handle one vehicle per week. He found out that Mann was the program manager, and invited him to see a test. The most important part of the demonstration was the need for greater throughput. Mann understood; after a few weeks Rooney convinced him to spend \$14 million to triple overall capacity. From November 2006 through January 2007 ATC built ranges to prepare for triple test pads. The first trucks arrived in February 2007. At that time there was no idea how large the program would become, so Rooney concentrated on creating test capacity. He knew he would have to provide quick support for decisions. Ultimately the MRAP vehicle program accounted for a large fraction of Rooney's survivability test workload and the bulk of his personal time. (That said, ATC did many kinds of tests daily, MRAP accounted for a small percentage of overall testing.)

Mann clearly cared about the sort of tests Colonel Rooney and his test team wanted to run. In the first year of the program, he typically called Mann three nights each week to tell him which trucks were passing their tests. Every six months Rooney went to Iraq partly to stay current with the threat and with how well vehicles were doing in theater. He saw Iraq as an extension of Aberdeen, feeding the same process of continuous improvement.

In combination with the Defense Department live-fire test organization, the test team developed a three-phase testing plan, which accorded with the spiral development philosophy adopted in the MRAP program. The first phase (DT-C1), which decided whether a vehicle was accepted or rejected, was a minimum test using an explosion placed where a vehicle was most likely to be hit, e.g., near the front wheels. This type

of testing was first done on a bare vehicle as delivered by the manufacturer. It had to be repeated when the vehicle was fully equipped, because any explosion would affect the setup inside the vehicle.

Vehicles were subject to two later series of more comprehensive tests (DT-C2 and DT-C3) designed to suggest improvements, but not explicitly to decide whether or not to buy the vehicles in the first place. For example, DT-C2 moved explosions closer to the rear of the vehicle and explored the extent to which protection was not uniform along the length of the vehicle. Where DT-C1 used a few dummies, DT-C2 used water dummies with accelerometers, and DT-C3 used the 128-channel dummies. The lessons of these tests flowed into other vehicle programs such as survivability modifications to the Army's Stryker vehicles. The results, however, were a consideration in selecting which vehicle manufacturers were awarded initial contracts, and in some cases, follow-on awards.

The overall idea that testing should be a partnership between the program and its suppliers was radically unlike the usual testing philosophy. The original intent was to allow vendors to fix problems in order to qualify vehicles for production orders, not to improve them, *per se*. What was truly radical was that the manufacturers were invited to take part in all the tests of their vehicles in hope that they would be able to improve their products. They were allotted space at ATC, and they were given tapes of all the data coming out of the tests. Manufacturers were not allowed to see data from their rivals' vehicles, but that was the only limit on what they were given. At one point all manufacturers were allowed to sit together and see the results of all the different MRAP vehicles that met initial requirements.

Colonel Rooney and many others realized that data might come from sources normally considered almost irrelevant. The Defense Department stood up a joint medical system, Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) initiative. JTAPIC collected medical data and thus obtained nearly real-time data on injuries in the events (explosions). The MRAP vehicle program had to analyze these data to understand performance in action. JTAPIC data were used to identify relevant trends. For example, increased leg injuries pointed to a problem with vehicle floors. That trend helped indicate how the threat was evolving. Rooney's constant concern, and that of the program as a whole, was to use real-time feedback to identify and cure weak links in the vehicles.

The National Ground Intelligence Center (NGIC) in Charlottesville, VA, formed the Anti-Armor Analysis Program (AAAP) that captured all events in Iraq and Afghanistan. The ATC/AAAP combination made it possible to see what events were significant. Often the MRAP vehicle program could see a trend developing before the theater command did, and could begin work on a solution before anyone asked for it. The program also knew the MRAP vehicles, so it could envisage possibilities not obvious to the operators. For example, in 2010 it talked to the U.S. military leadership in Afghanistan about the M-ATV, indicating what it thought should be done to enhance survivability. The leadership in effect ratified (and modified) plans that enabled rapid fielding of significant survivability enhancements.

Real-World Feedback

Quite aside from their value to the MRAP program as tests of its vehicles, experience in theater was also a way of validating the evolving process of learning to predict the effects of explosions. The DoD live-fire testers became expert at what they called “cross-walk.” They could identify a particular explosion in theater with a particular test or tests. In those tests, they knew that the dummies sustained a measured g-force, which could be associated with a particular injury threshold. What injuries were seen in theater? The results were reported rapidly to the interested parties outside the MRAP vehicle program: particularly Secretary of Defense Gates and Congress. Gates used the reports to explain to Congress what the MRAP vehicle program was doing to improve itself and to adjust to experience in theater.

One of Rooney’s roles in his visits to the theater was to tell the troops what the test program was learning, hence what they should do at once to improve their own survivability. One of his early visits was to debunk folklore among the troops that they could defeat EFPs by lining the doors of their Humvees with ballistic glass. Tests by the Aberdeen test team showed that the glass would shatter, creating splinters that would kill everyone inside a vehicle. The result was filmed from inside the vehicle. Shown in theater, the film made the point. Another point was the use of sand in expedient solutions before MRAP vehicles. These applications often increased the likelihood of injuries and the sand caused a greater chance of infections in wounds.

This was a continuous process. For example, in the summer of 2012 the Joint MRAP Vehicle Program (JMVP) saw a damage trend in the MaxxPro Dash used in Afghanistan. Based on that, the program conducted several test shots, which

confirmed particular damage modes. In cooperation with the vehicles' manufacturer, fixes were developed. They were proven by August. JPO representatives went to the theater, explained the proposals, and communicated them to senior OSD officials, who approved them. This was nothing new. As a result of this evolution, in 2013 MRAP vehicles with modification kits were routinely surviving threats far beyond those envisaged at the outset of the program, and far beyond what Humvees could survive in 2003-2005. Those inside were surviving events beyond comprehension.

The key was never to be satisfied with a "good-enough" solution. The JMVP leadership constantly asked whether the vehicle could have done better in any given test event. This was true spiral development. It began with something reasonably good, so that even if improvement proved impossible, there was still a baseline capability. That was the heritage of the South African vehicles. But the spiral meant that there was continuous pressure to do better, and the effect of that pressure was to transform MRAP vehicles completely. The program might look like a truck program using off the shelf vehicles, but it was actually an intense RDT&E program creating rapid change from the baseline.

The program produced vehicles, but their users had to understand what they could and, importantly, could not do with them. It was easy to generate myths that would create a false understanding of how the protection worked, and that could attract a lot of energy to incorrect solutions and also to dangerous practices. Troops had to understand, for example, that the vehicle hull was not enough; they had to learn to worry about where to sit, where to place their equipment, and how to tie things down. Training was generally about how to drive these often-heavy trucks safely, not about how to sit in them. Few of the passengers got much training in the MRAP vehicles before meeting them for the first time in theater.

Considerable effort also went into modeling and simulation, and it might be asked whether so much physical testing was needed. The program's experience was that no computer program existing prior to the MRAP vehicle tests predicted well enough how they would come out. The physics was far too complicated. Experience with tests made it possible to adjust some of the programs to the point where they are about 80 percent right. They are used, not to replace test shots, but to model them to decide which particular shots are most likely to challenge the technology. That makes it possible to focus testing better. It is still always necessary to compare the results of a shot with

reality. Shots are no longer fired if there is no pre-shot prediction. The computer models give useful insights.

For example, in 2013 further underbody protection was needed for the M-ATV. There were five very different approaches. Modeling showed which two were likely to be best, and they were tested. The result was a great improvement in survivability.

Improvements in modeling and simulation, and the new approach to the way in which modeling and testing should work together, are among the important legacies of the MRAP program.

Beyond the 80-Percent Program

The JMVP's attitude toward tests changed the MRAP vehicle program from a program to buy and adapt off-the-shelf vehicles into a program to produce better and better vehicles capable of keeping up with improvements in IEDs.⁴ From the outside, it might seem to have been a commercial-off-the-shelf (COTS) program, but in fact it supported a continuing intensive research and development (R&D) effort bolstered by rigorous test and evaluation. The R&D program greatly advanced understanding of how blast affected a vehicle and those inside.

For example, it became clear that an explosion occurred so quickly that venting due to the shape of the vehicle hull could not have much of an effect. It followed that the South African vee-shape had worked mainly because it had made the hull much more rigid, and also because it lifted the inside of the hull further from the explosion. That in turn made it more important to focus on what happened to those inside the truck and to the contents of the truck. Much of the explosion resistance of later MRAP vehicles could be attributed to sophisticated seat design (particularly suspension) and to special explosion-resistant floor mats. Overall, tests showed that details mattered. The trucks provided layers of survivability—hull, standoff, floor, seats, etc. For example, unsecured objects inside a truck became deadly shrapnel, and it mattered enormously just how things were secured. That was both a training issue and an issue when the trucks were outfitted.

The requirement threshold might be taken as 1X, with an objective of surviving 2X.⁵ Every MRAP bought could survive a 1X explosion. In 2013 trucks normally survived 4X attacks, and one truck successfully survived a 6X explosion—an achievement

unimagined at the outset. The MRAP vehicle program might have begun with commercial trucks (albeit rather unusual ones), but it soon went much further. Survivability depended on almost everything in a truck, from seat material on. Every change had to be tested to verify that the improvement achieved the desired results. There was a growing knowledge against which to design explosion-resistant vehicles. The situation was far too complex to be handled only analytically. Even in 2013 an adequate dynamic model was still evolving. This model, and the body of evidence that supports it, is an important enduring legacy of the JMVP.

This was new work. It was well known that tanks were vulnerable to belly mines, and much work had gone into means of clearing mines from tanks' paths. It was also clear that one reason tanks were vulnerable was that, for other reasons, they had to be built so low to the ground. The JMVP recognized from the outset that it had an alternative, to keep the crew further from the blast, the higher up the better, because the effect of an explosion weakens rapidly with distance (faster than an inverse square).⁶

By 2006 the effect of projectiles and explosives on armor was well understood, partly as the result of considerable testing by the Army Research Laboratory (ARL) (formerly the Army Ballistics Laboratory), Aberdeen, MD. There were good mathematical models. The armor problem was far simpler than the effect of an explosion under a vehicle filled with equipment and people. Even in 2013 there is no complete suite of blast models that could replace actual tests. There was no alternative to continued live-fire testing. ATC typically ran 128 channels of data from the test dummies inside a vehicle. It turned out that combat data from the theater correlated well with what ATC saw, and that in turn gave the program confidence that it could predict how well modified vehicles would behave in combat.

This was just the sort of live-fire testing already advocated by the Director of Operational Test and Evaluation (DOT&E) in OSD. Generally the argument for full-scale live-fire testing is that modeling, which is often advanced as an alternative, cannot capture the complexity of the situation. The success of full-scale testing in the MRAP vehicle program would seem to have important implications for future requirements for such testing. Good models could help to identify possible solutions, but live fire tests were still the ultimate confirmation of solutions.

Defeating the Explosion

Factors in an explosion are overpressure, shrapnel, and accelerating forces (shock), of which the last turned out to be the most significant. An early surprise was that a hull breach in itself did not kill. Acceleration from below was far more significant. The upward and then downward acceleration from an explosion (and the resulting slam down when the vehicle lands) crushes spines and shears off legs. It turned out that overpressure was less significant, except when the turret gunner was exposed, and also except in a huge car bomb. Shrapnel from an IED was insignificant (the armor kept this out), although loose items inside a vehicle could create vicious shrapnel.

The vee hulls that were initially seen as a solution to underbody blast turned out to be the beginning, not the end, of what was needed. They were effective against relatively small explosions, but as the IEDs became more powerful it was necessary to work on the material between hull and floor to mitigate forces. Ultimately, it became clear that the main virtue of the vee hull was not that it directed the blast away but that it made the hull rigid enough to absorb the murderous accelerating forces. That conclusion was reached only after extensive tests. They showed that the explosion and the acceleration happened much too rapidly for the supposed venting effect of the vee shape to dissipate enough of the force of the explosion. The M-ATV developed for Afghanistan did not have the deep-vee hull of the earlier MRAP vehicles, and it benefitted from the more sophisticated understanding of explosions developed through extensive live-fire testing. That was necessary for a vehicle designed for maneuverability; the earlier MRAP vehicles inevitably had high centers of gravity (due to their vee bottoms) and were much heavier and more prone to rollovers. But the largest cause of rollovers was the ground giving way because of the weight of the vehicle.

Conventional automotive seats were built to protect their occupants from crashes, not from blast. The JMVP evolved technologies to deal with blast effects, particularly from below. Many of the original seats did not mitigate that effect at all; the seat rose with the floor of the vehicle as the blast hit it. The next step was to deal with the way in which the vehicle rose off the ground. The seat stroked to counter that acceleration. However, once it was launched off the ground, the vehicle rose only so high. It fell back, its wheels usually having been blown off. Later seats were mounted on rails, so they could go both up and down. That emphasized the need for headroom for space, so that

the seat could stroke both up and down. It also meant that putting items under seats could create a survivability issue for the occupants.

Adding material under a truck sometimes actually reduced survivability, because that provided more metal to catch the force of an explosion and transfer it to those inside the vehicle.

Vehicles were outfitted completely and occupied by test dummies in seats, eventually all fitted with numerous sensors and cables leading to recorders. The questions were not only whether the vehicle as a whole survived a blast, but also what happened inside. What were the best places for the seats? What sort of seats should be used? Dummies in conventional seats fixed to the floor suffered shattered legs and compressed pelvises. Those in seats with blast-mitigation technologies suffered much less. It turned out that the floor itself undulated under blast, and protecting legs was a tremendous challenge.

Overall, tests showed that details mattered. Instrumentation tracked the entire sequence of blowing up and slamming down, finding where in the cycle the dummies were subjected to peak accelerations, hence where they had to be protected. Video cameras inside the truck showed how unsecured objects inside a truck became deadly shrapnel, and it mattered enormously just how things were secured. Tie-downs were clearly crucial, and all of the equipment inside the truck had to be mounted so that it did not become a danger in an explosion. Industry also produced better seats in response to test data. Much of the explosion resistance of later MRAP vehicles could be attributed to sophisticated seat design (particularly suspension) and to special explosion-resistant floor mats and floors.

The program spent some \$60 million on tests. Instead of the usual approach of minimizing testing, the JMVP soon acquired over 100 test assets, so testers did not have to wait in line for the next asset; they could do twice the testing in half the usual time. That was deliberate. There was a sense that as much as possible had to be learned as quickly as possible (which, incidentally, shows that no one imagined that the South African trucks were a complete solution). At the end of the program, it had 250 test assets. The philosophy was that testing was the only way to reduce program risk, and ultimately program cost, and, most importantly, save lives.⁷

Moreover, the program adopted an unusual attitude. In the interest of improving all MRAP vehicles, each contractor could have all their test data (the Army view

of testing was far less transparent). Early in 2008 the program began to make major survivability upgrades. This was relatively unprecedented. It reflected the 80-percent solution way of thinking, acceptance that no one knew enough when the program began. As chief tester Colonel John Rooney put it, “never be satisfied with what was originally, always adapt to new conditions.” After all, part of the survivability requirement was to “prevent fatal effects.” With many events in theater fatal effects were seen and the specific test requirement was to prevent them. When he retired from the Army in 2009, Rooney became Deputy Chief Engineer and then Technical Director of the MRAP program, so he got to put into practice what he had learned in testing. He emphasized the importance of looking everywhere for solutions—in many cases, in small things such as the details of seats and their suspension. Any solutions had to be developed in the context of maintaining mobility, for example by upgrading suspensions and increasing tire size to reduce ground pressure (doubling the tire footprint on the ground).

The Proof is Lives Saved

The outcome was that more about 95 percent of those riding in an MRAP vehicle when it was attacked were back in action in a day. Had the vehicle been an up-armored Humvee, all could have been dead. The MRAP program office kept receiving bits of blown-up MRAP vehicles signed by those who had been riding inside, who wanted the program office to know that it had saved their lives. Typically the truck did not survive an “event,” because its external elements were blown off. It could be rebuilt. This type of survivability placed particular stress on the supply of spare parts and on the support facilities in Iraq and later in Afghanistan.

It is impossible to say publicly how many lives were saved and how many casualties were avoided. As pointed out earlier, the number of events had to be kept secret because it would have indicated to the enemy how well anti-IED measures were working (and how many IEDs were duds). At one point in 2012, in response to an argument that MRAP vehicles had cost far too much and were an inefficient means of saving lives, a figure of 40,000 lives saved was cited. This figure represented all those Warfighters, up to that date, that were occupants in an MRAP when an IED event occurred. There have been many more since. It was impossible to tell exactly how many of them would have been killed but it gave great insight into the number of casualties averted: most of

those blown up riding MRAP vehicles walked away after the smoke cleared. Statistics were published showing that riding an MRAP “truck” was at least four times safer than riding a Humvee. Moreover, the mere existence of MRAP vehicles that were clearly survivable in the face of IEDs likely had an impact on the enemy’s tactics. How can the number of lives saved due to this shift be estimated, let alone measured?

The problem is that testing is typically used not to learn but rather to support choices, such as the selection of one design over another. That is almost inevitable if the government side of the program has little engineering depth and hence has little capacity to draw lessons from test results. At one time, when there was greater engineering depth, developmental testing was conducted to learn how to improve equipment. Operational testing was conducted to decide whether a program had succeeded or failed. Over the years this distinction has sometimes been lost.

In a spiral program, the question of life or death does not arise: the program has already been established on the basis of demonstrated capability, the baseline capability. Test data are used to decide what step(s) to take to improve the system. That is very much the program manager’s business.

In the case of the JMVP, this philosophy translated simply to the idea that everything was about knowledge. If everyone had it, the money could be kept flowing. The JMVP deliberately set up a system to allow the right people to know quickly enough to make a difference. As the program wound down in 2013, the more conventional way of doing things made itself felt. People felt they were being put back in the “box,” and decisions were slowing down. It was still possible to do upgrades relevant to Warfighters (as in the case of the MaxxPro Dash), but the mantra was shifting to the “pursuit of perfection,” which really meant the fear of making mistakes. The program had often been criticized for its 80 percent decisions, but it had always been agile enough to fix whatever failed.

End Notes

¹ The essence of spiral development is to start with some, however limited, capability and then build on that. The alternative view (concurrent development) is that only radical jumps from one system to another can provide the needed jumps in capability. The risk of concurrent development is that if the radical jump fails, there is no capability at all. In the Navy’s case, the “get-well” program was the consolation prize offered when the radical-jump anti-air warfare system (Typhon) was cancelled as too ambitious and too expensive. It would have entailed both an entirely new missile and an entirely new command/control system, and the usual view is that the only real issue was command/control (in reality entirely new missiles impose their own problems). This was the world out of which Admiral Meyer and his disciple, Paul Mann, came, and it is therefore relevant to Mann’s understanding of what he had to do. In the Navy missile case, the first step was to achieve the desired maximum performance. The next, “get-well” stage was to achieve that performance on a regular basis.

After that the same missile could be embedded in a new warfighting command/control system (Aegis), which turned out to provide much better performance and which could handle a much-improved missile. The MRAP vehicle program analogy was that the original trucks could survive the initial test blasts. Once that minimum capability had been secured, the program could look to survival in the face of worse threats, with remarkable success.

² Rooney Interview. He became Chief of Staff at Aberdeen Developmental Test Command in June 2003. On retirement in 2006 he was awarded the Distinguished Service Medal, a very unusual decoration for an Army O-6.

³ That is not to say that damage to internal organs alone could not kill, but that such cases were generally so gross an overmatch of explosion to protection that protection would be impossible. That is why it was enough to see how badly an explosion would damage skeletons; hence it sufficed to use relatively simple dummies. Nikki Brockhoff interview.

⁴ David Hansen, who succeeded Paul Mann as Project Manager, points to a considerable change in program philosophy after Mann left. Mann was clearly concerned with maximizing production. It could be argued further that the more vehicles were produced, the more widely a useful level of protection was spread. Once there was a large MRAP vehicle fleet, improvements in the vehicles themselves were more viable. As tester, John Rooney pressed continuously for the higher levels of protection his tests showed that vehicles could have. Hansen recalls that the program's orientation towards protection upgrades became pronounced only after Mr. Mann left.

⁵ David Hansen interview.

⁶ The explosion creates an expanding volume of gas. The surface of that volume grows like the square of the distance from the explosion, meaning that the effect of the explosion is spread over a wider and wider area.

⁷ Rooney cited the example of a perfectly ordinary cargo truck (e.g., an FMTV) developed just before his time. It was tested to prove that it could carry its maximum payload successfully across country, and that seemed to be enough. It was never tested empty on a highway, because it seemed that would be a lesser requirement. It turned out that at highway speed the empty truck developed a harmonic vibration in its drive train, which would build to a catastrophic failure. Correcting that problem was hardly inexpensive, yet the test had not been done because unloaded truck performance did not seem to present any risk.





CHAPTER 9

SECDEF “TOP COVER”

Late in 2006, the MRAP vehicle program’s principals thought the Marine Corps program should be a joint effort with the Army, since both Services shared the IED problem. The Army leadership was less than enthusiastic. Nevertheless, Secretary of Defense Robert M. Gates made the program truly joint, and he was the reason it expanded as explosively as it did. When Gates entered office, the Marines wanted 3,700 MRAPs for the 22,000 Marines in Iraq. The Army wanted some 2,500 for 110,000 Soldiers. The Marines said they wanted to replace every up-armored (UAH) and Marine Armor Kit (MAK)-upgraded Humvee they had with an MRAP vehicle. The Army could not accept anything that drastic. Secretary Gates reversed the Army’s decision. One consequence was that the Army appointed a new Army MRAP Program Manager (PM) and Deputy Joint Program Manager (JPM), Colonel Kevin Peterson.

From the program's perspective, Dr. Gates provided enormously important continuity from above: he had an extraordinary six-year term as Secretary of Defense, spanning two Administrations. Without his personal interest, the sheer turnover of personnel during his tenure would have disrupted or changed any program.¹ Once Gates left, the program was so well established and so successful that his successors did not change it.

Gates and the IED Threat

Gates became Secretary of Defense in December 2006. He saw the IED as the enemy's weapon of choice and thus understood the importance of defeating it from the outset. That meant a variety of counter-IED measures, including vehicles, plus initiatives for better intelligence, surveillance and reconnaissance (ISR), and for more troops to carry out the Administration's "surge" strategy in Iraq. The combination of these initiatives would choke the enemy's capability to resist. For example, in Gates' view, a successful MRAP vehicle would force the enemy to make bigger IEDs, which would be more difficult to assemble, and which would create larger bomb-production signatures, which in turn would make it easier to find the bomb-makers. Given enough of a signature, Special Forces could locate the bomb-makers and wipe them out. That would greatly reduce the threat. It also saved a lot of Iraqi citizens, making their neighborhoods safer. Thus, Gates saw the MRAP vehicle as a national asset that would change enemy strategies, tactics, techniques, and procedures. It would also create greater confidence among U.S. troops.² Gates was very proud of his part in making the MRAP program work.

Early on, when MRAP was still a Marine Corps program, John Young, then-OSD DDRE, contacted the Marine Corps program principals to get more information on the program. Then-DepSecDef Gordon England called a meeting attended by Secretary of the Navy Winter, ASN RD&A Dr. Etter, and Brigadier General Brogan, who provided the status and background of the Marine Corps MRAP program.

Shortly after that, Secretary Gates learned more about the MRAP program when he read a 19 April 2007 article from *USA Today*, which had been reprinted in the Pentagon "Early Bird" summary of current news items.³ By that time he had been Secretary of Defense for about five months. He previously had been unaware of the MRAP program because it was still so small, an ACAT II (second tier) program among many others. The article recounted the Marines' experience, and pointed out that in more than 300 IED attacks no Marine had been killed. He was soon briefed on the

program and on 2 May 2007 issued a memorandum designating the MRAP program as the highest priority acquisition program in the Department of Defense (DOD), one of the key events of the program.

Gates' tenure as Secretary coincided with a shift from a garrison to COIN (counter-insurgency) strategy, at least within the Army, due largely to the appointment of General David Petraeus as Commander, U.S. Central Command. The earlier garrison strategy distanced U.S. forces from the population and entailed a firepower-response to attacks. Through 2006 the Army shifted toward a COIN strategy, which required small units to be able to circulate freely, without taking casualties merely by moving about. This had been a significant issue even in 2005; operational commanders wanted freedom of action. Unarmored vehicles had to be kept "behind the wire" in secure areas, but COIN operations were constrained by the limited number of protected vehicles. By the time Gates was Secretary, the enemy had upgraded his attacks to the point where the up-armored Humvees were no longer sufficient.

Well before Gates took office, the trend lines in Iraq were bad, and doctrine was changing toward COIN and the surge. Internal discussion of the surge began in the summer of 2006 and straddled the transition from Secretary Rumsfeld to Secretary Gates. When Gates took office, the issues were the size, schedule, and configuration of the surge (including how much to go into Anbar, where the Marines were fighting), and these issues were central during Gates' first trip to Iraq. In retrospect, the MRAP vehicles helped make the surge effective, because they restored mobility to—and the morale of—the troops in Iraq.

Gates recounts that he was sick of writing letters to the relatives of those killed by IEDs. He was certainly aware that unless the IED problem was solved, the United States could not remain in Iraq. As a long-time veteran of the defense and intelligence worlds, Gates seems to have realized from the outset that no jamming effort could be 100 percent effective, even if the enemy did not deploy jam-proof IEDs (as he did). The solution, moreover, had to be convincing to those in the field. Indirect solutions such as jamming might well reduce the threat, perhaps significantly, but it was impossible for anyone in Iraq to say that he felt much safer as a result. Riding in a vehicle that could shield him from a blast was a very different proposition; it encouraged confidence among those fighting. MRAP vehicles also had a direct effect on the enemy. It is one thing for an IED trigger not to work as a vehicle passes. It is another to have the IED explode, only

to have those inside the vehicle emerge firing, very much alive. That sort of failure was likely to demoralize the insurgents.

Opponents of the MRAP vehicle program argued that the key to counterinsurgency was for troops to be out and about in the population, not riding in protected vehicles. Gates' reply was that the troops had to get there in the first place, not be blown up en route in a Humvee.

Making it Personal

When Gates took office, the Marines in western Iraq already had a handful of MRAP vehicles. At this time U.S. forces were losing about five people killed per day, with several hundred wounded each week. Sixty to eighty percent of the casualties were due to IEDs. Gates found it bizarre that the need for protected vehicles was being questioned, e.g., the Army resisted procuring the Marines' MRAP trucks. And, he was soon aware that the up-armoring of the Humvees was reaching its limit, to the point that their doors were so heavy that they could not easily be opened if a vehicle flipped over on its side.

Gates took the problem personally. After delivering a commencement address at William and Mary College, in May 2007 he went to Aberdeen to see anti-IED tests—a test of an up-armored Humvee, followed by an MRAP vehicle test. The MRAP truck survived even after it was blown into the air. The UAH did not. Reinforcing his recently issued memorandum on the “highest priority” status of the program, Gates immediately formed an MRAP Task Force.⁴ He ensured that it would have clout by requiring that he be briefed every two weeks on the progress of the MRAP vehicle program. That made it clear that anyone obstructing the program would quickly be identified. Gates believed that the MRAP vehicle program needed this level of management because so much money was involved. Given such high-level oversight, Congress could reasonably appropriate sufficient funds. The mere existence of the MRAP Task Force considerably streamlined decision-making, since it brought all of those involved together. Each senior official involved could sign off directly, instead of waiting for others to make their own decisions.

Gates remarked that the problem was that the Defense Department is organized to plan for, but not wage, war. No one in the Department, except the Secretary, is charged with getting things to a battlefield on an urgent basis. His personal engagement mattered

enormously. He was told that the MRAP program was the only major defense program since World War II to get from decision to full production under a series of LRIP contracts in less than a year.

He used the MRAP Task Force approach to handle some other problems he considered crucial.⁵ He remarked that, apart from the Secretary, virtually all other elements of the Defense Department had an impact on the program, including his OSD staff, the Joint Chiefs of Staff (JCS) Joint Staff organization, and the individual services. Only by bringing their leaders together under the umbrella of the Task Force could one organization tell all the components of the Department what was needed, and get them moving. Only the Secretary could tell all of them what to do. Everyone knew that within two weeks Gates would hear everything that was happening, and that obstruction would be punished.

Gates knew that most programs are slow because so many participants get to participate independently—each has his own “chop” chain. If everyone has his say once, and then the decision is firm, the program moves a lot faster. Gates’ Task Force meetings had exactly that effect on the program. This was not “rubber-stamping”—everyone had a say in the decisions—but it enormously streamlined the process.

MRAP Task Force

On 26 May 2007, a Saturday, Gates attended a high-school rocket event with John Young, his Director of Defense Research and Engineering (DDR&E). He had already seen the MRAP vehicles at the Aberdeen Test Center (ATC). He talked about it with Young, emphasizing its potential for saving lives. By 30 May, he had signed a memo establishing an MRAP Task Force.⁶ Gates’ memo showed that he would personally accept the inherent risk of getting to the largest numbers most rapidly. The SECDEF thus overcame possible problems with the DoD Inspector General (DOD IG) and Congress.

In order to accelerate the program, Gates reprogrammed money. The original FY 2007 request for MRAP program was \$2.6 billion. In July 2007 the program had \$4.2 billion, a considerable jump. Gates also reprogrammed another \$1.2 billion, to provide a total of \$5.6 billion for MRAP vehicles. He also sponsored the program’s transition to ACAT ID Major Defense Acquisition Program (MDAP) status, which went into effect on 6 September 2007.

Gates' reprogramming and further fiscal support for the MRAP program required congressional approval at every step. He and others in the program established a close relationship of trust with the congressional committees responsible for defense funding. The committees came to support strongly the MRAP program and to offer it an unusual—probably unique—degree of flexibility in allocating funds.

Gates made John Young his deputy on the Task Force, retaining him in this role through Young's move from DDR&E to USD AT&L (Undersecretary for Acquisition, Technology, and Logistics, the level above DDR&E). Assigning so senior an executive to the Task Force underscored Gates' priority.

Although the MRAP program was envisaged as a joint program from the outset, initially the Army maintained a completely separate program office at its Tank Automotive and Armaments Command (TACOM) (Warren, MI), and coordination was difficult. For example, when the Army turned down available Cougars in mid-2007, Secretary Gates' Task Force (in the person of DDR&E Young) directed that the Army office be absorbed into the Joint Program Office (JPO). The JPO grew accordingly, but it always retained its lean-team character, with a core group of only 10 to 20 people with program-wide responsibilities. In May 2007, there were more than 40 government and 60 contractors, and additional 60 positions were requested to support stand-up of the JPO. In sum, by the Spring of 2007, the JPO organization had grown to what was expected of a program of its size and would continue to grow as the program expanded, although not at the same rate.⁷

The Task Force reported weekly to Gates and to the Deputy Secretary of Defense (DEPSECDEF) on its formal tasks:

- Validation of MRAP vehicle program scope and timelines,
- Adequacy of funding,
- Integration of MRAP vehicle and Humvee requirements,
- Establishment of MRAP vehicle distribution and sustainment,
- Setting of near-term production priorities, and
- Establishing priority-setting mechanisms.

Initially MRAP vehicle program sponsor Dr. Delores Etter (ASN RDA) said that the Navy had sufficient control of the program to run it as desired, and that there was no need for a separate Task Force. Young pointed to Gates' memo; Gates wanted personal involvement. Within a week there was a four-hour Task Force meeting, with another a week later. These meetings included the Navy and MRAP manufacturers. Later there were weekly or biweekly three-hour meetings. Because the Secretary of Defense called the meetings, the most senior officers—those with decision-making power—had to attend. This assured that decisions could be made quickly, and the program moved. These meetings focused on the issue of how to move the vehicles to theater and how to train troops to use them, topics that were outside the normal purview of the Navy program manager. The issue of outfitting inevitably came up; Gates doubted that the Navy's Space and Naval Warfare Systems Command's System Center, Charleston, SC, (SPAWAR Charleston) could handle 1,000 vehicles per month, but in the end it could and did.

The Task Force represented active management supporting the 80-percent solution and spiral development. It accepted Joint Staff requirements, but it decided what was possible at once and what could and would be added later. Uniquely, it handled the requirements it was given as advice, not a mandate, to be traded against delivery schedule. In effect, the Task Force replaced the mass of staffing that normally precedes any major program decision. It demanded quick decisions by all of the senior people involved. Because the meetings were so frequent, anything that had to be processed was staffed very quickly and quickly routed through offices that were aware that their principals would have to answer to Under Secretary Young and ultimately to Secretary Gates if something was taking too long. If a decision was requested at one meeting, and a decision was not ready at the next, the principal was asked for a decision then and there. Knowing that was very important. The Task Force became a forcing function.

To one participant, the Task Force was a radical solution to a common procurement problem. Normally everyone involved has good ideas about how to proceed, but only the program manager is accountable for what comes out of them. He must figure out how (or whether) to implement the ideas, and how to pay for them. The same helpful ideas surfaced within the Task Force, but the difference was that a highly placed individual was made accountable for carrying each one out. Tasks were assigned to the relevant organizations, and their chiefs had to come back to follow-on meetings to say

how well they were being accomplished. The Secretary of Defense put his power and prestige behind this process; he personally demanded performance. Key decisions were made on the spot. Normally a program manager would have to find the funding to pay for whatever he decided a program needed. The Defense Department Comptroller attended the Task Force meetings; he had the resources, or could find them.

For the Task Force, the question was what the program needed and whether (and how) that was to be provided. That made for unusual meetings. Normally there would be several layers of staff between the Task Force chairman and the Joint MRAP Vehicle Program's (JMVP) Joint Program Manager (JPM). After the 2008 election the chairman was Ashton Carter, the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L). The Task Force eventually became the Senior Integration Group (SIG).⁸ At these meetings Carter asked the JPM, Paul Mann, and his successor David Hansen, who initially served as Deputy JPM, directly what he needed, something unheard-of in other contexts. Mann and Hansen briefed the chairman directly, and the outstanding issues were resolved right there.⁹

DX Priority

It was the Task Force that addressed the difficult problem of resources. Secretary Gates was well aware of the problem. On 1 June 2007 he granted the MRAP program a DX industrial priority, which made the JMVP officially a program of overriding national importance. U.S. commercial contractors were required to give JMVP orders priority over other business, both military and civilian.¹⁰ (See Figure 4 in Chapter 6.) It also required other defense programs to yield resources to the JMVP. The JCS staff and the Services resisted. Even though the MRAP program was being financed out of Supplementals—later called Overseas Contingency Operations (OCO)—funds, and thus did not require other programs to surrender their budgeted funding, they did compete for some of the same resources. The Army, for example, resisted what it saw as an attack on its truck (hence mobility) programs.

Without this prioritization, MRAP vehicles could never have been made—or at least made quickly enough—in the quantities necessary to equip initially the Army and the Marines and later the Navy, Air Force and Special Operations Command (SOCOM). No one below the level of the Secretary of Defense could have enforced this kind of prioritization in the face of numerous service interests, not to mention in the face of

global shortages of items essential to the JMVP. The program was unique for its time in having both the personal support of the Secretary of Defense and the necessary resources, which was also due largely to the Secretary's personal support.¹¹ In addition, the MRAP program had the support of Congress and eventually the media.

One of the first JMVP briefs to the Task Force explained that if all the desired MRAP vehicles were produced, they would consume all world capacity to produce large run-flat tires. Existing capacity equated to about 1,000 vehicles per month, and the combination of new production and vehicles in theater would ultimately need a total of some 20,000 vehicles. The Task Force directed that funds be allocated at the DOD level to expand capacity. Ultimately that meant using the DOD's industrial mobilization funds to support Goodyear in the United States to build a new plant and expanding a Michelin tire plant in France.¹² At the Paris Air Show, Dr. Etter ensured arrangements were in place with the French tire plant to provide tire molds to increase capacity at the facility.

Armor steel was a similar problem: world production of the steel used in an MRAP vehicle in 2007 could support no more than 800 vehicles per month, and of course it would be difficult to "corner" the steel (or the heavy-duty truck, run-flat tire) market. It took an organization at the level of the Task Force to develop solutions.¹³ The Task Force agreed to spend to expand production capacity and to stockpile what was available ahead of vehicle production. This justified having the State Department exhort Sweden to earmark their full production of ballistic hardened steel. The U.S. Defense Attachés in Israel encouraged Plasan to increase its own armor production, which was going into MaxxPros and later into M-ATVs.

To obtain the necessary resources, Secretary Gates had to exempt the JMVP from two key restraints: the Buy American provision of the defense appropriation and the Berry Amendment limiting imports of specialty metals.¹⁴

A Priority Allocation of Resources (PAIR) Task Force was convened, consisting of Joint Staff, OSD, and buying activity members, to evaluate current and projected defense requirements that might compete with MRAP for scarce resources. Sydney Pope from the OSD Industrial Policy office was a key player in these actions. The PAIR Task Force also became involved in the decision balancing upgrades against a possible new MRAP II to meet a changing threat and also to improve vehicle safety (e.g., against rollover).

This approach worked because Gates wanted to be kept informed, so that he could step in to solve problems. He made sure that the program was never short of money, beginning with reprogramming more than \$1 billion at the outset. He was comfortable with production orders written so that the program would be at risk if no more funds were available at the beginning of FY 2008, 1 October 2007. He told the relevant congressional committees, who strongly supported the program, that it would be mortally wounded without strong and continuing funding commitments. Even though Congress passed only a continuing resolution, which normally would have provided no funding for this kind of out-of-budget program, Gates convinced Congress to include a special \$7 billion JMVP allocation in the resolution. That was extraordinary, and the congressional resolution kept the program alive and growing at a critical time.

Getting Scarce Resources

One of the daunting tasks was to provide resources out of cycle. Normally small projects can be accommodated outside the five-year Defense Future Year Defense Program (FYDP) program objective memoranda (POM) cycle, but the practical limit is about \$100 million. The JMVP was going to be far larger, in the tens of billions. Someone had to pay, and pay quickly, but the budget process was seen as too glacial. It takes a year or more for a budget to be assembled. That pace usually kills large, quick projects.

When SECDEF Gates made MRAP vehicles his first priority, he called in the DOD Comptroller and asked for a holistic solution, not only a solution to the usual process but also direct access to the required funds. To get a political commitment, he personally sold the program on the Hill, circumventing the normal congressional liaison process requiring both Supplementals (OCO) and re-programming. Note that Supplementals were normally intended to pay for current operations and for expendables, such as ammunition, not for fleets of vehicles. In this case, considerable reprogramming absorbed surprises in the program, but the major funding came out of Supplementals subject to detailed congressional scrutiny.

As Gates' deputy in the Task Force, Young was concerned that the sheer variety of vehicles would create serious problems. The Marines would take whatever MRAP vehicles were produced, but the Army was far less enthusiastic. It disliked the variety on offer. Gates badly wanted the Army on board the program, despite a fight about standardization.¹⁵ Young saw the Army's point, and wanted the program necked down to only one or two series vehicles. The Army wanted mainly MaxxPros and a few

RG-33s, but no Cougars. Gates' view was that the Army should take what was available, because that was the fastest way to save lives. At the second Task Force meeting in May 2007, Young summarized what was in theater:

- MRAP: Marines 117, Navy 9,
- MRAP-like: 75 Buffaloes, 153 Cougar/JERRV/Husky, 328 RG31/Cougar,
- MRAP-lite: about 640 Armored Security Vehicles (ASV), and
- Strykers: about 640.

There were also 15,700 Up-Armored Humvees unprotected against bottom attack and at the weight limit for additional protection. It seemed that more than 7,774 vehicles would be needed capable of operating “outside the wire” in the face of IEDs. That figure was presented to the JROC on 7 May 2007. It seemed that it would take another year to get to the desired 7,774. This was the basis for the push for FY 2008 and then continuing resolution money; as of May 2007 the program had \$3.9 billion, but it needed another \$4.9 billion in FY 2008 just to produce the 7,774, and clearly many more vehicles were desired.

Gates used the same model (resource-doctrine-personnel-input) for other high-priority wartime projects: pushing ISR into theater and improved medical evacuation (MEDEVAC). In each case he created an ad hoc structure, empowering it, making it an agent adjunct to his personal direction.

As Gates wound down his tenure in 2009-2010, he wanted to discern the lessons in the JMVP. His premise was that the acquisition system as a whole could not be fixed. The question was whether a more targeted set of changes could be made in high-profile high-priority programs. He challenged Ashton Carter, USD AT&L, to define an “acquisition fast lane” beyond projects such as the existing Rapid Fielding Initiative. This applied particularly to counter-IED projects other than the MRAP program; by 2009 it was clear that the Joint Improvised Explosive Device Defeat Organization (JIEDDO) was too bureaucratic to move very rapidly. The enemy was evolving his threat rapidly; what could be done head-on against it? Carter and Lieutenant General John “Jay” M. Paxton, USMC, JCS Director of Operations (J-3), were asked to find out how much could be done in 30/60/90 days. There was not time to work this out before Gates left, so the JMVP is the most visible legacy of his concern with changing procurement.

To one participant, the Pentagon never really reconciled itself to the JMVP, because it never shifted from peacetime to wartime thinking. The program was a typical wartime program: a surprise urgent large requirement. All such requirements are disruptive, as any history of World War II procurement shows. Many World War II programs had few or no pre-war antecedents. To some extent the World War II programs were acceptable because the peacetime U.S. military budget was so small. Mobilization was relatively sudden, and there was no backlog of existing programs with which the new ones had to compete; these new programs, however, did have to compete with each other, and that caused serious problems. In the context of a large, steady Defense budget, the JMVP could be attacked as too large (in money terms), too narrow (focused on safeguarding vehicles from roadside bombs and IEDs) and not being a program of record: it was new, suddenly born. These three “strikes” could easily have killed a program not backed personally by the Secretary of Defense; and it mattered that he was energetic enough to make his views count. To Gates, the JMVP was symbolic of the shift he wanted, to a wartime frame of mind within the Pentagon.

“Virtual” MRAP PM

In effect, Gates made himself the MRAP vehicle program virtual program manager, with John Young as his deputy. He called on the Marine MRAP vehicle program team leader, Brigadier General Brogan, to decide on the focus of the program and to generate the necessary support beyond the Marine Corps.¹⁶ Gates was not a micro-manager, but he accumulated knowledge at the micro-level; he understood the challenges and could evaluate what was being done to solve them. At that point a key question was what defense programs would have to pay for the JMVP as it grew.

Gates held, at a minimum, monthly meetings with all interested parties, including USD AT&L, Service chiefs, DOD Comptroller, and legal chiefs. All had to report what they were doing to advance the program. For example, he was personally involved in solving the transportation problems; U.S. Transportation Command (TRANSCOM) was asked how quickly the vehicles could be moved to theater. Gates also had an unusual capacity to handle detail; he would read and digest commanders’ reports of the results of firefights and of the status of the Humvee up-armor and MRAP vehicle programs.

In the Secretary's view, the JMVP was part of a much larger range of counter-IED programs that had to be applied not only to equipping troops but also to training them and developing their tactics. The program had to begin in the schools and at the National Training Center where units trained before deploying. The IED threat had to be inculcated into the mentality of the units in Iraq and then in Afghanistan. Secretary Gates considered the counter-IED program the great achievement of his tenure. This went far beyond JIEDDO, which had become too bureaucratic and routine.

Secretary Gates was aware at the outset that although the JMVP was joint in theory, in fact it was a Marine program with reluctant Army participation. There were several reasons the Army was holding back at the outset. First, it was encountering few underbody IEDs, and some senior Army officers were concerned that it focused on a yet-to-be-validated threat. Second, the Army Tank-Automotive and Armaments Command (TACOM) doubted that a few Marines could run a major vehicle program. Also, when the Army was given a large tranche of MRAP vehicle funding, it decided to buy out its GFE requirement rather than put the funding into new vehicles. That would have had enormous effects on the production program, which had been predicated on a large Army order. Secretary Gates considered Army resistance unacceptable, and he broke it. As a result, the Army became the largest MRAP vehicle user, since it had many more troops in Iraq than the Marines. That shift might have made the Army the program's lead Service, but Gates personally chose to leave the Marines in control because they had already been so successful.¹⁷

As the program grew into 2007, it expanded to the point where its many facets were beyond the direct control of the program manager. The Navy set up weekly conferences to ensure that all parts of the program were properly synchronized.

Gates knew that as the JMVP expanded it would have to take funding from established programs, when the program eventually became a program of record (POR) and transitioned from OCO funding, where it did not necessarily compete with other programs, to POM funding, where it did. They would resist. To make that work, he demanded progress data, and he held frequent meetings with those responsible for the program. The original Marine Corps team continued, but now that the JMVP was consuming large Defense Department resources, managers outside the Corps were involved, and they had to be coordinated with the Marines. The combination of Gates' authority and his personal involvement protected the Marine Corps acquisition team

from the sorts of internal Defense Department infighting they might otherwise have encountered. In any other environment a misstep by JMVP management would have made the program vulnerable, perhaps fatally so, to attack by those who had been forced to sacrifice for it. No one would have held back to admire the procurement courage of those inside the program.

Gates gave the JMVP a DX priority, but there was real opposition. The Army produced a laundry list of programs. It included a truck that had not been produced for a decade. The Joint Staff backed the Army. Even the Navy was unenthusiastic. It took Gates to force the issue. He was aghast that the Services could not see how vital MRAP vehicles were. For example, it helped that the OSD Office of Industrial Policy assembled a study of U.S. steel capacity that showed that the JMVP would not shut out other programs.

The DX rating made it possible for the program to demand that a contractor give it priority over civilian customers as well as other defense customers. The Defense Department has an industrial program intended to finance increased production of key items. In the case of run-flat tires, the only available sources were Michelin in France and Goodyear in the United States. Defense funds went into expanding Michelin's capacity and into qualifying Goodyear as a second source.¹⁸ Armor steel was another bottleneck. Sweden and Israel were major sources. Diplomatic exhortation increased the supply of Swedish and Israeli armor steel. None of these measures would have been possible without decisions at the level of the Secretary of Defense.

The MRAP program exemplified Gates' view that a CEO had to show up to prove that results mattered personally to him. Leadership mattered at every level. Those who failed should be fired, not quietly reprimanded. For example, Gates fired senior Army officers because they had failed at Walter Reed Hospital in Washington.¹⁹ He went there personally. He felt that only leaders who personally attack problems are likely to succeed: they showed that they cared, and they cleaned up the problems. So it was for the Joint MRAP Vehicle Program.

End Notes

¹ David Hansen interview. He counted four Undersecretaries of Defense for Acquisition, Technology, and Logistics; three Assistant Secretaries of the Navy for Research, Development, and Acquisition; and multiple Service chiefs and vice chiefs.

² Ryan McCarthy interview. McCarthy was the military aide to Secretary Gates.

³ Gates interview.

⁴ Gates recalled a key meeting on 2 May 2007 with the senior Department leadership, including the Secretaries of the Army and the Navy and the Chairman of the Joint Chiefs. He told them that he wanted to increase MRAP funding dramatically. There was no money as yet and no large-scale procurement plan. Those at the meeting showed no enthusiasm for the crash program he envisaged. That did not matter. The same day Gates issued a memorandum making the MRAP program his highest priority procurement program. He also told the Army to get on board. At this time the projected size of the program was 6,000 to 7,000 vehicles; a week later it was 25,000. It helped that Gates made it clear that he was going to Congress for additional funding, so that those at the meeting would not have to sacrifice their budgets. Once they realized that MRAP vehicles would be built in numbers, the Services provided realistic estimates of their needs. Dr. Gates sees the entire MRAP vehicle program as an excellent illustration of the need for a strong Secretary of Defense, who can break the peacetime mind-set of the Defense Department.

⁵ His examples were intelligence, surveillance and reconnaissance (ISR), medical evacuation (MEDEVAC), and Wounded Warrior care, all of which he counted as successes comparable to that achieved with the MRAP vehicle program. ISR in particular was closely related in that it was partly an anti-IED measure. In two years the ISR Task Force managed to expand Predator unmanned aerial vehicle (UAV) coverage in Iraq and Afghanistan from two to nearly 60 Predator orbits, offering something much closer to constant surveillance. That in turn would help deter those planting IEDs. It would also dramatically reduce the enemy's mobility, and it would support U.S. forces chasing the enemy. The Predators could hardly be everywhere at once, so the ISR program also funded aerostats (sensor-laden captive balloons) that could be flown over U.S. forward operating bases. They were seen both as a means of improving the bases' security and also as a deterrent to the enemy and an encouragement to those looking to U.S. and coalition forces for security. Another element of ISR was the Army's IEDN (IED Network) using adapted twin-engine King Air aircraft (called Liberties) in an attempt to find the IED makers so that SOCOM could destroy them.

⁶ John Young interview.

⁷ In response to Brigadier General Brogan's 1 May 2007 DX rating request, Secretary of the Navy Donald C. Winter formally requested DX priority in a 10 May 2007 memorandum to the Secretary of Defense. See the Edie Williams history, *op.cit.* He was responding to a 2 May 2007 request by Gates to provide options to overcome constraints in accelerating the program. The DX rating would address serious potential constraints in the forms of armor plate, axles, bearings, alternators, and other basic components. It would thus make a ramp-up of production possible. Given DX priority, it was predicted that the MRAP vehicle could produce 900 vehicles per month by December 2007. By this time the Secretary had already met with the Swedish ambassador to improve access to Swedish armor steel produced by SSAB Steel as a way of alleviating steel industrial base problems. MRAP vehicles were already using this steel, but it was going to other countries outside the coalition fighting in Iraq at the same priority. It took Gates to convince the Swedes to give the MRAP vehicle program a higher priority. The other constraint was money.

⁸ The SIG was an expansion of the Task Force concept to other urgent Warfighter requirements. From an MRAP vehicle program perspective, there was no change.

⁹ Hansen interview. Typical Task Force attendees were the DOD Comptroller, the Joint Staff's J-8, J-4, the Army's G-8, the head of TRANSCOM, and the Marine Deputy Commandant for Programs and Resources (DC P&R).

¹⁰ This did not apply to foreign entities that were vital to the program. As it happened, fortunately the Canadians, Israelis, and South Africans played along. French manufacturers (presumably primarily Michelin) gave the U.S. orders higher priority when asked to do so.

¹¹ This combination recalls the strategic missile programs of the 1950s, particularly the Polaris Fleet Ballistic Missile program, which came to be seen as a primary national priority.

¹² The beginning of the tire story is told in detail in a 26 June 2007 MRAP Task Force Update assembled by John Young (DDR&E). The initial question was whether Goodyear was capable and willing to make a tire that met all MRAP requirements, followed by the question of how quickly the company could be qualified and how quickly it could bring production on stream. It appeared that Goodyear could be qualified in eight months at a cost of \$1.5 million. After that it could produce 30,000 to 40,000 tires per month. At this time it appeared that Michelin could increase production (with additional investment), but it would still be a single point of failure, albeit one mitigated by the existence of multiple Michelin plants. It was assumed that ultimately there would be 25,000 MRAP vehicles. Goodyear was currently qualified only for Cougar tires. Michelin could ramp up if the U.S. government invested \$4 million in unique molds (6 month lead time). The estimated time line to develop and produce a new tire was lengthy: 180 days to test, 180 days to purchase molds, 60 days to produce and test. Tread life durability was 10,000 miles on paved roads, but only 2,500 miles in a severe off-road test. These figures set the requirement for numbers of tires. The estimated wartime replacement ratio was 140 percent (15 percent in peacetime), which meant

roughly six tires per year for a 4x4 MRAP. There was some good news: Goodyear already had a load range tire it thought was equivalent to the Michelin tire (but testing would be required to confirm that). Goodyear was already making FMTV tires, and it was ramping up production. Presumably the relationship between FMTV and Caiman suggested that these times might be suitable. None of the MRAP makers had contacted Goodyear, however. Goodyear estimated that it could produce as many as 122,000 tires per year. A comparison between Goodyear's LR G tire and Michelin's LR J showed that only Cougar used LR G (and was phasing it out), whereas all the others used LR J (except Buffalo, which used a different Michelin tire). To make matters more complicated, the Goodyear and Michelin tires had the same NSN numbers, which suggested equivalence. At this time MRAP was the only military user of the Michelin J tire.

¹³ The specific problem in the United States was P900 steel. Only a few foundries were qualified to make it. DoD paid to assist foundries to go through the qualification and testing processes so that they could produce it.

¹⁴ This point is emphasized in the Neuberger Draft analysis of MRAP vehicle program management. The document does not identify the manufacturer. Exempting MRAP vehicles from "Buy American" made it possible to use RG31s made in South Africa alongside those made in the United States.

¹⁵ Young interview.

¹⁶ Young recalled that Paul Mann and David Hansen were also involved, but Hansen doubts that he or Mann was in the room. Presumably Brig. Gen. Brogan relayed the request to them in the JPO. Mann was very much involved in bringing the Army on board.

¹⁷ As an indication of what was expected, the internal history produced in March 2008 by the JPO included a planned section on the shift to Army leadership of the program.

¹⁸ Some in the program believed that DOD also paid for a new Goodyear plant, but that was not true.

¹⁹ Gates interview.





CHAPTER 10

RUNNING THE PROGRAM

A program like the Joint MRAP Vehicle Program (JMVP) is run on several levels. One is the level inside the program, run by its program manager. He has to negotiate with other program managers or resource managers within his Service. The Marines are part of the Department of the Navy (DON), which provides their resources, so there are trade-offs within the larger DON program. Because the JMVP was always a multi-Service program, it had to work within the larger Department of Defense (DOD) arena. Even had it been limited to the Marines, it had to draw on unified command resources, the U.S. Transportation Command (TRANSCOM), for example, to get the MRAP vehicles from the assembly lines to Iraq and later Afghanistan. Because resources are always limited, there are inevitably tradeoffs between one program and another at each level. Even though the JMVP was being funded almost exclusively with Overseas Contingency Operations (OCO) funds,

outside the normal DOD budget, and therefore was not directly competing for budget dollars, resource trade-offs still had to be made. And negotiation requires staff analysis to support decisions.¹

Key People

At the outset, the two responsible Marines were Brigadier General Michael Brogan, who commanded Marine Corps Systems Command (MCSC), and his civilian Executive Director, Barry Dillon. Brogan represented the program in Congress, winning over key supporters, and at times Dillon met with key congressional staffers. In his view the key to congressional support was that the program lived up to the promises it made, both to the appropriators and to the Warfighters. Brogan later remembered his association with the MRAP program as the most rewarding three years of his professional life.

In the unusual case of the JMVP, the negotiation process was boiled down to decisions taken at executive meetings. Obviously those at the meetings had (and needed) staff support, but the staffs involved were given little scope to reassess the program, as might otherwise have been the case. The high-level meetings, moreover, enforced a sense of urgency. It mattered when Secretary of Defense Robert Gates issued his 2 May 2007 memo that made the MRAP program his “Number-One” Department-wide program. By that time he had already made sure that his senior subordinates were pressing ahead. On 8 February 2007, Undersecretary of Defense for Acquisition, Technology, and Logistics Kenneth J. Krieg issued a memo making the Navy Executive Agent for the MRAP vehicle program and expressing his intention to make the Commander, MCSC the JPEO. He envisaged rapid growth to an ACAT 1D program, with Army participation, and he asked for a formal document describing a joint acquisition approach within a month (by 15 March 2007). Note that assigning the Department of the Navy, a DOD Component (not the Service), as executive agent, was not the same thing as assigning Secretary Delores Etter, the Navy’s Assistant Secretary for Research, Development and Acquisition (ASN RD&A), the MRAP vehicle program’s Milestone Decision Authority (MDA).

Krieg signed his letter after Deputy Secretary of Defense Gordon England convinced him that the program would be effective—that the enemy would not be likely to win a predicted armor/explosive race. Limiting his chain of command to Dr. Etter made for

flexibility based on trust. As Deputy Director, Research and Engineering, (DDR&E) John Young could warn his RD&A successor of what to expect, and she in turn could warn the Secretary of the Navy. Once the program was running, the usual attendees at Etter's meetings included Claude M. Bolton, Jr. (a retired Air Force one-star who served as Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA AL&T)) and was the Commandant of the Defense Systems Management College (DSMC)), a representative of the OSD Comptroller office, Lt. General Emo Gardner (the Marine Corps Deputy Commandant for Programs and Resources (DC P&R)), Steve Daly (Defense Operational Test & Evaluation (DOT&E), Land and Expeditionary Warfare), and others, including a representative from the office of the Army Deputy Chief of Staff (G-8).

Krieg's designation automatically set up two layers of management. As Executive Agent, the Navy could call upon resources outside those of the MCSC, such as the Navy's SPAWAR (Space and Naval Warfare Systems Command) Systems Center Atlantic, the organization that ultimately integrated and outfitted the vehicles at Charleston. The Navy also provided funding from its overall budget. The MRAP Joint Program Office was staffed from MCSC and there was an Army component at Warren, MI, staffed from a variety of organizations at the Army's Tank-Automotive and Armaments Command (TACOM).

At the outset, the funding for each Service's MRAP vehicles, by law, had to come from appropriations supporting that Service. Managing those funds was very complicated, and required the use of the MRAP Transfer Fund, a highly unusual non-Service appropriation that provided temporary "parking" for MRAP funding, pending transfer to a specific Service appropriation.

A Synchronized Approach

Once Krieg designated the Navy as Executive Agent, Dr. Etter exercised her responsibility by holding weekly "synchronization" meetings whose frequency and high level greatly reduced the level and depth of staffing required at the Navy level. In that indirect way they enormously speeded the program, because they were able to take decisions rapidly. Dr. Etter's synchronization meetings predated the MRAP Task Force meetings and produced the rapid decisions needed, a process that would continue with the Task Force. The Army saw the meetings as discussions of what should be sent on to

its staffs for further consideration, rather than as Etter's quick way of reaching essential decisions.

This was an extraordinary approach, justified because the MRAP vehicle program was considered so urgent. All of the decisions reached in the synchronization meetings involved trade-offs between different programs. ASN RDA had to manage those tradeoffs, and normally Dr. Etter and her staff would have made those decisions after a lengthy staffing process. Staffing would have revealed advantages and disadvantages of any particular choice. Avoiding or compressing staffing involved risk; what was special about the MRAP vehicle program was the perception that delay was an even worse risk. Normally the executive office running the program would have circulated the program manager's requests and each recipient would have dealt with them separately. Every decision made would affect other programs, and their reactions would have to be taken into account. This web of connections makes it difficult to move any large program rapidly. Dr. Etter assembled every manager involved in one room to make decisions. Every objection could be raised and every suggestion put forward. But all of that happened once and only once, and by the end of the meeting firm decisions emerged. It was tacitly accepted that they might not be the best conceivable ones, and that in this case relatively quick firm decisions were far better.

The procurement regulations explicitly advocate accepting 80-percent solutions rather than seek perfection. In practice it is very rare for anyone to explicitly accept that idea; managers naturally aspire to something better. Etter's meetings were an implicit application of the 80-percent idea.

Moreover, Etter realized from the outset that the MRAP vehicle program would involve many decisions she could not approve, because they had to be made by organizations, such as the U.S. Transportation Command (TRANSCOM), outside of her jurisdiction. They could all come together at her meetings. She made it a rule that only individuals who could sign off then and there for their organizations should attend. Some flag officers attended by video link. That made it possible for decisions to be taken on the spot. The Army was initially very reluctant to join the program, sending only lieutenant colonels. Dr. Etter wanted real contributions, so she tried to convince the Army to allocate sufficiently senior people to ensure that its interests were taken into account. At least at first she got all of two officers. Most of the time Air Force representatives attended, and often the Coast Guard also attended.

Dr. Etter began to run the synchronization meetings in January 2007, once the MRAP vehicle program reached Milestone I (now Milestone A), and regularly held them on Fridays at 3 PM. As a measure of the importance Dr. Etter attached to the program, she appointed a Senior Executive Service staff member, Elaine McCusker, with responsibility specifically for the MRAP vehicle program. Ms. McCusker was critical to the success of the meetings. She set up the agendas and she also produced a one-page document that showed program progress and thus indicated what crucial problems had to be solved.² It encouraged participants by showing how many lives MRAP vehicles had saved. Eventually it included a map showing how many vehicles were in various stages of the program—in production, in test, in theater—which became commonly known as “The Pipeline Chart.” Indeed, the most important metric that was tracked in every one of these meetings was “MRAPs fielded.”

The synchronization meetings continued after Defense Secretary Gates and the OSD staff became directly involved in the JMVP in mid-2007, but they became less essential. By that time, a great deal had been done to shape the program. In effect, the OSD MRAP Task Force meetings subsumed the work done at the synchronization meetings, but the latter continued to work out allocations of vehicles among the Services. The OSD Task Force was concerned more with keeping the program moving as fast as possible.

The major contrast between the RDA synchronization meetings and the Task Force meetings was the speed with which decisions could be reached. The object of the synchronization meetings was to obtain all decisions on the spot, for maximum speed. The Task Force involved more stakeholders, and decisions became more difficult as the program grew. It was virtually impossible for them to be reached as quickly. However, by normal standards the Task Force did get its work done very quickly, because the typical lag between raising a question and reaching a decision was a week.

The mechanism of agreement was also different. Dr. Etter had limited authority and had to gain consensus. Everyone in the meetings came to understand how important the MRAP vehicle program was, and the individuals involved wanted not to delay it. That encouraged them to decide quickly, and to abide by their decisions. It was probably Dr. Etter’s great achievement that she created and maintained this attitude among those who had to reach agreements at her meetings. The OSD Task Force was different. Secretary Gates saw it as a way of assigning responsibility to force quick action. He did

have the ability to hold senior decision-makers in the Defense Department accountable, and it was probably instantly clear that he intended to use that power. It helped of course that many of those present appreciated the urgency of the problem.

Keeping Track

In all of these groups, a key element was a way of tracking the progress of the program. Lt. General Gardner worked one out. Early in 2006 he saw the growth of the IED problem in Iraq and went directly to Commandant of the Marine Corps (CMC), General Michael W. Hagee, to press for action, which within a few months resulted in the MRAP vehicle program. He appreciated from the outset that the challenge would be to produce vehicles in sufficient numbers. Gardner's experience with a large Marine Corps barracks-building program convinced him that a properly handled program could move rapidly.³ At the time he was the Deputy Commandant responsible for the Marine Corps Programs and Resources office (DC P&R). Gardner had been involved in an aviator-training program called "Street to Fleet." It visualized the process as a step-by-step pipeline, broken down into small steps each of which could be identified. The number of people at each step could be measured, and the efficiency of the entire pipeline understood.

Gardner adapted this pipeline technique to track the progress of the MRAP vehicle program, in terms of vehicles at each stage of production, outfitting, and transportation to the theater. The whole process was broken down into steps, each of which could be measured. The pipeline approach made it possible to set targets and to evaluate the time vehicles spent at each stage. Bottlenecks became visible. For example, production at armor plants could be tracked. This kind of tracking made it possible to balance the needs of the MRAP vehicle program with those of other programs that had to sacrifice critical materials, such as armor. The entire MRAP vehicle fielding process could be optimized. For example, it was pointless to force up the production rate at SPAWAR Charleston only to have vehicles pile up on the ramp, waiting for transportation. Similarly, productivity at Charleston had to be matched to productivity at the factories making the vehicles.

Etter's staff initially rejected the MRAP vehicle production request on the grounds that documentation was not mature enough to support a Milestone I decision. On that basis

she doubted her authority to buy hundreds of vehicles (the original proposal was for about 400).⁴ Normally producing the documentation would have taken weeks or more. Instead, Paul Mann, the Program Manager (PM) and his staff spent Thursday through Sunday putting together a formal plan that could justify the initial production decision. This “hard overtime” made it possible to meet the standard documentation requirements much more rapidly than anyone outside the program imagined was possible.

When the first vehicle, a Cougar, passed its tests at Aberdeen, Mann said the way to spark industry was to order a thousand (he had 70). Dr. Etter was unhappy, she recounts: “We don’t even know this will work.” In April 2007, she told Brogan and Mann to forget about the thousand. General Gardner heard about this, and talked to her. Gardner directed Mann to rebrief Dr. Etter, which resulted in her agreeing to buy a thousand vehicles.

That lit a fire under all manufacturers. FPI, which made the Cougar, said that it could produce its thousand in four months, and Mann wanted every truck he could get if the “surge” occurred. The model for production award was to ask each manufacturer how many trucks it could produce (assuming it passed the test). This order was a major turning point, because it told industry that the MRAP vehicle program was serious. There would be no further small purchases of EOD trucks...70 here...30 there.

Management Issues

As in any other program, money was the hydraulic fluid that made it work. The MCSC already had another U.S. Navy Aegis “graduate,” Michelle Cresswell, on board. Since leaving the Aegis program in 2004 she had been strategic and business manager for The MCSC Ground Transportation and Engineer Systems (GTES) division, the MCSC arm that managed the MRAP vehicle program.⁵ As such she was involved in up-armoring, Hardened Engineer Vehicles (HEVs) and Joint EOD Rapid Response Vehicles (JERRVs) in 2006. She did some innovative things to get the necessary funding for up-armoring. Before joining Aegis, she had worked for ten years as a contractor, so she understood both the government and the contractor sides of a program.

Cresswell was particularly adept at presenting financial data; one participant said, “She made it all look so easy.” Her long experience had shown her that few program

managers had any idea of how funding worked. Early in the program she created formats with which to present the data so that all concerned could see what they had and what they needed. Her charts showed what the technical changes had been since the previous briefing, and what the current situation was. She used simple transparent cost-estimating methods. This was exactly what was needed in Etter's synchronization meetings and the OSD MRAP Task Force. Congressional leaders appreciated the presentations, which enormously boosted the program's credibility on the Hill. Congress gave the program the money it needed not only because the need was urgent but also because it could see why particular funds were needed to address that need. Cresswell would soon become the MRAP vehicle program's Budget and Finance Manager (BFM).

A few months after Dr. Etter began her meetings, Secretary Gates set up the OSD Task Force to run the MRAP vehicle program as a kind of super-executive agency. Initially there was an inherent mismatch between his level of management and hers, as she considered that he should be concerned with overall policy, not details. But, Secretary Gates wanted details, and eventually the dual level of control worked well. Those involved in the Task Force felt that Dr. Etter's level of management lacked the authority and status within DOD to tackle the larger joint logistical issues raised by MRAP vehicles, not just transportation to theater but also acquisition of much of what was needed. For example, it took OSD to obtain enough armor steel and enough run-flat tires to keep the vehicles flowing.

The OSD Task Force came on the scene at the same time that Secretary Gates ordered the Army to participate on a large scale and thus enormously expanded the scope of the MRAP vehicle program. This expansion in turn made the original JPO concept of sustainment by direct contractor support impossible. There just were not enough spares or enough maintainers, and the solutions to these problems included the creation of "MRAP University" (MRAP U) for training and also an enormous effort by the Defense Logistics Agency (DLA) that was responsible for stocking spares. Particularly key at DLA was then-Brigadier General Patricia E. McQuiston at the Columbus, Ohio command. MRAP vehicles consumed spares at a particularly high rate because most times they encountered IEDs their chassis and suspension were blown off and parts such as transmissions and radiators were destroyed. The OSD Task Force provided the support necessary for DLA to take revolutionary steps to solve the spares problem, and also for the JPO to change the basis for MRAP vehicle sustainment in theater. That

could only be done at the OSD level, because DLA is a Defense Department agency, not a Service agency.

DLA's task was difficult. There was no experience on which to base predictions of how many of which parts would be needed. The task was complicated by the enormous variety of MRAP vehicles, and the size of the MRAP fleet kept growing very rapidly. The parts involved had never entered DLA's system, hence were not stockpiled. For example, the disc brakes used by the various MRAP trucks were not catalogued. A truck might need only a brake, but if that was not standard, DLA had to order an entire new axle. One of the major program challenges was to build up the necessary logistical base. It did not help DLA that the MRAP vehicle program was a moving target, because it kept modifying vehicles to make them more survivable.

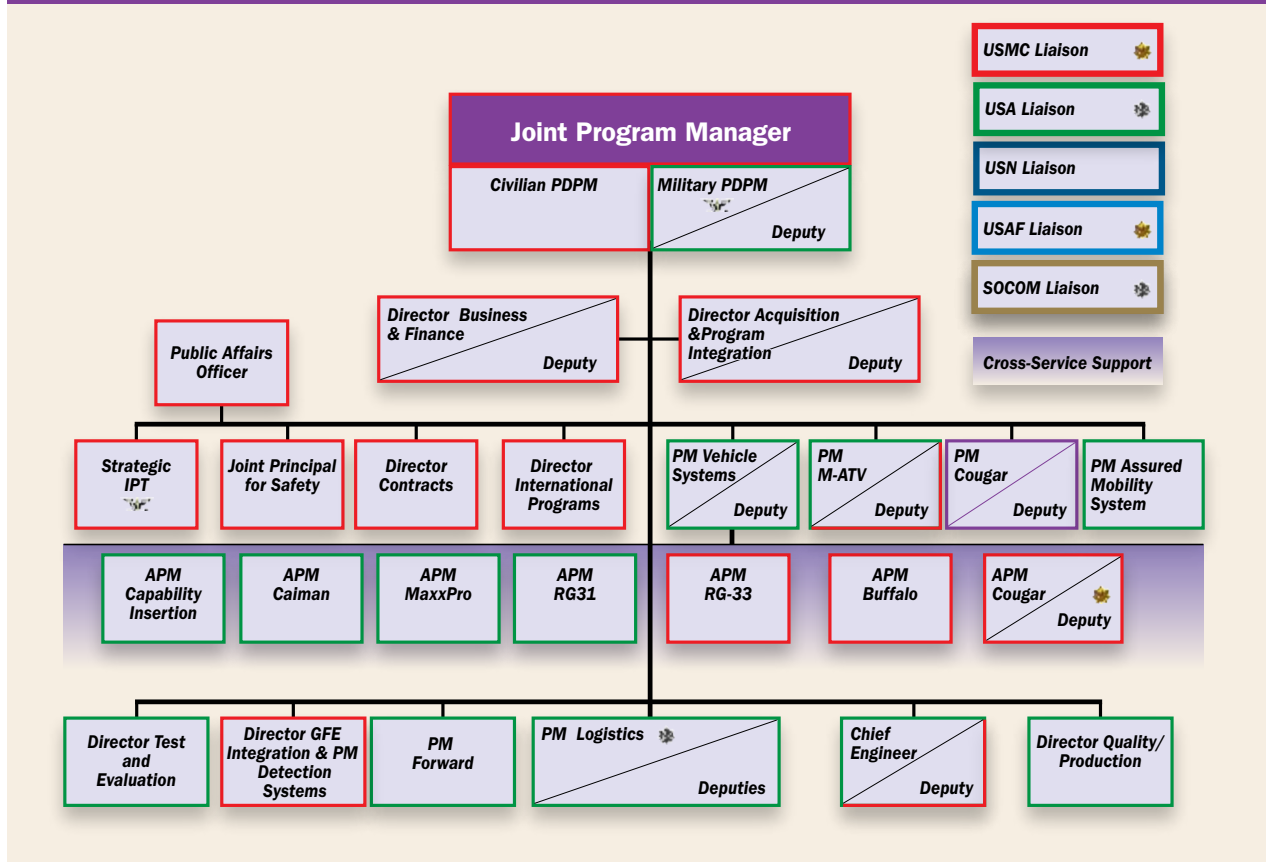
Initially, the expectation was that the vendor spares packages were all that would be needed, and if more were needed, they would be procured directly from the vendor who would create and manage spare parts inventories.⁶ This was the way that spares had been managed for all previous MRAP vehicles. When the size of the fleet quickly outgrew this approach, there was no existing DOD logistics system to take its place. DLA stepped into this vacuum, and had inherited a difficult job. The Army at TACOM later came on line and did the real "heavy lifting" to create a long-term, fully sustainable logistics system.

These were very much the spectrum of issues it took the OSD-level Task Force to resolve. There was a real trade-off between what might be needed to keep vehicles operating in theater and what was needed to keep them survivable as the enemy ramped up the threat. If MRAP vehicles required significantly greater logistical effort than more conventional vehicles, some other vehicle program had to pay for that, in terms of reduced logistical support. Someone had to decide. The OSD Task Force made those decisions.

Multi-Service...Joint...

Although the MRAP vehicle program began as a Marine Corps program, it was always envisaged as a joint program, because it seemed clear from the outset that the Army and probably the other Services would become involved. The Marine Corps part of the program, which centralized decision-making, was based at Stafford, VA, near the

–Figure 5–
JOINT MRAP VEHICLE PROGRAM OFFICE – 2009



MCSC headquarters at Quantico. The Army element was in TACOM at Warren, MI. At its peak, Stafford/Quantico had about 115 government employees supported by 250 contractors; Warren had another 300 government employees supporting the JMVP. Figure 5 illustrates the JPO organization in mid-2009.

There was no formal chain of command authority from MCSC to the JPO's Army arm in Michigan. There was never an agreed manning document between the Marines and the Army; everything was based on a handshake agreement. The JPM was a Marine; his deputy was an Army colonel or civilian. This was ad hoc, grassroots-up jointness, not the more usual top-down enforced jointness. The JPO office at Warren functioned as part of the MRAP JPO, and it was responsible for three of the MRAP truck variants. This ad hoc jointness worked very effectively, due in large part to the personnel chosen at both ends of the JPO.

At the outset the Army was unenthusiastic, but once the program was moving, it bought in. (Secretary Gates was doubtless an important reason why, although he kept overall management of the program with MCSC.) Note that the Army is normally the lead Service for wheeled vehicles, and it has a much larger truck program than any other Service component. Ultimately it received 20,801 MRAPs of various types, compared to 4,053 for the Marines, about 815 for the Air Force, about 690 for the Navy, and about 1,000 for SOCOM.

Speed of execution required flexibility. Budgeting is normally the opposite: it is a deliberate policy and process that translates predicted needs into allocated funds within a more or less fixed budget. Normally the national defense budget is allocated on a line item basis among the Services. These lines might include numbers of MRAP vehicles for each Service, and normally flexibility would amount to allowing the Services to reallocate numbers among themselves.

That turned out not to be good enough. Because MRAP vehicles were heavily equipped, its funding included both the basic trucks and their government-furnished equipment. The Army provoked a crisis when it decided to use most of its MRAP money to buy out its planned total GFE rather than to buy vehicles. The program had already allocated the considerable Army MRAP vehicle budget to pay for production. If the money were not forthcoming, the manufacturers would be unable to continue. The whole program would collapse, because from the outset it had assured rapid growth by ordering more than it could immediately pay for, depending on congressional assurances that money would be forthcoming. Congress was certainly good for the money, but the money was still provided on a line-item basis.

Transfer Fund Flexibility

The MRAP vehicle program managers went to Congress for relief. The appropriations committees took an unprecedented step.⁷ They established an MRAP Transfer Fund within which OSD Comptroller, Robert Hale, enabled MRAP JPM Paul Mann to allocate resources as necessary, based on requirements. Senate Appropriations Committee ranking minority member Senator Ted Stevens and Senator Daniel Inouye personally put the new arrangement into the 2008 Defense Appropriations Bill. Stevens was a WW II Army Air Forces veteran, and he understood what was at stake: too many Soldiers and Marines were being killed or maimed by IEDs. He had spent enough

time in Iraq to see what was happening. Secretary Gates went personally to the Hill to support the idea.

The congressional committees were impressed by the simplicity of the solution, by the broad industrial base, and by the speed of execution. Several Services, particularly the Army, were not as pleased: MRAP trucks were big, heavy, and cumbersome, and everyone understood that configuration management might be a nightmare. But everyone in the committees also understood that there was finally a solution to the IED problem. The Transfer Fund centralized responsibility and decision-making, and thus made the program run more efficiently. It was also an unprecedented relinquishment of the usual congressional control over appropriations.

The Transfer Fund happened because the Committee came to trust and respect the rather junior (GS-15) program manager, Paul Mann, his BFM, Michelle Cresswell, the team they had assembled and the results that team had produced. Mann spent time visiting his contractors and listening to their concerns. The committee members heard, too. For instance, Senate Appropriations Committee professional staff member, Kate Kaufer, understood the focus on the mission and self-discipline: the Fund would not be misused. To ensure this, Congress imposed a ten-day waiting period on decisions to take money from the Transfer Fund. Still, it was “speed of light”—or perhaps more appropriate, “MRAP Speed”—budgeting.

In establishing the Transfer Fund on its own initiative, the Senate Appropriations Committee recognized that this approach could not be applied to a broader and less defined program, such as the Joint Improvised Explosive Device Defeat Organization’s (JIEDDO’s) Counter-IED initiatives. The narrow scope of the MRAP vehicle program made it reasonable to leave choices to those within the program. Moreover, by this time the MRAP vehicle program management had established a level of trust with the committee that justified the creation of the flexible fund (“colorless money,” that is, not R&D, acquisition or operations and maintenance funding). The Committee did exercise control in one important way. It wanted to keep the program finite, to set a sunset date so that it was not creating something self-perpetuating. So it eventually asked the DOD when troops were likely to come home, when production would likely be complete. The Committee and the Department agreed that the joint program and

its special fund would disappear after a set date, 30 September 2013. After that MRAP vehicles would be the responsibilities of individual Service components.⁸

The Transfer Fund greatly simplified running the JMVP, and it must seem an attractive way of running many others, particularly complex joint Service programs. What is less obvious is that the Fund was created only after the Senate Appropriations Committee came to appreciate how well the program was being run, and so came to trust its leadership.

The Transfer Fund seems to have been unique, at least in the world of normal defense programs (there might have been a parallel in the intelligence world).⁹ Through FY 2012, the program spent a total of \$46.6 billion to buy 27,702 vehicles, mostly between late 2007 and January 2011. All had bought in by 2009. All had become convinced that the program was too urgent to be worth a few weeks' delay due to negotiation among the Services; allocations were worked out after vehicles were ordered. Although all of the Services were involved, the Transfer Fund ensured that the entire program would be centrally executed, because the money all came out of the Stafford/Quantico program office.

When the Services finally accepted that program execution had to be centralized, when the need was most urgent in 2008-2009, they found that it could take up to ten days for one of the Services to release money. The program office could not wait that long to let contracts. The Services found that they did not suffer; they were brought in quickly enough, and the program was flexible enough to reallocate vehicles as needed. For their part the Services had enough other priorities to be glad to be free of the responsibility to allocate funds in detail. Once they had validated their requirements, they found that the JPO could get money to meet them within 24 hours. For example, on 16 November 2010 the JPO received a letter from the Under Secretary of Defense asking for 250 wreckers (recovery vehicles), a type not previously produced. They were on contract three days later. Congress was briefed (by phone). All was in order.

End Notes

¹ Brogan interview.

² Dr. Etter had hired Ms. McCusker out of the professional staff of the House Senate Armed Services Committee, initially as her assistant for programs connected with the Global War on Terror. After three days of the job, however, she assigned McCusker full-time to the MRAP vehicle program. McCusker had gained considerable experience on the committee staff in preparing the sort of extremely concise summaries that senior senators needed. Their needs were very similar to those of the senior decision-makers who attended the synchronization meetings and later the meetings of the OSD Task Force. McCusker interview.

³ Gardner interview.

⁴ Dr. Etter's hesitation exemplifies the "chilling" effect of the applicable procurement regulations. The details of the wording allow for considerable latitude, but no one faced with the mass of regulations will lightly go from what is recommended to what is allowed. Etter wanted clarity, and she therefore needed her lawyers to explain just how much flexibility she had. Most administrators would not have gone anywhere near so far. The personal courage demonstrated here was critical to the program's success.

⁵ Many of the original MRAP personnel came from GTES, as might have been expected. The program management did not so much choose those it took on board as reject those who came on board but turned out not to be compatible with its schedule and operating style. Program management was acutely aware that it had to avoid penalizing anyone who had to leave for this reason, as otherwise it would have been very difficult to form the necessary like-minded MRAP JPO community.

⁶ The contracts with the vendors were set up for direct contractor logistics support (CLS). They lacked the contract line items (CLINs) that would have permitted the MRAP program simply to order what was needed for organic support.

⁷ Kate Kaufer interview.

⁸ Kate Kaufer interview. David Hansen recalls having to sell the committee on the idea of a sunset date, which was connected with his concept of a transition from the special circumstances of the MRAP JPO to more normal Service-oriented programs. He also recalls that the OSD Comptroller preferred the Transfer Fund, because it concentrated all MRAP fiscal information in one place.

⁹ William King interview.





CHAPTER 11

OUTFITTING FOR NETTED OPS

At the outset, no one in the MRAP vehicle program realized how much government-furnished equipment (GFE) was involved, which is one reason that many in the program think of an MRAP vehicle as little more than an explosion-resistant truck. In fact, it was a protected *fighting* vehicle, in much the same sense that an armored personnel carrier is, and in much the sense that the earliest tanks were. MRAP vehicles, including the later M-ATVs, became the armored personnel carriers, and often the command vehicles, of the Iraq and Afghan wars.

Vital Technology

From the outside, an MRAP vehicle might seem to be no more than a truck with a machine gun turret on top. However, the MRAP vehicle program coincided with a

massive jump in the sophistication of tactical vehicles. That meant not just the radios of the past and the jammers developed by the Joint Improvised Explosive Device Defeat Organization (JIEDDO), but also, for example, the new situational awareness technology (land navigation and blue-force tracking) and infrared (IR) sensors. There was also an intercom. There were more electronics in an MRAP truck than in a contemporary tank. The Army and the Marines agreed to standardize some GFE (e.g., turrets and intercoms) and to maintain the ability to interchange jammers and radios, but in the end each Service and the Special Operations Command (SOCOM) had its unique requirements. In all, there were about 300 different vehicle configurations. (Appendix A provides information on many of the major variants.)

The war in Iraq and later the war in Afghanistan could not have been fought without this technology, which made it possible for those in a single vehicle or a small group of vehicles to understand where they were in relation to other units and to the enemy, as revealed by other units and by robot sensors such as those aboard an unmanned aerial vehicle (UAV). The same technology made it possible to call in air and other support. All of this meant that outfitting an MRAP vehicle was anything but simple.

From a command and control (C2) point of view, the MRAP vehicle represented a significant improvement for a new kind of netted operation. Past practice had been to locate command and control at a fixed center, with vehicles having radios so that they could receive commands and report to the command center. The MRAP vehicle, on the other hand, was part of a generation of vehicles that could function as individual, mobile command centers.¹ Operating in a convoy, often at night or in poor visibility, the individual MRAP vehicle also had to be linked to its surrounding vehicles, and radios all had to have back-ups. There was of course considerable debate as to how much to put on board each vehicle, but the base requirement was substantially greater than in the past. Much of this technology had been developed by the Army for its Force XXI program, exemplified by its new wheeled-combat vehicles, such as Stryker. However, Strykers could not operate freely in Iraq because they were far too vulnerable to bottom-attack IEDs. That made MRAP vehicles vital.

The core of the system was the Blue Force Tracker (BFT), whose screen told the viewer where friendly (“blue”) forces were. It had been developed as part of the Army’s Force XXI Battle Command, Brigade and Below (FBCB2) system. BFT was associated with a global positioning system (GPS)-based land navigation system, as a vehicle had to know

where it was both to use the picture of where blue forces were, and to report its own position to keep the blue force picture updated. All of this was done through a satellite link, which meant that the vehicle had to have antennas with clear upward views. The other elements of the vehicle command and control system were smart displays, radios, a communications interface unit (CIU), and a video and data distribution system (VDDS). Vehicles were integrated into networks using digital links. There was also a SIXNET Ethernet switch (the network that ran the BFT was an Ethernet). Video screens could also be used to enhance vehicle survivability by providing those inside with a better view. Thus vehicles had an IR camera called a Driver Vision Enhancement (DVE), which enabled a driver to operate at night without showing headlights.² They had rear-vision devices called a Check 6 Situational Awareness and Security System, initially in the form of two rear-view cameras molded into the taillight housings. Some vehicles also had gyro-cam, a rotating camera on a pole to give 360-degree vision around a vehicle.

The Marines had unique communications, and were particularly determined early on to give all their MRAP trucks command and control capability. The Army later followed much the same path, but with its own networks and radios.³ Vehicles had intercom-radio access systems that allowed each crewmember to monitor both an intercom (vital for coordination in the noise of combat) and radios.⁴

Air Force Challenges

The Air Force, which used the vehicles mainly to control air strikes, presented the greatest outfitting challenge, because it needed the most complex electronic outfits. Some of its vehicles had as many as 27 systems because they had to talk with the Army, with Army aircraft doing surveillance, with other U.S. and coalition forces, with the Army's Enhanced Position Location Reporting System (EPLRS) situational-awareness system, with computers, and the like.⁵ The Air Force's success whetted SOCOM's appetite for greater complexity and communication power, at least partly because a small SOCOM team riding an MRAP vehicle gained so much of its firepower from its ability to call on external resources (and gained so much of its situational awareness via resources such as specialized drones).

MRAP trucks made useful scouts because they were so well protected. To be effective in this role, they were sometimes fitted with the Long-Range Scout Surveillance System

(LRAS 3), which was intended to permit them to conduct surveillance while remaining outside an enemy's own threat acquisition and engagement range. LRAS 3 was conceived very much as part of the new integrated combat system. It used GPS to tell where its own vehicle was (and, using a ranging laser, to tell exactly where an enemy was), and it was designed to export location coordinates into the ground combat system, FBCB2, of which the blue-force tracker was also an important element. The sensors were optical, including IR.⁶

All of this was in addition to devices intended specifically to deal with the enemy, both his IEDs and his ambushers. There were a variety of JIEDDO-produced IED jammers, whose antennas had to sweep the road ahead of and alongside a moving MRAP vehicle.⁷ There were also Rhino and Self-Protection Adaptive Roller Kit (SPARK). Rhino, which looks like a giant horn, was intended to detonate IEDs at a safe distance ahead of the vehicle.⁸ SPARK was a set of rollers a vehicle would push with the objective of detonating mines and IEDs.⁹ Together, Rhino and SPARK were expected to deal with mines that could not be jammed and which were not remotely detonated. Some vehicles had Boomerang, a sniper-detection system, which was associated with the upgraded Crew Remote Optical Weapon System (CROWS II) remotely operated gun (the gun would automatically engage a sniper located by Boomerang).¹⁰ Vehicles were provided with a special rear-view camera called Check 6: it consisted of a taillight combined with an embedded Forward Looking Infrared (FLIR) (camera). The camera display was the existing DVE display unit.¹¹

Some vehicles had the Improved Target Acquisition System (ITAS) and the associated TOW wire-guided anti-tank missile. All of this equipment changed over time. It required a power management system, and vehicles needed periodic upgrades of their alternators to maintain sufficient power.

Some vehicles were given fittings for massive slabs of explosively formed penetrator (EFP) armor, although in practice it was rarely carried, particularly in Afghanistan. Much more frequently used were countermeasures to rocket-propelled grenades, whose shaped charges were a small-caliber equivalent to a massive EFP. The usual measures were bar armor and nets.

The most visible piece of GFE was the machine gun turret atop the vehicle. The Services differed as to whether it should be covered. The Marines in particular wanted the top of the turret to be open, because they used the gunner as a lookout. Initially

they used their own Marine Corps Transparent Armored Gun Shield (MCTAGS) turret; ultimately the program standardized on the Objective Gunner Protection Kit (OGPK) turret. The major change, for most vehicles, was from a manned turret to a turret controlled remotely from inside the vehicle, the Crew Remote Optical Weapon System (CROWS).¹³ Seating had to be changed so that the gunner would face forward, giving him the same orientation as the vehicle. Otherwise it might be difficult for him to use his screen.

MRAP vehicles were very tall, and in Iraq they sometimes fouled power lines. To avoid that, they were fitted with masts carrying horizontal Overhead Wire Mitigation (OWM) wires that would keep the power lines clear.¹⁴ Despite being fitted with more powerful alternators (570 amps by 2009), their mass of electronics and air conditioning could overload the power supply.¹⁵ MRAP vehicles also had winches. Overload Interrupt (OLI) devices were added to cut off power at a preset amperage set to the overload capacity of the winch.¹⁶ And, there was other manufacturer-furnished equipment, such as an automatic fire suppression device. Considerable effort also went into special lighting.¹⁷ Another safety measure was a special rollover-warning device.¹⁸

Outfitting changed not only to accommodate new equipment (such as new radios and jammers), but also as experience taught lessons. For example, at the outset it was assumed that those riding MRAP trucks would want to fire out the sides. Vehicles were given rifle ports and rifle racks. It turned out that neither was wanted, and the rifle ports were a source of vulnerability, although they were specified and used on some SOCOM vehicles. Internal communications had to be fixed; everyone inside had to have earphones. Escape hatches had to be added, and heavy armored doors powered (door assist) so that troops could escape, particularly if vehicles rolled over.

Within the program, all of the post-production additions, done either during outfitting or in theater, were described as Capability Insertion (CI).

The MRAP vehicle was not unique in carrying a lot more electronics than previous vehicles. Before there were any MRAP vehicles, the Humvees assigned to Iraq and Afghanistan carried considerably more electronic equipment than their predecessors. Typically each Humvee had up to four major pieces of electronic equipment: a blue-force tracker (situational awareness) with a GPS receiver so the vehicle knew where it was; one or two radios (sometimes including satellite communications); an intercom; and an IED jammer.

The Humvee experience showed that some formal outfitting process was needed. Initially up-armored Humvees arrived in theater without electronics, and what they received (and where on the vehicle it was fitted) depended on the order in which those from different programs got access to each vehicle. Different equipment could and did interfere. Where an antenna is located on a vehicle determines how well it works, whether its signals affect other equipment, and even whether it will receive or send signals in some directions. In some cases signals reflecting off parts of the vehicle will interfere with those an antenna receives directly, ruining the performance of whatever is attached to the antenna. How well equipment worked in service also depended on how well controls and displays were arranged internally. There is a world of difference between a thought-out integrated design and a random combination of elements “kluged” together.¹⁹

Critical SPAWAR Support

Formal involvement of the Navy Space and Naval Warfare Command Atlantic Systems Center (SPAWAR Charleston) with the up-armored Humvees began in the summer of 2005.²⁰ Humvees were shipped from the manufacturer (Armor Holdings) to SPAWAR to be outfitted using designs developed there, then shipped to theater. That became the model for MRAP vehicle outfitting, though the scale for MRAP trucks was vastly greater. Ultimately 2,400 up-armored Humvees passed through SPAWAR. This program was the foundation of the later MRAP vehicle outfitting program, and it energized the SPAWAR work force. It made a considerable difference that about 30 percent of the work force had a personal connection with the wars in Iraq and in Afghanistan. Later, those who received the MRAP trucks (and were saved by them) wanted to meet the workforce and tell them how grateful they were. Indeed, this kind of personal feedback was characteristic of the entire MRAP vehicle program. The Humvee integration program was just shutting down as the MRAP truck program came on stream.

As there were 17 different Humvee mission packages integration did not go smoothly at times, even when SPAWAR was designing it. SPAWAR found itself reconfiguring radios and BFTs, and even then they sometimes did not work. The first jammers were liquid (Freon)-cooled, and SPAWAR found itself diverting vehicle air conditioning lines to add that function (later jammers were air-cooled). It had to hire specialists in air conditioning (cooling) and welding to deal with the piping involved. SPAWAR had

never needed welders before; at the peak of MRAP vehicle integration, it had 50 of them. This Humvee-driven hiring proved very helpful as the MRAP truck outfitting program geared up.

None of this had really been a problem in the past, when the electronics on a vehicle typically amounted to a single radio.

Given their early experience with the Humvees in Iraq, the Marines asked SPAWAR to help. Its facility in SPAWAR was responsible for Navy ship electronic arrangement. SPAWAR Charleston had long pre-Iraq experience in the integration problem, albeit on a much larger scale, on ships. It was well aware of the way in which the metal of a hull, not to mention the reflection of the water surrounding a ship, affected the performance of the individual radios and other transmitters and receivers on board. There is a reason why performance charts for radars are marked “free space” rather than “on board a typical ship.” The same logic applies to a BFT (which is essentially a radio receiver plus a computer) on board an MRAP truck. Outfitting design required specialized testing, because it was impossible to predict interference based on computer models; the situation was far too complicated.²¹

With the advent of high-powered IED jammers, it was also necessary to measure radiation strengths so that occupants of vehicles were not subject to radiation hazards (RADHAZ)—something new in the wheeled vehicle (but not combat vehicle or ship) world. Radiated power had to be optimized, to make the jammers as effective as possible, without endangering the occupants.

In the case of a vehicle, test gear was initially walked around a vehicle to measure interference patterns. Later the Marine Corps gave SPAWAR Charleston funding to build a specialized test facility at nearby Poseidon Park. It has a turntable and a standoff building, so that near and far antenna patterns can be measured.

When it was stood up, the MRAP vehicle program looked for a location to integrate and outfit its vehicles. It was to SPAWAR’s advantage that it looked upon MRAP truck integration as a serious large-scale project.

Humvee integration was not nearly as complex as MRAP vehicle integration, which became the number-one priority at SPAWAR Charleston. Its first experience with what

became the MRAP vehicle program was when the Navy's explosive ordnance disposal (EOD) program asked it to integrate its Joint EOD Rapid Response Vehicles (JERRVs), which evolved into Cougars. Compared to a Humvee, a JERRV added communications channels and also added facilities to remotely control an EOD robot, which meant additional communication channels to and from the robot. That meant more command, control, communications, computers and intelligence (C4I) space and more power. Increased demands for C4I were met in theater, incurring the same problems that the Humvees had originally had. For SPAWAR, the JERRVs were a small job; they were integrated in the parking lot, and then sent on their way.

The MRAP vehicle program added a new requirement. Outfitting design also had to take account of the need to protect those inside from blast and from possible injury due to the equipment inside, if it were dislodged by blast or if the occupants collided with it due to shock and blast effects. Even cutting holes in the side of a vehicle to install antennas could affect its performance under the effect of an explosion.

Given the sheer number of MRAP vehicles, it also became necessary to rapidly prototype configurations so that training manuals could be produced and installation problems solved. Typically SPAWAR Charleston found itself producing heavily illustrated 200- to 300-page manuals; it learned how important pictures were to an installer in the field. Their installers turned out to be some of the best manual creators in the program. The process was very important to the remote operation in Kuwait, which outfitted vehicles built in South Africa. The extensive use of pictures to illustrate installation sequences made it possible to move much faster. It turned out that interactive fully electronic manuals, which were often touted as a step beyond paper, took too long to produce and were unwieldy. Paper also made it possible to maintain configuration control.

Because there were so many different MRAP vehicle variants (by manufacturer and by Service), SPAWAR Charleston could not use a conventional assembly line. Instead, its engineers laid out 25 bays, each large enough to accommodate a vehicle. The process was broken into two stages: the disassembly of the vehicle, and then installation of the C4I elements. Because the bays were individual, it was possible to work on a different kind of vehicle in each of them, in parallel. The work force had to be cross-trained so that it could handle so many different vehicle types.

In normal defense procurement terms, it was bizarre that SPAWAR Charleston was even needed; typically the manufacturer outfits vehicles once a design is firm. In historical terms, in wartime, however, post-production outfitting has often been the rule rather than the exception. During World War II, for instance, from 25 to 50 percent of the labor involved in Army aircraft production was performed at 20 post-production modification centers. Airplanes were rolled out and flown to the centers before they went overseas, a process not so different from shipping vehicles to SPAWAR before they could go into combat.²²

SPAWAR found itself trying to outfit 50 vehicles per day, a goal it met in early December 2007. To achieve that, it used a standard manufacturing design technique called Lean 6 Sigma.²³ This is a systematic way of analyzing a process to find and delete wasted steps. It divides a process into batch, push, and pull elements. The analysis seeks critical items that can be pushed to the sides so that they do not delay batch production. “Batching” is continuous production, each step requiring that the previous one be completed. “Push” is moving material in on a planned basis. “Pull” is calling up material as the production process needs it.

In some cases SPAWAR Charleston encountered thorny challenges due to poor manufacturer quality control. The placement of ports, wire holes, and the like in some vehicles differed significantly from the drawings, and from vehicle to vehicle. This was a huge problem. Integration kits for each piece of GFE had wiring of fixed size and length. If the vehicle did not meet spec, the integration kit would not work. SPAWAR Charleston did an amazing job of developing procedures to deal with this variance.

SPAWAR is on the coast, and it is vulnerable to hurricanes. Some observers, including congressional staffers, asked what would happen to MRAP production in that event. In response, SPAWAR set up a second facility at Orangeburg, South Carolina, about 70 miles away, as a backup. Orangeburg was also needed to add production capacity as the MRAP program accelerated. At peak, SPAWAR was turning out 40 vehicles per day and Orangeburg was adding another ten to 15.

Ramping Up Deliveries

Production ramped up, but to some in Congress it did not seem to be accelerating fast enough. Whether as a prod to SPAWAR or as an attempt to divert outfitting to the

manufacturers, in September 2007 SPAWAR Charleston was told that it had to reach a target rate of 50 vehicles per day by 15 December. The challenge was formalized during a November 2007 House Armed Services Committee hearing. SPAWAR had to have Orangeburg up and running by that time, and there had to be 1,500 vehicles in Iraq by 31 December. If these conditions were not met, the MRAP JPO would have to “farm out” outfitting to the manufacturers. The rate in the summer of 2007 was 25 vehicles per day, and it must have seemed unlikely that could be doubled in a few months.²⁴ In fact everything was achieved. By 7 December Orangeburg was under way, three days later SPAWAR turned out 50 outfitted vehicles in a 24-hour period, and on 31 December 1,650 vehicles were in Iraq.

The achievement was so impressive that on 8 January 2008 Secretary of Defense Gates came to SPAWAR to thank its workers personally. He said that World War II, with its floods of heavy bombers and Liberty ships, was the last time this much had been produced this fast with this much impact. On the day SPAWAR Charleston managed to outfit 50 vehicles, Assistant Secretary of the Navy, Research, Development, and Acquisition (ASN (RDA)) Sean Stackley said, “a lot of people in Washington are

IEDs are the tactic of choice for our enemies. They are cheap, and deadly, and difficult to detect on the dusty streets of Baghdad, Samarra, Mosul, and elsewhere. They have been the biggest killer of our troops in Iraq...

There is no failsafe measure that can prevent all loss of life and limb on this or any other battlefield. That is the brutal reality of war. But vehicles like MRAP, combined with the right tactics, techniques, and procedures, provide the best protection available against these attacks...

IEDs will be with us for some time to come—in Iraq, Afghanistan, the battlefields of the future. The need for these vehicles will not soon go away...

To put it in the words of one Sergeant Major... “Troops love them, commanders sleep better knowing the troops have them.”

Robert M. Gates, Secretary of Defense
8 January 2008

eating crow tonight.”²⁵ Through early 2009 SPAWAR had to update OSD at the end of every 12-hour shift with the number of vehicles produced—not that the program was micro-managed from above.

Orangeburg developed some of its own techniques. It discovered that some items could and should be assembled off-line and installed as sub-assemblies (an Army antenna was a case in point). That eliminated some dead time.²⁶ The sub-assemblies were batched separately and held in reserve for vehicles as they reached the point of installation. The rub was that different variants required different antennas and other sub-assemblies. For them the key was to know which variants were coming in, so that sub-assemblies could be scheduled accordingly. Each truck that came into the facility was tagged for such planning purposes.

SPAWAR was concerned mostly with vehicle electronics. Thus it installed weapons platforms, but not the weapons themselves. However, it was responsible for the redesign of the extendable IED examination arm on the Buffalo. The arm was typically used to scoop up a mine or IED. SPAWAR designed and integrated a blower, so that when the arm was extended the operator could blow dust out of the way to see the threat properly before putting it in the mine plough.

In retrospect it might seem remarkable that SPAWAR Charleston integrated the vehicles, rather than the Marine Corps Logistics Command (MCLC) in Albany, GA or the vehicle manufacturers.²⁷ SPAWAR, which usually integrates ships, submarines and aircraft, seemed to be an odd choice to handle ground vehicles. The answer is that from a C4I point of view MRAP vehicles were more like ships than traditional trucks. In its Humvee program, SPAWAR Charleston learned to integrate a complex C4I outfit in a small space. It had a demonstrated and unique capability.

OEM Outfitting

The manufacturers also pressed to integrate trucks at their own plants.²⁸ SPAWAR's rejoinder was that only a central government facility could learn lessons from its experience on one manufacturer's truck and apply them to others.²⁹ It could also migrate systems, such as the DVE, from one Service to another (in this case, Army to Marines).

SPAWAR Charleston also made the point that the manufacturers' automotive experience was not easily applicable to electronic outfitting, and that they could not change what they were doing (to suit different equipment or different users) as nimbly as SPAWAR could. Nor could the manufacturers be expected to solve electronic problems that cropped up during outfitting (or, for that matter, to produce the necessary

designs). Some of the automotive work had to be redone to accommodate the electronic systems, and every time that was done trucks had to be retested.

The manufacturers were concentrating on producing vehicles as fast as possible. In the process, they made subtle changes that affected electronic performance. For example, it might not seem very significant that a producer who had not been painting part of a frame suddenly began painting it. In electronic terms, the unpainted frame was part of a ground plane for an antenna, because it reflected radio waves. Once painted, it no longer had that electronic effect. The associated radio would no longer perform the same way. A subtle change in a circuit board might create electromagnetic interference. Problems like these had to be isolated quickly and fixed. It took electronic engineers and physicists to find the causes of problems and to design solutions. They would have been unlikely additions to an automotive manufacturer's staff, but they were the usual denizens of SPAWAR.

SPAWAR Charleston could also collate warfighters' experiences in its outfitting designs. For example, it could take into account the way in which troops entered and exited a vehicle carrying their gear, so that the C4I equipment inside was not a hindrance. SPAWAR found itself building mock-ups to test human systems integration. Equipment had to be available when needed, but it could not be allowed to impede troops when not needed. To test arrangements, SPAWAR had workers put on full body armor to see whether they could easily enter and exit vehicles outfitted to its designs. The high percentage of retired military personnel in the workforce helped bring real-world experience, such as how troops would normally exit an MRAP truck. There was also some modeling and simulation to support the design process.

More, SPAWAR had to work fast. It had 30 days to design and demonstrate a complete outfit for each type of truck, starting with what came from the manufacturer. In that time it had to complete an outfitting design suitable for production. It had to test that design electronically at Poseidon Park for both electro-magnetic interference (EMI) and electro-magnetic compatibility (EMC) among devices. The design and development process included items such as mounting brackets and cabling.³⁰ Once a prototype had been built, it had to be blast-tested, because what was inside the truck changed the way an explosion would affect its occupants. This testing was done at the Army's Aberdeen Test Center (ATC), at Aberdeen Proving Ground, MD. Fortunately it was generally successful, as SPAWAR Charleston was well aware of what was being learned in the

explosion test program. After that, the design had to be adapted for production, and handbooks had to be produced for the users.

The speed with which the program had to be executed might actually have been an advantage. It forced SPAWAR to face the issues rapidly and to concentrate on quick solutions. The normal system encourages the feeling that there will always be time to fix whatever problems come up.³¹

Prototyping was necessary not only for vehicles SPAWAR delivered, but also for the modifications conducted in the field to keep vehicles up to date. For this, SPAWAR maintained a fleet of test vehicles. Normally it would apply an outfit to eight vehicles to set a baseline, adapting them along the way. To do that it had to create a process that would capture changes and adapt. Fortunately one major EMI problem arose because of an unexpected change by Warfighters to a base (radio) station. SPAWAR would normally surge personnel into theater to quickly solve modification problems, with as many as 160 field service representatives (FSRs) at maximum strength (normally there were two or three government engineers in theater).

Configuration Control

Vehicles were bought fast because the need was urgent. As a result, there was no real attempt at configuration control even within any one manufacturer's vehicles. There was no integration plan at the outset. Manufacturers were not ready to do any integration, and there were too many different kinds of vehicles.³² Moreover, the different Services involved (Marines, Army, Air Force, Navy, and Special Operations Command (SOCOM)) each had their own equipment. Ultimately there were more than 60 variants, and numerous sub-variants (different vehicles produced at different times by different manufacturers) in some 300 configurations (variants crossed with outfits).

As Under Secretary of Defense for AT&L (Acquisition, Technology, and Logistics) (USD AT&L), John Young pressed for standardization, but that did not survive the meeting at which it was brought up.³³ Looking back, he believed that he had achieved only a 40 percent success, and that this was a fight he should have won. The Services protested that their personnel had to use the equipment on which they trained, which, moreover, was coming out of their logistical pipelines. Ultimately trucks were produced in a kaleidoscope of different configurations.

Each Service had to produce GFE somewhat faster than vehicles so as to avoid slowing integration. Looking back, it was miraculous that the integration process proceeded smoothly. That was thanks to a good hard-working work force, many of which felt personally involved in the MRAP vehicle³ program through either their own experience or that of relatives in the Services.

The problem was given to SPAWAR. For each configuration, the Naval Surface Warfare Center at Dahlgren, VA (NSWC Dahlgren), produced an integration design that took into account both explosive testing and the demands of electro-magnetic compatibility, for example between radios and nearby IED fuze jammers. It was clear early on that manufacturers were not equipped to install such GFE as electronics and gun turrets. Instead, that function was centralized at the SPAWAR Charleston facility. SPAWAR was an attractive location because it was near transportation airlift and sealift facilities.

Integration was perceived as the major potential bottleneck in production; thanks to SPAWAR Charleston, it never was. Manufacturers could produce trucks relatively quickly, but the complicated work was done at outfitting time. SPAWAR received GFE “black boxes,” whose position in each vehicle had to be determined, and positions differed by type of vehicle. They had to be cabled, and again that depended on the specific vehicle involved. SPAWAR received GFE and assembled it into kits for installation so that assembly would be simplified. Because there was limited configuration control even within a line of vehicles, SPAWAR had to some installation engineering on the fly.

As they gained experience in integration, it passed back to the manufacturers modifications that would simplify outfitting.

GFE—radios, jammers, and weapons—came out of completely separate supply chains. The manufacturers involved had had no advance notice to ramp up their production for thousands of vehicles. This was a case in which higher-level attention helped enormously, since other programs had to sacrifice so that enough GFE was made available quickly enough. There had to be enough GFE not simply to outfit vehicles, but also for explosive testing, since what counted was what happened inside a fully outfitted vehicle, and the results of tests affected the way in which outfitting was done. Users had to test to make sure that internal arrangements, which satisfied the blast tests, were also acceptable to them. The same outfits also had to pass automotive tests.

Initially SPAWAR saw integration and installation as essentially a manual process. It was faced with many different kinds of trucks and with many GFE configurations. It fitted out the first 10 pre-MRAP vehicles in February or March 2007, then 20, then 30 per month, then more than 100 per month in the summer of 2007. These rates reflected the difficulty of outfitting: at the outset it took an unacceptable 23 days per vehicle.

The urgent schedule of the program demanded that as many as a thousand trucks be fitted out each month by January 2008. That seemed impossible, but it was achieved. To that end SPAWAR converted its big production bays into parallel production lines. Vehicles were tracked as they were completed, stored briefly, and then quickly modified. Configurations were not always as expected, because the program was soon producing for all its users, and Service requirements kept changing. Vehicle outfitting was tracked on a daily basis and reported to the MRAP JPO.

As elsewhere in the MRAP vehicle program, outfitting worked not only because it was well designed by production engineers, but also because those doing the outfitting were inspired to work unusually hard. A visitor to the program recalled flags hung from the ceiling. Outfitters slipped messages to crews into the vehicles before they were completed. They knew they were at war, and they treated their program accordingly. This was the sort of dedication familiar from World War II, but not nearly so familiar since then.

For SPAWAR, the legacy of the MRAP vehicle program is considerable expertise in outfitting vehicles with their newly complex electronic systems. These systems are likely to be more rule than exception.

End Notes

¹ The Army's end of this network-centric revolution was its Force XXI concept. The network revolution was connected to the idea of operating in smaller units that could call in support (for example, from the air) rather than carry a great deal of firepower with them. In theory, the change makes for far more mobile and far more agile forces. It is associated with ideas such as the "non-linear battlefield," in which a ground force operates in small self-constrained distributed units rather than in a connected mass. The main difficulty is logistics, and the usual solution is resupply to individual units by air. Like everything else in this kind of operation, such logistics depend on a combination of situational awareness ("where are you?") and reliable communications, which in turn means mobile command posts with excellent C4I. The C4I in an MRAP was central to this concept of operations. Those involved in C4I integration typically used the phrase "Information Dominance for the Warfighter."

² DVE was needed because the armor glass windshield was so thick that a driver could not see properly using night vision goggles (NVGs). Using DVE, the driver could see the road, and experience during Desert Storm (1991) showed that this kind of camera could make operation possible in the face of weather and natural and man-made battlefield obscurants (smoke, fog, dust). There was a question as to where the DVE should be, for example on the front bumper or up over or near the windshield. There was a problem with placement, because the natural position atop the windshield would interfere with the gun turret atop the vehicle. The Marines accepted a position on

the front bumper, but the Army hated that, because the camera bounced as the truck hit bumps in the road. They wanted it as close to the driver as possible, and ultimately that meant in the center of the truck.

³ A July 2008 chart of MRAP vehicle electronics gives some idea of the variety involved. The Army alone used the SINCGARS radio system. SOCOM used its own PRC-148 radio. Everyone else used a tactical network called TOCNET and VRC-103 and -110 radios. Everyone but SOCOM used the VRC-104 radio as well. The Air Force alone used VRC-111, in addition to the other radios. All vehicles had satellite communications (SATCOM). Only the Army and SOCOM used intercoms (VIC-3) at this stage. SOCOM had two unique devices, a vehicle display called Rover that integrated information from multiple airborne systems, and WALK, a litter and medical aid kit.

⁴ The radio connection made it difficult to standardize between the services. The Army used VIC-3, which was clearly on board other vehicles, but which, in 2007, was nearing the end of its life cycle. It could connect with only 2 of the 4 Marine Corps radio nets, hence could not be used by the Marines. It was a 'party line' to which all the occupants of a vehicle were connected, and it could handle only two radio channels at a time. Due to its party-line character, conversation on either a radio channel or the intercom would disrupt all other conversation. The technology was dated in that it was not designed for software reconfiguration. However, VIC-3 had an established logistical tail, and 1900 per month could be provided. TOCNET represented the desirable future, but it cost more, and it was just entering service (the briefing showed that more than 650 per month could be had beginning at the end of November 2007, although that date could be brought forward. In this case the future meant providing enough capacity that each occupant of a vehicle could independently configure his set as either a radio (on a chosen channel) or an intercom. A user might choose to participate in multiple radio/intercom nets at the push of a button.

The Marines considered TOCNET essential to support their CONOPS for MRAP radio distribution. The Army planned to incorporate TOCNET in their next vehicle intercom system. This was very much an instance of the best being the enemy of good enough, and the effect of the time factor. The issue was not merely how quickly TOCNETs could be produced, but the training and logistics tail involved; the Marines, who were less numerous, found it easier to switch systems. Not surprisingly, the same considerations applied to radios. The Army had adopted SINCGARS, a single-channel digital radio. It was being produced at the rate of 4500 per month, and many Soldiers were familiar with it. The superior replacement was the Dual Vehicle Adapter/Amplifier (DVA) connected to a pair of JTRS Tactical Handheld Radios (THHRs). There were two alternative types (Thales VRC-111 and Harris VRC-110). Each incorporated two hand-held multi-band radios in a vehicle adapter. Because they could operate on both UHF and VHF bands, they could communicate simultaneously with aircraft and with other vehicles. That was very much the Marine Corps model, the Marines considering their aircraft integral with their other elements. An Army vehicle calling in air support would do so via an Air Force air-ground controller, a very different CONOPS requiring different types of communication. DVA was part of the technology push towards software-defined radios, which the Marines had already embraced. As in the case of the intercom/radios, the most important factor was not production rate but the degree to which a service could not easily shift to an entirely new system requiring an enormous training and logistical burden. Details from the GFE part of the 26 June 2007 MRAP Task Force Update assembled by John Young (DDR&E),

⁵ Although EPLRS was conceived as a surface data link (to create a tactical picture), its significance in this war was that aircraft providing support to troops on the ground used the EPLRS picture as their means of situational awareness—to attack the right targets rather than their own forces. The July 2008 chart of outfits shows EPLRS and the VRC-111 radio specific to the Air Force version.

⁶ The sensors were a second-generation FLIR with long-range optics, an eye-safe laser rangefinder, and a day video camera. The device consisted of a tripod mounting a sensor turret (which was designated LRA 3), a control box, and a battery recharger. The sensor turret could be dismounted. As of March 2009 the Army wanted 391 LRA3s for its MRAP trucks. The system was already in service, and some parts for use in MRAP trucks were to be taken (harvested) from theater. The first vehicle adapted to LRA 3 was Caiman, the design for which had just been completed. Work was also proceeding on MaxxPro, RG-33, RG31, and Cougar. Plans called for 137 A-kits (installations for vehicles) in FY 2009 and another 134 in FY 2010. APM Capability Insertion Report, March 2009.

⁷ Jammers changed as the enemy changed the way in which he triggered IEDs. Nearly all the jammers were code-named Warlocks of various types, the word following indicating the type. Examples were Green, Red, Duke, and Chameleon. Later some vehicles had CVRJ (CREW Vehicle Receiver Jammer). CREW meant Counter-Radio Controlled IED Electronic Warfare. CVRJ was a broadband reprogrammable jammer, whereas the Warlocks had more limited repertoires. At one time there were 14 different types of jammers in Iraq, each handling a specific signal. Duke was a broadband set-on jammer capable of detecting a specific signal quickly enough to choose a specific response. Most or all of the jammers were developed by JIEDDO and its predecessors and therefore were joint-service, but different services preferred different jammers, as shown in diagrams of vehicles indicating which equipment was common to all the services.

In all, about 50,000 jammers were bought to fight the war in Iraq. At least some vehicles also had to have receivers so that they could detect the signals the enemy was sending. A survivable MRAP truck was an ideal place for such a receiver, since it would most likely survive an IED that the signal detonated. The jammers initially caused serious interference with standard radios, exactly the sort of problem SPAWAR Charleston had to solve. These details are from Noah Schachtman, "The Secret History of Iraq's Invisible War," an article published on-line by *Wired Magazine* in June 2011, based on an approved visit to ITT, which made most of the jammers used in Iraq. See <http://www.wired.com/dangerroom/2011/06/iraqs-invisible-war/>. This is actually the story of JIEDDO jamming in Iraq. It points to low-tech Afghanistan as the place where jamming could not solve the IED problem in any way, which in turn made the M-ATV absolutely

vital. The article also mentions that the jammers pushed the enemy towards non-radio methods of detonating IEDs, which also made explosion resistance vital. To make matters more complicated, each service had its own PM for jammers, so vehicles for different services had different jammers. Regional differences in the threat had to be accommodated. The July 2008 chart of equipment on board MRAP trucks shows different jammers for the different services: CVRJ for Army and Air Force, Chameleon for Marine Corps and Navy, and Duke for all but the Marine Corps and SOCOM. SOCOM had its own jammer and radar-warning receiver (details unspecified).

⁸ Rhino, which was sometimes called a “toaster on a stick,” typified the ingenuity that went into electronic solutions to the IED problem. It projected a false infrared vehicle signature ahead of a vehicle so that an IR-triggered IED would explode prematurely. The website of the Army Project Manager for Close Combat Systems calls Rhino a convoy protection device for all vehicles. By 2013, 34,000 had been delivered to theater. Rhino standoff could be extended using a device called Caligo, which could be mounted on MRAP trucks and on Humvees. Rhino in turn could be integrated with SPARK (Self-Protection Adaptive Roller Kit) or Cyclone. SPARK is a classic mine roller that a vehicle would push to deal with pressure-activated IEDs. Cyclone is a high-powered debris blower intended to uncover IEDs. It was mounted on RG31s, IVMMs (Husky-type mine countermeasures vehicles), and the M939 series of 5-ton trucks. In addition to Rhino, the Army fielded Jackal, another means of pre-detonating IR-triggered IEDs, which was specifically designed for integration with MRAP trucks, including RG31 Mk 5 and MaxxPro. It won the Army’s greatest invention award in 2010. In theory the combination of IR and pressure would handle all IEDs that did not have human operators, because they covered both the methods of automatically detonating an IED. That left insurgents to rely either on radio control (which could be detected and jammed) or on a wire leading to a fixed detonator, which might leave the operator vulnerable to counter-fire. All of these devices were in addition to sniffers intended to detect the vapors created by explosives.

⁹ The Marines seem to have originated the mine rollers used in Iraq; fielding of 407 of them was completed in February 2007. They were conceived as convoy protection, and they were suited to many Marine vehicles, including Humvees, MTVRs, and LAVs. The roller protects the host vehicle and also clears the center of the travelled lane for follow-on vehicles. It can be used at convoy speeds. In response to calls from the theater, the Marine Corps Logistics Base quickly designed and built 53 roller systems; Naval Surface Warfare Center (NSWC) Panama City refined the concept and designed a smaller system that could be used on multiple vehicles. SPARK was a new modular system employing a front roller consisting of two roller banks on either side of the vehicle. In theory the blast from one such bank would be directed mainly down and away from the vehicle, so even vehicles vulnerable to under-body mines could employ them. Given the sheer weight of a mine roller, such devices are intended mainly for a vehicle leading a convoy. The JPO tested mine rollers with all its vehicles. The OEF designation indicates that SPARK was intended mainly for Afghanistan, where IEDs were typically detonated either by a vehicle or remotely by wire, not by radio. The July 2008 chart of outfits shows only the Army receiving SPARK and Rhino II.

¹⁰ As described in the March 2009 report of APM Capability Insertion, Boomerang employed a sensor mast with three sets of microphones protruding from it on bearings 120 deg apart (two microphones per set) plus a control unit. It was described as a sensor to provide immediate awareness of a threat and orientation (threat direction) to the shooter. The Army wanted 1,167 Boomerangs for Afghanistan and 1,838 for Iraq. Installation took four man-hours. By this time all RG-33s were expected to be fitted by the end of the second quarter of 2009, and designs had been completed for Caiman, MaxxPro, and RG31. In addition to Boomerang, there was Double-Shot, which used a forward-facing camera feeding into a tough-book computer. In March 2009, TARDEC was testing a single system. The Army wanted 2,238 anti-sniper systems, of which 387 would be Double-Shot. This Phase 1 was called Vanguard. Phase 2 was a stand-alone configuration with Boomerang, amounting to 1,851 units. It does not appear from the APM Capability Insertion report that as of 2009 the other Services wanted Boomerang or Double-Shot.

¹¹ This was an interesting example of the way in which sensors on board a vehicle could be networked to use displays intended for other sensors. That was inescapable both because those in the vehicle had to integrate what they could learn from different sensors, and because space inside a vehicle was limited. Because networking was limited, Check 6 needed its own control box. Presumably the planned digital backbone would have made it possible for one control box to control any vehicle sensor.

¹² ITAS incorporated both a FLIR and an eye-safe laser rangefinder, which made it a surveillance device as well as a targeting device. Integration included displaying its output on the smart screens inside the vehicle. As of July 2008 ITAS was installed only on board Army MRAP trucks. According to the March 2009 report of APM Capability Insertion, the planned quantity was 28 kits for Afghanistan, to be installed only on board RG31s. The kit was dismountable. At this time the prototype truck was to be ready for firing the week of 30 March 2009.

¹³ The CROWS II Remote Weapon Station (RWS) consisted of a remote weapon station, a joystick controller, and a display monitor. It could support the M2 heavy machine gun (0.50), the M240 (7.62 mm machine gun), the Mk 19 grenade launcher, and the M249 (5.56 mm) machine gun. As of March 2009 (APM Capability Insertion Program Management Review), the SOCOM version on board RG31s and -33s was already in the field, and manufacturers’ designs to fit RG31 DO4 and Cougar LRIP-13s were either in process or in test. Designs were in train for Caiman, MaxxPro, and RG-33. Installation was expected to take 15 hours per vehicle. At this point the Army wanted 2495 and the Air Force 176 of these stations, of which 1210 were for Iraq and 1285 for Afghanistan. The initial gun stations, as described in an MRAP GFE Over-view dated 25 June 2007 (in the 26 June 2007 MRAP Task Force Update assembled by John Young (DDR&E), were OGPK (Army) and MCTAGS (Marines), both of which were already installed on board Humvees. OGPK (850 pounds) was heavier (MCTAGS weighed 625 pounds), but it had better resistance against most bullets (both were equivalent against 0.50 caliber FSP). Both were power mounts, but OGPK

had an integral electric motor. OGPK was made of 3/8 in rolled hard alloy steel (RHA); MCTAGS had composite construction (a layer of 1/4 in high-hard steel backed by polyurea to protect an operator against spill due to bullets hitting but not penetrating). MCTAGS had 15 deg angled plating to improve its ballistic performance. At this time OGPK was being made at the rate of 1,900 per month, and MCTAGS at the rate of 500 per month; OGPK was government-owned design, hence production could easily ramp up. The Marines' resistance to an entirely remote-controlled weapon station refers to the replacement of both these manned stations by CROWS II.

¹⁴ As described in the March 2009 report of APM Capability Insertion, OWM was typically integrated with Boomerang. Blue Grass Army Depot was producing about 250 kits per week. At this time a design had been developed for MaxxPro, and three MaxxPro prototypes were being produced. Designs were being developed for all the vehicles.

¹⁵ The March 2009 report of APM Capability Insertion describes a variety of solutions to the power problem, including the 570-amp alternator, a Marine Corps Auxiliary Power Unit (APU), the PIF APS (Auxiliary Power Source), CMPS (Common Module Power Unit), and Dual Alternator. A study by the Army's TARDEC indicated that more power was needed. At or near idle, the current demand was for 500-700 amps, and in the near term 1,000 amps would probably be needed. The existing 570-amp alternator provided only 360 amps when the vehicle was idling, because it was driven directly by the vehicle's engine. At this time CMPS, which was expected to become available in 2011, was the preferred solution. The Dual Alternator offered 640 or 760 amps when idling, simply by doubling up the alternators; it also had the advantage that all components were already in production. APS coupled the 570-amp alternator to a 3-cylinder Kubota engine. That added weight, but it offered the desired idling power level. The Marines were testing their APU (about 860 amps when idling) on a Cougar. Unfortunately it demanded considerable space and added 1,500 pounds (1,900 pounds with armor). CMPS offered about 1100 amps at idle, without an alternator. It was powered by the vehicle's engine. It was preferred even though it added 600 pounds.

¹⁶ Pilot production began on 29 September 2008, and the first 100 units reached Warren (TACOM) for inspection on 9 October. By 30 November 2008, 7,400 were available. The entire fleet was upgraded. As of 4 February 2009, the Army had 10,671 kits; the Marines had 1900; the Navy had 390; the Air Force had 531; and SOCOM had 280 (not all in theater). OLI was associated with upgraded winches, such as the 12,000 lb winch installed on upgraded Cougars.

¹⁷ The March 2009 report by APM Capability Insertion describes two different kinds of special lighting. One was emergency lighting and exit marking to make vehicles safer if they rolled into water. A Tier One ("Quick") solution was glow-in-the-dark tape kits that could be applied to vehicles, using magnetic adhesives. Tier Two was automatic lighting that would be activated by water. They were wanted for all MRAP vehicles. The other aspect was external, in the form of Ibis Tek 360 deg lights to be applied on all sides to enhance overall situational awareness, i.e., awareness of one MRAP truck by the crew of another. This was both visual and IR lighting, the latter useful because it was covert (U.S. troops had IR vision equipment, but the enemy most likely did not). Lights were to be visible out to 300 feet in all directions. The first 699 kits were bought in FY 2009, with plans to buy 1,680 per year through FY 2015. Initial applications were 204 Caimans, 228 RG-33L (five for testing), 229 MaxxPro (five for testing), five RG31 (for tests), and four Cougars (for tests).

¹⁸ As illustrated in the March 2009 report of APM Capability Insertion, it was a simple curved inclinometer for the driver, showing how far from the vertical the vehicle was. All vehicles were to be fitted. The same package of APM reports included a 5 March 2009 report on the rollover problem. At that time, non-battle fatalities (not all due to rollovers) had exceeded combat fatalities for four of the past five months, testimony to the survivability of MRAP vehicles as much as to non-combat dangers. As of 31 January 2009, 46 percent of all MRAP vehicle mishap events involved rollovers, which killed 10 and injured another 116. Standard practice was for military unit personnel to receive 40 hours of driver training when they got to theater, but there was no standard licensing process in theater. Rollover was generally due to poorly maintained and unstable road and ground surfaces. To the extent that poor roads in Iraq caused the problem it was likely to worsen considerably in Afghanistan. Between 1 November 2007 and 31 January 2009, there had been a total of 103 rollovers, of which 65 were due to falls off roads and 23 to maneuvers. That compared with 50 cases of injured personnel due to other causes, to 26 traffic accidents, and to 12 power line problems.

¹⁹ Another way to see this was to consider the load outfitting in the field imposed on the Warfighters. Having them try to outfit their vehicles while living and fighting in them would reduce their focus. Ward interview.

²⁰ James Thigpen interview. He was a Science Applications International Corporation (SAIC) contractor supporting SPAWAR Charleston. As a Marine colonel, he worked on C4I and was therefore naturally attracted to SPAWAR after he retired (he joined SAIC in 2003). In the summer of 2005 Marine Corps System Command (MCSC) (where he had worked as a colonel) called him to ask whether his company could rapidly integrate 1,300 up-armored Humvees. That was when the Marines were beginning to take heavy casualties from IEDs, hence were buying UAHs. He went across the street to SPAWAR and put his SPAWAR customer in touch with MCSC at Quantico. SPAWAR then formally accepted the role of rapidly integrating UAH en route to Iraq. Together, SPAWAR and SAIC succeeded spectacularly, integrating about 2,500 vehicles in 2005-2006. They stood up the engineering facility and production line to take radios, jammers, SATCOM, and blue-force trackers and integrate them into the vehicles, doing the integration design. This was often called "GFE on GFE." Typical production was from four to six vehicles per day.

²¹ In much the same way, interference between antennas on board a ship has to be modeled physically. The characteristics of the antennas are affected by the complicated shape of the vehicle and by the presence of other antennas.

²² I.B. Holley, *Buying Aircraft: Materiel Procurement for the Army Air Forces* (Washington: Office of the Chief of Military History, Department of the Army, 1964), 530-532, reference provided by Dr. Thomas C. Hone, U.S. Naval War College.

²³ The name comes from sigma, the symbol for the standard deviation. In a standard distribution, 95 percent is within 6 sigmas.

²⁴ James Thigpen remembered September through December 2007 as the most stressful time in his working life, as he was partly responsible for the successful ramp-up.

²⁵ Thigpen interview.

²⁶ Rodgers interview. He recalled an antenna that had to be attached to a ground plane. The glue involved needed 45 minutes to cure. If the antenna were added in the bay, the vehicle would have to wait the 45 minutes until it had been cured. If instead the work was done separately on a gray cart, the antenna sub-assembly was simply attached in complete form.

²⁷ There was considerable debate in the Marine Corps in October-November 2006 between Paul Mann and MCSC as to whether to have SPAWAR integrate the vehicles. James Thigpen recalled meetings at FPI (as a venue, not with that manufacturer) in the late summer or early fall of 2006, which he attended with Pete Ward of SPAWAR. That was when Paul Mann decided that integration would be done at SPAWAR Charleston and not at the Marine Corps Logistics Command (MCLC) at Albany, GA (the other government candidate) or by a contractor, ManTech, in theater. Albany already had the depot maintenance role. Mann said simply that he “wanted to go with a sure thing,” given SPAWAR Charleston’s success with the Humvees. It already had a hot production line for UAH outfits, and Mann did not see the leap to MRAP vehicles as very great—they might be five times the size, with much more equipment, but the basic job was the same. SPAWAR Charleston and its SAIC partner ramped up steadily between the fall of 2006 and the fall of 2007 to meet the expected demand.

²⁸ It would have been hugely expensive to stock each manufacturer with GFE for each of the services using its vehicles. It would also have been necessary to certify each manufacturer for the classified equipment being fitted, particularly jammers and crypto gear. Just clearing workers would have added considerable delays to a program whose first requirement was to get fully equipped vehicles into the field. Consideration was given in 2007 to having the manufacturers install non-C4I equipment such as gun mountings and Digiracs (provision for digital radio). This is also when the alternative site (Orangeburg) was chosen. MRAP briefing, GFE Program Review, August 2007.

²⁹ IMG/Navistar eventually argued successfully that it should install wiring harnesses and Digirac before delivery. Its president Archie Massicotte recalled watching DCMA contract inspectors “beat him up” for paint blemishes before Charleston tore vehicles apart to outfit them. He complained to Brigadier General Brogan, who convinced Charleston to allow Navistar to do the pre-outfitting. Massicotte thought that pre-outfitting had contributed greatly to Charleston’s accelerated outfitting capability.

³⁰ They would begin with a computer model of a bracket, then progress to a cardboard model, then a two-dimensional model, then a bracket built at their small fabrication shop. SPAWAR Charleston found itself making cabling and modifying cables from suppliers, for example to provide the appropriate pin connectors. It had already gained expertise in cabling from its work on the Navy’s submarine Common Submarine Radio Room. Sometimes it had to build the necessary interfaces, as well.

³⁰ Ward interview. He thought that Toyota’s Lexus provided a good model of fast spiral development and error correction. Toyota pushed rapid development with initial production of small batches of cars, which it tracked (early on, it even gave people cars to gain operating experience). It paid attention to the customers. The MRAP JPO followed much the same path, and it certainly tracked its vehicles’ performance in theater.

³¹ This was also an issue in World War II, but integration was usually simpler, so the manufacturers could do it. The exception was the considerable work that had to be done on aircraft. That was necessary because equipment requirements were changing rapidly, largely as electronics developed. Manufacturers oriented to mass production could not stop and adapt their production lines to such rapid changes. It was much simpler to deliver aircraft with earlier outfits of equipment and then modify them extensively at special modification centers. MRAP vehicle outfits changed rapidly and were different from service to service. Such individual requirements would have frustrated any manufacturer trying to produce masses of vehicles.

³³ Young interview.



**1. Components
Manufactured**



**2. Vehicles
Assembled...**



**4. Transported
to SPAWAR**



3. Tested...

**5. Systems
Integrated**



**6. Sealift and
Airlift**

FROM THE FACTORY TO THE FIELD...



**7. Vehicles Arrive
in Theater...**



**8. Delivered to
the Troops**





CHAPTER 12

FROM THE FACTORY TO THE FIELD

Vehicles produced in the United States and South Africa had to be delivered to troops in Iraq and Afghanistan. That was the responsibility of the U.S. Transportation Command (TRANSCOM), a joint command. The bridge between the Joint MRAP Vehicle Program (JMVP) Joint Program Manager (JPM) and TRANSCOM was the Assistant Secretary of Defense for Logistics and Materiel Readiness (ASD L&MR).¹ In turn, TRANSCOM had to tell the JPM what it needed in order to keep vehicles flowing smoothly to theater.

The U.S. Central Command (CENTCOM) prioritized shipments for the Services and the U.S. Special Operations Command (SOCOM) according to joint transportation allocation processes.² In the spring of 2007 industry was expected to produce up to 1,300 vehicles per month, and that figure shaped transportation planning.³

In the planning process, the Joint Program Office (JPO) provided a production schedule and CENTCOM provided a fielding plan. Given that plan, the JPO provided further fielding information. As initially planned, the next step was for each Service logistics agency to feed data into CENTCOM's computer for further refinement. The Joint Operational Planning and Execution System (JOPES) logistics tracking system was then populated. At that point the decision was made whether to ship vehicles by air or sea. In 2007 movement by air to destination was expected to take 11 days, followed by a day of de-processing and five days to move to the Warfighter. Movement by sea was expected to take 41 days, with additional delays after de-processing in theater.

The JPO created a virtual transportation coordination cell to plan, manage, and support transportation of MRAP vehicles overseas. It included representatives of the Services, CENTCOM (the user), TRANSCOM, and the Navy's Space and Naval Warfare Systems Command (SPAWAR) Systems Center Atlantic in Charleston, from which the vehicles were shipped. The JPO also had on-site liaison with TRANSCOM and with CENTCOM operations centers. But there were constraints. TRANSCOM had its own arcane computer system to track cargoes, and needed a week's notice to schedule transport, when SPAWAR Charleston was a day away from delivering a vehicle.

SPAWAR Charleston forecast deliveries by Service and by variant when it was ready to ship. Those in the transportation cell coordinated with CENTCOM for priority of efforts, to decide which shipments should go where most quickly. Then they coordinated with the Service components to get vehicle data loaded into the TRANSCOM JOPES to ensure visibility to the de-processing sites in theater.

The key issue in the transportation system was the quality of the forecasts used to assign transportation assets. The MRAP vehicle program made considerable efforts to minimize forecasting errors. Forecasting was particularly important in deciding how much commercial contract airlift (which was most of the airlift involved) was needed, and on what schedule. This was not an issue peculiar to the JMVP; generally the military transportation system worked as intended. What was special was the constant successful attempt to squeeze delays out of the pipeline.

The progress of each truck from manufacturer to theater was tracked because the entire JMVP had a high profile and it revealed bottlenecks in the vehicle pipeline. This kind of detailed tracking was certainly unusual. However, overall the movement program was

not; the Department of Defense (DOD) has become expert at moving mountains of materiel over long distances.

SPAWAR Charleston Was Crucial

SPAWAR Charleston was a key factor in the JMVP's success. The organization was responsible for integrating government furnished equipment and coordinating shipment to theater. The Charleston facility outfitted every MRAP vehicle produced, with the exception of a handful of South African-produced RG31s that were integrated by SPAWAR Charleston personnel in Kuwait and one other small order of RG-33s that were integrated by BAE.

Centralizing outfitting (except for vehicles built in South Africa) in Charleston greatly simplified transportation to theater. Even so, transportation from Charleston could easily have been a bottleneck. MRAP trucks are large and heavy, and only a few heavy-lift ships and even fewer heavy-lift aircraft could transport them. In order to field the first MRAP vehicles as quickly as possible, TRANSCOM chartered Russian An-124s, the largest cargo planes in the world, to work alongside U.S. Air Force (USAF) C-5 and C-17 strategic airlift aircraft. An early pipeline chart (15 April 2007) showed the steps envisaged at that time from factory to the field. (See the two-page center-spread graphic.) At this time air transportation was expected to take one day, compared to 35 by sea.⁴ The steps involved, with their lengths in days as of 23 August 2007, were:

- Defense Contract Managing Command (DCMA) acceptance to SPAWAR (three days),
- Receiving at Charleston (nine days, with a goal of two),
- Integration (ten days, with a goal of one),
- Movement from SPAWAR to embarkation (seven days, with a goal of one, since SPAWAR was near the air base),
- En route by air from port of embarkation (two, later three days),
- En route by air to arrive at Al-Taqqaddum Air Base in Iraq (four, to be reduced to three), and
- De-processing (three days, reduced to one by 27 September).

Once vehicles arrived in theater, they had to be de-processed (made ready for use) and then delivered to the users, typically by common-user land transportation. In the early days of the program the worst bottleneck was Integration at Charleston, which was expected to take 30 days. Vehicles built in South Africa were shipped directly to Kuwait and outfitted there.

Airlift

The JPO divided the transportation effort into Phases. Phase I was the push to bring vehicles into theater. Through October 2007 all vehicles were flown into the theater, a function of the Air Force's Air Mobility Command (AMC). At the peak of this Phase, MRAP vehicles may have accounted for half the available airlift assets, squeezing out other cargo being brought into theater.⁵ Phase II introduced some sealift provided by the Navy's Military Sealift Command (MSC).

Using TRANSCOM-chartered Russian An-124s created some challenges, however. To ensure that vehicles were not interfered with (or closely examined, to uncover their secrets) in flight, the JPO hired two riders for each aircraft, so that at least one would be awake throughout the flight. In addition to An-124s, the airlift program included U.S. C-5s and C-17s. Airlift offered quick delivery but limited throughput, because even the largest airplane could not carry many vehicles. It also complicated de-processing, because gun mounts had to be removed before flight so that vehicles could fit into aircraft cargo holds.

The vehicles themselves might be classified "For Official Use Only," but large elements of their outfits were far more sensitive: radios, the command/control system and the jammers, for example. Before they could be shipped overseas, these elements had to be removed for separate secure shipment, with reassembly in theater. That removal and packing constituted pre-shipment processing, so when the trucks arrived in theater they had to be de-processed.

Initial planning emphasized airlift, which could handle a total of nearly 1,400 vehicles over the period between July 2007 and January 2008. After that sealift would be required. Analysis showed that the potential for commercial contract airlift considerably exceeded that of dedicated organic USAF airlift. In addition, the bulk of organic air capability was expected to be otherwise engaged.⁶

Strategic Sealift, Too

Once enough MRAP vehicles were in theater, the program turned almost entirely to sealift (Phase III), which was slower but offered greater throughput on a sustained basis, because each ship could carry many heavy vehicles. Secretary Gates had to be personally convinced that there were enough MRAP vehicles in theater to justify the shift. The combination of greater quantity on board each ship and greater transportation efficiency cut the cost of shipping per vehicle by four-fifths compared to airlift.

As of March 2007, plans called for moving up to 360 vehicles per month via airlift, phasing to a combination of air and sea lift beginning in October 2007. Sealift would be phased in when production approached 360 vehicles per month, the maximum airlift capacity. Overall, the JPO intended to move up to 8,000 vehicles by May 2008. It expected to attain a 40/60 air/surface split in February 2008, after which the proportion of airlift would decline. Ultimately it would be reduced to one organic USAF and two An-124 missions per day.⁷

The U.S. government did not control enough shipping to move all the MRAP trucks. In addition to ships owned by TRANSCOM (MSC), the government used regular freightliner service and it chartered ships. This was and is standard procedure. Note the inherent security difference between TRANSCOM ships (MSC) and the others.

By March 2009, 10,000 MRAP trucks had gone by sea. However, shipments to Afghanistan were always a mix of air and surface strategic lift.

Because MRAP trucks were so heavy, ships could not fill their upper decks (on which they were carried) with them, as this would increase instability. That was not obvious to most of those monitoring the program—a lesson in the problems of jointness, because someone very experienced in one environment (e.g., land warfare) would not have the intuitive feeling for something like ship capacity and operating hydrodynamics.

Sealift went through a single port in Kuwait, so that all trucks would be de-processed at a single center.

In-Theater Processing

Vehicles arrived at the MRAP Sustainment Facility (MSF) in Kuwait, where they were de-processed—components removed for transit were re-installed—and where they were tested to make sure that they still worked; not all of them did. This was not a trivial process; it typically took 24 to 48 hours per vehicle. In a few cases, however, vehicles sat for months at de-processing sites due to problems despite special efforts keep vehicles from piling up at depots in theater, unused.

At this point, the vehicles were delivered to Iraq and to Afghanistan. Vehicles for Iraq were driven there in convoy or loaded onto flatbeds, or even flown in from Kuwait. All vehicles for Afghanistan were flown in, then driven to forward de-processing centers. There they were issued to drivers, who turned in their Humvees and drove their new MRAP trucks back to their units over the largely austere roads and difficult Afghan terrain.⁸ The de-processing centers provided some training to the drivers, who otherwise would not have been at all familiar with such huge vehicles.⁹

MRAP vehicles relied for sustainment on parts supplied by their manufacturers, and production and sustainment had to be balanced. The variety of different MRAP trucks might easily have been a logistical nightmare, but it was overcome like all the other problems. The Marines were fortunate in being able to field only a single type of vehicle (Cougar) in the early days. With its much larger fleet, the Army had to settle for several different types. There were not too many complaints because the JMVP provided a presence in the theater to address issues and break logjams. It worked.

The Services differed in their approaches to fielding MRAP vehicles, and that made transportation more difficult. With a 15-month tour in theater, the Army moved its MRAP trucks to Kuwait, where it trained drivers and then sent them along roads into Iraq. With the Marines' six-month rotation, drivers trained at Mojave Viper in California and married up with their vehicles that had been shipped directly into Iraq.

End Notes

¹ Estevez interview.

² Priorities were given in a Joint MRAP Vehicle Program JMVP Review: Joint Allocation and Distribution Board (JADB) Allocation and Transportation Processes, dated 20 March 2007. Totals given in this presentation were 17,770 for the Army, 3,700 for the Marines, 333 for

the Air Force, 544 for the Navy, and 697 for SOCOM. These were CENTCOM figures, the slide being unclassified because they were not identified by Service (but the identifications for the two largest users are obvious). Marine Corps and Navy figures included legacy vehicles. At this stage only the Marines were to receive CAT III vehicles.

³ This JPO estimate was based on estimated individual vendor maximum monthly production: 500 to 600 by IMG (MaxxPro), 300 by BAE OMC (RG-33), 300-400 by FPII (Cougars and a few Buffaloes), 400 by Armor Holdings (Caiman), and 300 by GDLS-C (RG31). Future orders would be shaped by this constraint and by Service and SOCOM preferences. At this point plans called for maximizing IMG production as CAT I vehicles for the Army; maximizing FPII production as CAT I vehicles, first to complete Marine, Navy, and Air Force tranche 1 requirements, followed by phasing in of Army CAT II and completion of remaining Marine, Navy, and Air Force CAT I and II requirements; maximizing BAE production to meet Army CAT I and SOCOM CAT I requirements; and tailoring Armor Holdings and GDLS-C production to fill out the 1,300/month and Army CAT I requirements. These figures defined the demand levied on TRANSCOM.

⁴ A slightly later chart of transportation and integration metrics showed up to three days to arrive by air from Charleston and then another four days to arrive by air from Kuwait to theater. These figures included waiting time. At this time the goal was to cut the total time from DCMA acceptance to the user from 38 to 16 days. The use of metrics made it possible to break down processes so that goals could be identified.

The August 2007 total of 38 days was a distinct improvement over the original total of 65.4 days, much of the improvement being achieved by cutting time in Charleston: from 17 to 9 days for receiving; from 15 to 10 for integration; and from 15 to 7 for movement to the port of embarkation. A later pipeline chart (17 February 2009) did not show expected times between stages, only how many vehicles were in them. It does show clearly that very few vehicles were caught up in transportation within the United States (12 out of about 1,600 vehicles being processed in various ways). No vehicles were being held at the port of embarkation; the transportation pipeline was running smoothly. At this moment 567 vehicles were at Charleston, of which 224 were in pre-integration (receiving), 71 were being integrated, and 272 were ready to ship, with 268 of the latter allocated for shipment. By this time air shipping was not much used; only six vehicles were en route by air, compared to 394 by sea. Only 35 were at the port of dis-embarkation. A total of 698 were in Kuwait, of which 625 were being de-processed (prepared for issue). Of those, 598 were being de-processed and another 117 were ready for issue. By this time 9,889 vehicles had been fielded in Iraq. Another 453 were being de-processed for Afghanistan (1,735 had already been fielded there). Total battle losses had amounted to 77 vehicles. Another 163 vehicles were at test facilities in the United States.

⁵ Scott Allen, who was involved, thought the 50 percent figure too high: priority was high but not the highest, superseded by force rotation, special operations, and some other items. Allen interview.

⁶ The March 2007 brief listed examples of more urgent requirements: Special Forces, force rotations, critical gear (as defined by commanders), sensitive equipment, OEF helicopters and Kevlar helmets, counter-IED and Abrams tank armor kits, NOMEX gear, body armor, fighter-bomber en route support (tanking), and coalition movements.

⁷ This was a shift from an earlier estimate in which 60 percent of vehicles moved by air in October 2007. That would have entailed a total cost of \$706.4 million, compared to \$519.6 million for the 40/60 split expected in October 2007.

⁸ There was also consideration of delivering vehicles to Afghanistan by road (ground lines of communication [GLOCs]). The GLOC through Pakistan was tested successfully, but it was not used; all vehicles for Afghanistan were flown in. Some were flown in directly.

⁹ Scott Allen pointed out that prior to the advent of protected vehicles, only a few soldiers and Marines drove large trucks, which handle very differently from the cars they had known in civilian life. The number of such vehicles exploded first as up-armored Humvees replaced the lighter more agile unarmored ones, and then as the much more massive MRAP trucks replaced the Humvees. The driver-training problem was reflected in issues such as rollover. Allen interview.





CHAPTER 13

SUSTAINING IN THEATER

The Joint MRAP Vehicle Program (JMVP) was brilliantly successful in its primary role, which was to protect those who rode in its trucks so that they could concentrate on defeating the enemy. No figures on numbers of lives saved were ever published, because they would have given the enemy an idea of how many of his improvised explosive devices (IEDs) had exploded vs. how many had been found and neutralized in various ways. However, some data have appeared. In the fall of 2008, for example, the Department of Defense (DOD) stated that MRAP vehicles had the lowest casualty rate of any vehicle deployed in Iraq and Afghanistan.¹ The challenge, however, was to keep these vehicles operating. Sustainment was the one major area in which the JMVP suffered, if only initially, from its unconventional origins in the Marine Corps.

The Marines regularly maintain complex weapon systems in substantial quantities, and an MRAP vehicle was not as complicated as many. However, it is unusual for the Marines to be the lead Service for a major new joint system and its supporting logistics system.² The original program was small enough that it made sense for the JPO simply to offload logistics responsibilities to the vendors. Once the Army was fully on board and quantities increased dramatically, the original sustainment plan was no longer viable. The JPO struggled to develop and implement rapidly the large area, multi-Service support capability that was needed. In the end, it took a joint service Army–Marine Corps team to make this happen.

Initial Logistics Support Plan

In the fall of 2008, more than 90 percent of MRAP vehicles were ready for duty. This is an excellent availability rate for any equipment system, much less one that was encountering IEDs on a regular basis. To maintain this level of readiness, the JMVP had to overcome enormous obstacles resulting from a fleet of very varied non-standard vehicles, support over a large operating area, and rapid fielding.

The MRAP vehicle program office understood from the start that logistics support was an essential part of the MRAP vehicle system. They planned to procure a complete logistics support package, including spare parts, maintainers and maintenance equipment, and training, from the vehicle manufacturers as part of the procurement. This support was included in the fixed price package supported by the original indefinite-delivery/indefinite-quantity (ID/IQ) contract.

This approach made sense in the context of the small numbers (approximately 4,000) envisioned when the ID/IQ contracts were awarded, and the urgency of the requirements. The previously fielded MRAP vehicles were supported in this fashion, with reasonable success. Additionally, investment in infrastructure to support large-scale supply and maintenance operations was not justified for these quantities, and the time to develop and implement that infrastructure could not be afforded.

The JPO's expectations turned out to be unrealistic. By the fall of 2007, as large numbers of different types of vehicles appeared in theater, there was a growing sense of sustainment crisis. Many operators, who felt insufficiently supported, doubted that most vehicles would remain serviceable after 60 or 90 days.

The logistics problem was solved, but never in terms of a standard sustainment strategy. Regardless, MRAP vehicle readiness climbed to an average of 90 percent or better, with some individual vehicle exceptions initially. Eventually, all variants exceeded that readiness level by significant amounts. As usual, the JPO focused on the important aspects and found a way to make it happen.

A Hybrid System

The JPO had designed the JMVP logistic support around heavy contractor support by the manufacturers, stove-piped for each series of trucks (by manufacturer). It now had to devise a bridge between that kind of support and the desired organic support in the usual DOD form, which had been conceived for a program with tight configuration control and the fewest possible alternative versions. The JPO had nothing like enough manpower. It hit on a solution: hybrid sustainment. The hybrid strategy combined organic supply assets with contractor maintenance augmentation, supported by a Joint Logistics Integrator (JLI) contract.

There was no time to set up an elaborate sustainment system. Initially it had not been expected that large numbers of vehicles would be in theater before June 2008, but the JMVP managed to produce and field vehicles far more rapidly than expected, and it was told to fix the sustainment problem by October 2007. At this time all investment in the program was going into production, and there was no real sustainment plan. No standard maintenance manuals were being produced, and production of complete vehicles was taking precedence over production of spare parts.

A joint July 2007 conference at the Marine Corps Logistics Command (MCLC) in Albany, GA, created the hybrid system to sustain all MRAP vehicles. The vehicle manufacturers were responsible for maintenance manuals in commercial-off-the-shelf (COTS) format, which were not standardized in the usual military form—there was never enough time for that. In-theater Service users had to provide a great deal of the maintenance support, supplemented by field service representative (FSR) resources provided by the manufacturers. This was recognized as a high-risk approach. But it worked. An important reason why was that the manufacturers were willing to lean forward, to provide parts and a logistical “tail” before contracts could be in place. This was another example of the way trust built between the JPO and the contractors paid off: the government/vendor *team* approach advocated for decades in the Navy’s Aegis program.

Manuals might seem a trivial issue to an outsider, but they are the only way in which sustainment personnel can be made sure of what they have to do. In this case COTS manuals produced by all of those supporting the vehicles (including those producing sub-systems) were assembled to support fielding packages.

This hybrid approach had never been tried before (at least in the vehicle world), probably because of the high degree of integration involved between contractors and the Army. Given the hybrid approach, it was possible to gradually steer away from the original concept of contractor logistics support, and institute a theater wide effective MRAP vehicle sustainment capability.³

Burgeoning Variants

The large number of different vehicles and configurations complicated MRAP vehicle sustainment. This was recognized by the JPO. They accepted multiple vehicles in order to reduce the risk of single point failure and, most importantly, build the industrial base, recognizing that this would greatly complicate in-theater support. The hindsight criticisms forget the value that was gained for these trade decisions.

Configuration management was extremely difficult given the constant changes, although changes to vehicles were certainly tracked. That was, first, because vehicles were constantly being improved at the production stage, from low-rate initial production (LRIP) contract to LRIP contract, as lessons were learned both from continuing tests and from the field. Second, many improvements were carried out in the field, particularly as vehicles were repaired after battle damage. Improvements included both survivability upgrades—which might mean new seats and new tie-downs and new blast mats—and new electronic equipment. Installation of new electronics might require other changes in a vehicle, such as a more powerful alternator or a new air conditioning system. There were also improvements such as provision to tow and to be towed and electric door actuators to help troops open heavy doors, particularly if a vehicle rolled over. Vehicles were also up-armored to deal with increased side threats.

The JPO had to manage requests for changes to avoid being buried in them. It devised four gates a request had to survive:

- Gate 1: at the Assistant Program Manager (APM) (each responsible for each vehicle line) level, what could be done to improve available trucks?

- Gate 2: coordination with the logistics team supporting the vehicles, to see whether a change could be implemented.
- Gate 3: identification of a formal requirement for a change for briefing to the program leadership.
- Gate 4: when approved at previous levels, reviewed by the Joint Program Manager (JPM) in briefing format for requirement vs. cost.

It took about six weeks to get from Gate 1 to Gate 4. Typically a Gate 3 briefing lasted 12 to 15 hours. Change requests were reviewed every calendar quarter. Once requests had been filtered down, the JPO Gate 4 briefings typically lasted four hours. None of the changes was lightly approved, but none was lightly rejected, either. In the typical Gate 4 briefing, an overview of costs was presented, followed by a brief by the APM responsible for each vehicle line. Modifications would all be accepted or vetoed at this stage.

One effect of rapid change was that large quantities of spares might be bought to support what was expected to be a large modification program, suddenly becoming obsolete when that program was dropped in favor of something better. In a peacetime program, this kind of excess purchasing would be considered grossly wasteful. In a wartime program such as the JMVP, such waste had to be accepted because otherwise the enemy's rapid evolution could not have been countered effectively. It was part of the tradeoff of money for time that was characteristic of the entire JMVP, a tradeoff that could also be characterized as spending money to save troops' lives.

Supply Support

While some MRAP vehicles used parts and components common to other military systems, most initial repair parts were unique to the various manufacturers and sometimes different among a manufacturer's variants. And, even the vehicles from established truck builders had many special parts associated with their protected hulls. Consequently, the manufacturers produced many components of the MRAP vehicles. In most cases, production capacity was insufficient to produce trucks at the rates required and with spare parts packages fielded with vehicles and supply system assets at the same time. They therefore literally had to choose between making new trucks and producing spares.

At the outset, the JPO decided that it was more important to produce vehicles in large numbers than to produce spares to keep them running. The more vehicles that reached theater, the more lives they would save. Vehicles were kept on the road by taking parts from others, in the expectation that as the spares situation improved it would be possible to put the remaining vehicles into action.⁵

MRAP vehicles in theater needed more spares and maintenance than previous military vehicles. They were used to support operations where encountering an IED was most likely, and as a result, they did. Most MRAP vehicles that hit an IED could be repaired and returned to service. They were designed so that the force of an explosion would be spent on replaceable elements outside the protected capsule. Repairing these vehicles, however, required parts and maintainers in much greater quantities than other vehicles.

It was necessary to fit vehicles that had never been conceived as part of the standard defense family into the DOD logistics system.⁵ That was a major challenge for the sustainment infrastructure, including the Defense Logistics Agency (DLA), which was responsible for the DOD's spares and supply system.⁶

Buying and fielding the right mix of spares is a classical sustainment requirement. That in turn requires a prediction of how much of what items will be needed. One reason for small-unit test operation was to measure sustainment requirements. The speed with which the JMVP moved made any such experimentation impossible. MRAP trucks arrived in theater in numbers, and the program management measured success in how fast that could be done. Without specific empirical logistics data, the logisticians had to try to estimate on the basis of more or less comparable vehicles, guessing what would drive requirements. They were sometimes spot-on, but it was difficult to predict the maintenance requirements associated with battle damage, with the success of MRAP vehicle survivability—hence the need to rebuild vehicles again and again.

To provide initial repair parts stocks to both users and retail supply system, the JPO established parts packages under the vehicle contracts with manufacturers. The repair parts blocks included spares for unit use, retail supply stocks, and JPO de-processing support. Initial parts packages also included a selection of spares anticipated for battle damage repair (BDR).⁷

One reason conventional DOD acquisition programs take a long time is that supporting logistics has to be organized before vehicles are fielded in quantity. Otherwise they

may perform impressively for a short time before becoming unmaintainable. One key element of sustainment activity is the provisioning process that begins early in the standard acquisition cycle. Provisioning is the process used to determine spares and support items needed to sustain vehicle operations by identifying and analyzing vehicle parts. During this time, too, experience is built up to indicate how often various parts are likely to need replacement. A body of technical data is assembled. Full definition of any one part (like, say, a bolt) might take two weeks—and there are thousands of distinct parts. Without full definition, it is impossible to invite bids or to buy replacements in the full knowledge that they really are equivalent to what is being replaced. It would not do, for example, to buy replacement bolts which were not strong enough, or which were made of material that might corrode the surrounding chassis.

Normally the provisioning process takes several years and is a coordinated effort among the program manager, DLA, users and support agencies. The parts documentation process, which might seem routine, is so important that a separate branch, the Defense Logistics Information Service (DLIS) under DLA, is the lead agency. It is headquartered at Battle Creek, MI. Faced with the needs of the JMVP, the supply system had to accelerate instantly, “from zero to sixty!” as one participant described it. Each part has to be assigned a National Stock Number (NSN); troops in the field normally order replacement parts by NSN, via the established parts system.

It began with one or two NSNs. That was when the entire process of assigning an NSN was worked through so that it could be streamlined, and termed the “rapid NSN assignment process.” The team got to the point where it could respond to an NSN assignment request within 24 hours, which was entirely unprecedented. The number of NSNs assigned to MRAP vehicle parts grew to about 10,000 within a month or two.⁸ The process of assigning NSNs has two important aspects. One is to connect vehicles to the Defense Department provisioning system. The other is to minimize the number of distinct parts; two manufacturers might use the same parts, but it took DLA to verify that was the case. Moreover, duplication consumes valuable shipping capacity.

Given the full analysis of spares and needs for spares, it was possible to transition from procurement to sustainment. This process made sense in the context of a conventional program. The program manager would choose a vehicle. Once the choice had been made, the vehicle would go into a limited procurement phase, one purpose of which was to estimate future spares needs. Once the vehicle had proven out, and once its

spares needs were understood, it could be procured in quantity and spares to match could be bought. A spiral program like the JMVP was entirely different. The vehicles configurations were never entirely frozen. Spares bought on the basis of one LRIP configuration plus a forecast of total MRAP vehicle numbers could easily become obsolete when the configuration changed. That happened most spectacularly with early forms of explosively formed projectile (EFP) protection, which were superseded by lighter and more efficient ones. Had the armor not been bought in sufficient quantity, and had the better armor not materialized, many vehicles would have been left without vital protection. Much the same could be said of alternators made obsolete by essential upgrades, whose existence could not have been predicted. A spiral program is a logistician's nightmare. Yet without sufficient logistical support the vehicles could not have been kept in service—a worse nightmare.

As soon as Secretary of Defense Gates designated the JMVP his Number-One priority, key players in the logistics infrastructure began to modify their standard procedures. In many cases the changes were unprecedented. General Ann E. Dunwoody USA (Army Deputy Chief of Staff, G-4, responsible for logistics) established as policy that all MRAP vehicle parts should be assigned NSNs so that they could be sustained within the existing automated parts system. This was a conscious decision based on experience with the Army's Stryker vehicles, which had the opposite system of through-life contractor support, including spares provision. The NSN policy was directly connected to the decision to set up organic supply support under the hybrid sustainment strategy.

With no time to analyze the vehicles, NSNs had to be assigned on the fly. That step was crucial, because it meant that no one in the field had to refer to a manufacturer's catalog to order parts. The burden of buying spares was moved to DLA and its large organization in the United States. The inefficiency of duplication (of the same parts used by different manufacturers under their own designations) had to be accepted. Duplication of this sort was inevitable, because each truck builder was buying parts from lower-tier suppliers, not making them in-house. DLA later went back and sifted down the list of NSN numbers to eliminate this duplication.

Because of the speed of vehicle fielding, operational use and resulting damage, the logistics community found new ways of meeting readiness requirements. As in other areas of MRAP vehicle development and operation, the spirit of enthusiastic cooperation towards a clearly defined goal made an enormous difference.⁹ One key

example was the initiation of a Supply Chain IPT that integrated JPO logisticians, DLA, manufacturers and retail supply experts effectively into one organization focused on optimum supply support. The Supply Chain IPT was chaired jointly by DLA and JPO Logistics and broke new ground for seamless coordination and execution of supply support to sustain vehicle readiness.

Typically the Services went to the vehicle manufacturers for the initial packages of spares shipped with the vehicles. Then DLA procured backup parts for use once the initial spares had been consumed. They had to be in the pipeline so that they would be available in theater as soon as the initial packages were used up. That made for some competition between vehicles, initial packages, and DLA for parts.

DLA found that it had to create an integrated support team at its Defense Supply Center Columbus (DCSC) headquarters to centralize spares provisioning. This was a new kind of organization for DLA, and it led to the needed unity of effort. It took only a few months for DLA to realize that the manufacturers did not understand what it needed; most of them were not primarily military contractors. DLA found itself assigning representatives to each manufacturer, and forming a program cell at Columbus to oversee the process. The cell at Columbus grew rapidly, as DLA came to understand the magnitude of the program and also the range of partners involved.

To complicate matters further, experience in the field showed that many parts had to be modified so that they would survive better under theater conditions. Normally such modifications would have been worked out during service tests, but there was no time. DLA found itself buying large quantities of parts that became obsolete before they could be used. That was part of the price paid for a rapid program.

DLA thus drew the lesson that it needed timelier information than the usual reports filtering back from the field. It had to maintain a running estimate of MRAP vehicle readiness requirements. To do that, twice each week it examined what was being requisitioned so as to focus on what was needed both in theater and en route.¹⁰ This was a new kind of logistical planning.

Ultimately DLA found itself managing 40,000 line items and stocking about 25,000.¹¹ Normally military manufacturers have to use standard parts, and it is their responsibility to create parts inventories.

The manufacturers never found it possible to provide complete standard parts lists, partly because normal commercial practice was to buy whatever was needed when it was needed, treating many alternatives as equivalent. That might mean that two MRAP vehicles in the same LRIP had entirely different brakes or air filters or even bolts. As long as all of them fit in much the same way, that was acceptable. The more a truck was built by hand, the less standardized the parts, because hand production allowed for adjustment to fit whatever was at hand. That applied particularly to Force Protection Industries (FPI), but all of the manufacturers had this problem.

The hybrid approach used in the JMVP was new, and it saved hundreds of millions of dollars by making it possible for MRAP vehicle maintainers to use the military supply system. In 2012-2013 DLA found itself reviewing the array of MRAP truck parts to discover which ones were really common to different vehicles, or even to standard parts it stocked under other NSNs.

This is where the absence of configuration control hurt, because multiplying variants greatly expanded the lists of what had to be stocked, compared to stockage for standardized vehicles. There is probably a lesson here for attempts to simplify procurement by giving contractors free rein to choose their sub-systems (as in the Navy's two-variant Littoral Combat Ship (LCS) program). The different MRAP vehicles had very limited commonality at the component level.

To Lieutenant General Patricia E. McQuiston of the Defense Supply Center–Columbus (DSCC), a key to success was that the JPO's PM, Paul Mann, appreciated how important sustainment was. He conveyed that understanding at monthly meetings at DSCC, where so much of the work was done.

In-Theater Sustainment

The Army, which by mid-2007 was the largest JMVP customer, understood just how difficult logistics would be. In October 2007 it elevated the JPO's chief of logistics, Lieutenant Colonel John Conway, to Product Manager level within the JPO. This action was critical to overall success of the MRAP program as it centralized fielding and sustainment experts to form a highly effective joint Logistics team under Conway's leadership.

In 2007 the Army also decided that it wanted many more vehicles than initially expected. At about the same time it spread its forces more widely within Iraq. It wanted

to maintain vehicles on a company-rather than brigade-level basis (this was a DOD initiative). Company-level support would make it possible to repair vehicles closer to their users, and thus to reduce the need for convoys between support sites and the users. The users also rejected the plan under which the contractor provided all the spares in a series of stand-alone or stove-piped logistics systems. Such systems (“FedEx logistics”) had been accepted for small programs such as special-purpose unmanned aerial vehicles (UAVs), but they put too much weight on the limited capabilities available at company level. The users wanted to apply the standard military system in which parts were requisitioned through the defense supply system, using NSNs. The desire for DOD-type supply may have been associated with the growing realization that the MRAP trucks might remain in service for as much as 15 years. Dedicated contractor support for each company’s MRAP vehicles just could not be maintained in the field for that long.

The JPO thus realized that it needed an in-theater management team to meet growing support needs. It set up a JPO team for Iraq, Afghanistan, Kuwait, and Qatar in October 2007 and established an MRAP Sustainment Facility (MSF) near Ash-Shuaibah port in Kuwait. The MSF oversaw maintenance and performed de-processing (preparation of a shipped vehicle for deployment), component repair, and battle damage repair—preparing MRAP vehicles returning from Iraq either for duty in Afghanistan or shipment back to the United States. The MSF also performed integration for General Dynamics Land Systems-Canada (GDLS-C) RG31s built in and transported directly from South Africa. In addition, it installed independent suspensions (ISS) (for Afghan conditions) on Marine Corps Cougars and U.S. Special Operations Command (SOCOM) vehicles.

The MSF was probably the single most important site the JMVP had in theater. Almost every vehicle went through it. It did all major upgrades, depot work and capability upgrades. Every flag and general officer visiting Iraq (and many senior civilian DOD officials) stopped there first to get a sense of the JMVP in theater.

At the tactical level, vehicles were maintained by the FSRs and by the maintainers trained in the United States. The JLI provided field and sustainment maintenance at Regional Support Activities (RSA) established by the JPO in Iraq and Afghanistan. The JPO set up 12 regional support activities (RSAs) maintenance centers in Iraq, backed by four fielding centers. (In mid-2013 nine RSAs remained active in Afghanistan.) Those in the program felt that the Army support organization ability

to operate a theater-wide logistics operation was a major factor in the MRAP vehicle program's success. As the JPO developed upgrades in the United States, the MSF in Kuwait and later the RSAs applied them to vehicles in-theater. Finally, vehicles suffered frequent battle damage, which often blew components off their survivable crew compartments. They were designed for relatively quick repair that was performed by the JPO RSAs.

Sustainment in Afghanistan ¹²

As the focus of U.S. operations shifted from Iraq to Afghanistan and as the U.S. force in Afghanistan surged, the JPO had to set up a new organization to feed vehicles into that theater: the MRAT (MRAP Rate Absorption Team). The theater operational commands felt that no more than 500 vehicles per month could be absorbed, but Secretary of Defense Gates and his Undersecretary Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L), Ashton Carter, insisted on delivery of no fewer than 1,000 per month. The MRATs were designed to handle up to 1,200 per month, more than had been absorbed monthly in Iraq.

The sustainment system in Afghanistan began analogously to that in Iraq, with a single center at Bagram, which had a large airfield suited to the heavy-lift aircraft that brought MRAP vehicles into the country. The Bagram RSA de-processed vehicles, conducted New Equipment Training (NET), and then did sustainment maintenance including battle damage repair. Later a second RSA was opened at Jalalabad, which also had a heavy-lift airfield. As the number of MRAP vehicles in Afghanistan grew, it was necessary to add two more RSAs, at Sharana and then at Kandahar. All became fielding sites, and the increase in RSAs made it possible to field vehicles much more rapidly. The additional sites also brought the vehicles closer to the units that would use them, reducing the load on their drivers.

Because Sharana had no heavy-lift airfield, vehicles were typically flown into Bagram and Kandahar, initially de-processed there, and then if necessary trucked to Sharana for final de-processing, including marrying them with their electronics.¹³ Their users picked them up at these RSAs, underwent NET, and then drove them to their units—virtually on-the-job-training. Eventually, as numbers in Afghanistan grew, NET was dispersed to the forward locations of the units.¹⁴

To some extent the RSA system also reflected the split in Service use of different MRAP vehicles. The Marines had their own portion of the Kandahar RSA to handle their vehicles, particularly their Cougars. Note that this split was reflected in the 2013 transition plan, in which the Marines remain lead Service for Cougars and the Army becoming lead Service for all other MRAP vehicles.

All of this would have been routine except that Afghanistan suffered from the lack of transportation infrastructure. Thus evacuation of badly damaged vehicles to RSAs for repair was a more difficult problem, though it was generally solved by contracting for third-party flatbed truck transport.

At peak strength in 2011, the JMVP had 3,500 personnel in theater (Iraq and Afghanistan). In mid-2013 there were still 1,500 left in Afghanistan.

“MRAP U”

The new sustainment team decided to use the organic (military unit) supply and maintenance chain, reinforced with contractor support under the hybrid strategy. To do that it had to train maintainers and “crank out” the manuals on which they would rely. To the maximum possible extent, units would do their own maintenance. FSRs would supplement them from the manufacturers. The FSRs were cross-trained to a considerable extent for all the variants they were likely to encounter, with non-disclosure agreements negotiated so that those from one company could work on another company’s trucks. There were also Logistics Assistance Representatives (LARs), government employees (GS-9 to -13) intended to provide technical assistance above and beyond that offered by the FSRs. They had direct access to the Product Managers (PdMs) responsible for the equipment at the U.S. end. Ultimately, all FSRs could handle about 70 percent of the jobs on each truck, but it took company-specific FSRs to do the remaining 30 percent. Their unique skills were not entirely transferrable. There were also JPO representatives on the ground directly connected to the JPO logistics team in CONUS. The FSRs and JPO representatives provided reach-back to the manufacturers and the SPAWAR Charleston integrators in the United States.

The JPO set up “MRAP University” (“MRAP U”) at Red River Army Depot (RRAD) in Texarkana, TX.¹⁶ MRAP U was created primarily to cross-train the manufacturers’ FSRs, so that they could maintain all variants of MRAP vehicles they encountered in

the field. LARs also received the same level of training as the FSRs. Ultimately MRAP U trained troops so that they could maintain MRAP vehicles as they took over from the FSRs and LARs. They also trained those who would train MRAP vehicle operators in theater. By mid-2013, more than 15,000 people had gone through MRAP U.

Ultimately, the MRAP U field level maintenance course lasted six weeks with round-robin training in maintaining each of the MRAP vehicle variants. This training was an in depth version of the maintenance training provided to units during fielding.

To train MRAP vehicle drivers how to safely operate these “trucks” in a combat environment, the JPO developed and conducted New Equipment Training (NET). In addition, various training devices and simulators were used to train operators to better deal with emergency situations.

The development and execution of MRAP vehicle training was done in an unprecedented, collaborative way. All MRAP vehicle training to include NET and MRAP U curriculum was developed jointly with Army TRADOC and CASCOM participation. All training material used in the various courses was approved by TRADOC and CASCOM.

Dealing with Rollovers

Once in service in theater, MRAP vehicles encountered new problems. They were unusually heavy (typically 65,000 to 75,000 pounds for CAT II vehicles), with a relatively high center of gravity. Rollovers were anticipated at the outset. Much of the problem related to the sort of roads MRAP trucks had to travel. Many roads in Iraq had high crowns, and curved down to waterways near the sides of the roads. Often the roads were made of dirt and sand, and could not well support a heavy MRAP vehicle. Sometimes the side of the road would crumble into the waterway, and the vehicle would roll over into the water. This became a serious problem, not only because the crew might find it difficult to get out (opening heavy, up to 400-pound doors that were now horizontal rather than vertical, for example), and it was not a simple matter to pull a truck as heavy as a tank out of a roadside stream. The problem peaked between mid-2008 and early 2009.¹⁷ It continued even as IED attacks declined. Afghanistan had even worse roads than Iraq, which were even more prone to giving way.

The road problem was combined with a driver problem, which had already been experienced with up-armored Humvees (UAHs). Armored vehicles had different dynamics than unarmored vehicles, and brakes worked differently. New UAH drivers had increased rollovers within their first five months, but if they survived they learned to avoid problems. Much the same was expected of MRAP vehicles—but there was no time to pull drivers out of combat to train. Drivers picking up vehicles often had to go straight into combat. Most of the MRAP vehicle drivers were young Americans whose previous driving experience was with cars. How could they be trained to anticipate what a heavy truck would do? That was particularly the case in Iraq, where paved roads made it possible to drive at higher speeds. A driver had to learn to anticipate the danger, which was so different from that of normal driving. How could drivers be trained while they fought? Normally new drivers could rely on experienced non-commissioned officers (NCOs), but MRAP trucks were new to everyone.

To deal with the rollover threat, the JMVP established a focused project to identify and respond to roll over causes. A safety lead in the MRAP program office collected rollover reports and consolidated lessons learned, and the JPO established an urgent requirement for emergency breathing apparatus, restraint releases, and emergency lighting.¹⁸ Considerable effort went into developing special restraints to keep gunners from being thrown out of their stations as trucks rolled over. Gunners were always the most vulnerable, and they represented 70 to 80 percent of casualties on board MRAP vehicles that rolled over. That was partly because, if the restraints were not done properly, a gunner could easily be thrown 30 feet from a vehicle. Late in 2008 or early in 2009 there was guidance from the Secretary of Defense: the modification was so important that it had to be reported on a vehicle-by-vehicle basis. It was easy to incorporate the new restraints into new production vehicles, but the retrofit side of the program was far more challenging when it had to be done at the RSAs in Afghanistan, 10,000 miles away.

Training MRAP vehicle crews and passengers to avoid and respond to rollovers was a top priority. Special rollover trainers were built. Luminescent tape was installed inside vehicles so that crews could find their ways out in darkness. This proved invaluable for real-world operations.

Readiness Based Operations

JPO MRAP continually focused logistics operations on maintaining high levels of readiness, ensuring that vehicles were available for warfighter use. JPO vehicle readiness was monitored closely by the logistics team, and reported to high levels of military and civilian leadership (OSD) on a weekly basis. Actions to enhance readiness included an unprecedented partnership between JPO and DLA to identify and fill critical repair parts requirements faster than ever possible before.

End Notes

¹ As of early 2008, the stated casualty rate was six percent, compared to 15 percent for the Abrams main battle tank and 22 percent for the up-armored Humvee (UAH). In more than 150 attacks against MRAP vehicles, only seven occupants had been killed. Data from a Congressional Research Service report on the MRAP vehicle program. See Andrew Feikert, *Mine-Resistant, Ambush-Protected (MRAP) Vehicles: Background and Issues for Congress* (Washington, DC: Congressional Research Service, 6 June 2008, RS22797), p. CRS-3, where he quotes the transcript of a DOD news briefing dated 10 March 2008.

² The Marine Corps has developed, fielded, and implemented many logistics systems for Marine Corps-unique equipment, including the Marine Corps-unique Amphibious Assault Vehicle (AAV), Light Armored Vehicle (LAV), Medium Tactical Vehicle Replacement (MTVR) and Logistics Vehicle System Replacement (LVSr). The Marine Corps successfully developed these systems, along with their logistics support systems. However, these equipment systems are Marine Corps did not have to meet multi-Service support requirements, and did not have to be fielded as rapidly as the MRAP vehicles.

³ Jerry Sotomayor, JPO MRAP Logistics Product Manager, characterized the reduction in FSRs due to the hybrid approach. With CLS, a unit would have had 10 to 20 embedded FSRs. Given training by the troops using the vehicles, which could be cut to a sustainable 1 or 2. The manufacturers resisted cross training and the non-disclosure agreements, but the JPO made it clear that they had to accept these practices. Sotomayor interview.

⁴ Lt. Colonel Haddon interview. Haddon was the first APM for the Joint Sustainment Activity in Iraq, and later set up the sustainment system in Afghanistan.

⁵ This section is based largely on an interview with Lt. General Patricia E. McQuiston USA, who has had a 33-year career in logistics, including command of Defense Supply Center Columbus, now DLA Land and Maritime. She assumed that post in September 2007, and prior to that she was ARCENT logistician in Kuwait; she came from determining requirements at the user end to fulfilling them at the DLA end. She considered the DLA MRAP vehicle experience absolutely unique in 33 years of service. McQuiston interview.

⁶ According to Appendix L (chronology) in the DLA “MRAP Playbook” (document courtesy of Lt. General McQuiston), the agency first became involved in the MRAP vehicle program in December 2006, when DLA WSSM (Weapon System Support Manager) Jeff Gamber was invited to the MCLC to discuss MRAP vehicle support. Gamber provided the MRAP vehicle team with DLA’s Weapon System Support Program 101 Primer. In January 2007, the MRAP vehicle program office requested rapid procurement of 40 critical DLA MRAP NSNs for HEV, JERRV, and Cougar. At a February 2007 meeting, Gamber first said that the program was likely to become very large. This was well before Dr. Gates greatly expanded it. The first MRAP vehicles arrived in Iraq in March, and in May 2007 the total requirement was 7774 vehicles. General Dunwoody’s crucial all-NSN decision came in June 2007. In August, the JPO asked DLA to procure sustainment inventory ahead of the provisioning effort. That month the hybrid support logistics strategy was formally adopted as a DOD Enterprise Strategy. The MRAP vehicle meeting at Battle Creek to map out Cataloging and Provision processes to speed NSN assignment occurred in September 2007. In October, 4,500 NSNs were assigned in less than a week. By the end of November, 6,500 had been assigned.

⁷ Many DLA documents refer to battle damage and repair (BDAR), to indicate spares needed both for normal repair and to repair battle damage. The simpler acronym BDR is used here.

⁸ According to the DLA “MRAP Playbook,” the DLA designation process began early in 2007, when the MCLC began submitting requests for Weapon System Designator Code (WSDC) assignments. Once they were established, DLA could code NSNs. DLA formed its first Weapon System Program Management Office (WSPMO) MRAP in July 2007, and the following month at an MRAP Joint Logistics Meeting at TACOM the WSPMO MRAP offered a Sustainment Briefing and overview of its capabilities. The Marines then asked for a sustainment inventory ahead of the provisioning effort, which led DLA to develop a Fast-Track Cataloging/NSN assignment system. DLA began to eliminate obsolete NSNs during 2009.

⁹ General McQuiston pointed out that nearly everyone involved felt a personal sense of connection, either having been deployed, knowing someone who had been through an IED attack, or was about to deploy. No one ever refused.

¹⁰ During October 2009 DLA formed a five-member Surge Team specifically to deploy to Afghanistan and assess the tactical and operational-level logistics posture and to provide dedicated parts support there. Presumably the situation in Afghanistan was unsatisfactory, since according to the “DLA MRAP Playbook,” the goal was to bring stability there to provide rapid issue, detection, and transport for DLA consumables in theater. The team also trained and educated logistics customers in Afghanistan. The training phase lasted 3-5 days, followed by an Assessment Phase, a development phase, and execution. By 2013 the forward deployment team was called the MRAP Support Team-Afghanistan (MST-A), and it was in its seventh rotation. The team provided weekly assessment reports.

¹¹ By August 2009, the total number of DLA MRAP NSNs with stock on hand exceeded 10,000, and by July 2010 it exceeded 20,000. By July 2011 a total of 7,078 obsolete parts and parts unrelated to MRAP vehicles had been removed from the NSN list for MRAP vehicles. This effort seems to have begun in January 2009, when about 1,300 NSNs were dropped (of which 77 percent were obsolete). By October 2011 MRAP NSNs with stock on hand exceeded 26,316, and about 43,000 NSNs had been coded. By the end of July 2011, DLA had shipped \$2 billion worth of parts.

¹² This section is based largely on the Haddon interview.

¹³ The two-stage de-processing was inescapable, because the trucks were generally third-party flatbeds. U.S. forces called them “jingle trucks,” because their drivers heavily decorated their cabs with hanging ornaments that literally jingled as they drove. Security forbade carrying classified electronics, such as jammers and communications equipment, on a third-party vehicle.

¹⁴ Forward Operating Bases (FOBs) were large enough to allow practice driving inside the wire, hence were suitable for NET. Company Operating Bases (COBs) were too small; it was difficult enough for a new driver to become acquainted with an MRAP vehicle or M-ATV, without having to brave enemy fire while doing so. The situation with M-ATVs was simpler, because many operators were already familiar with MRAP vehicles. To handle M-ATVs they needed only unique training in M-ATV maintenance and in operating characteristics (Delta course).

¹⁵ Every echelon did its own maintenance. Roughly at the time MRAP vehicles were introduced, the Army went from 3- to 2-echelon maintenance. The number of echelons indicated the number of levels in country at which a vehicle could be repaired before it was considered so badly damaged that it had to be evacuated (at one time there were five echelons). Two echelons meant that if a vehicle could not be repaired at field level it went directly to the sustainment echelon. The object was to reduce the burden on forces in country. MRAP trucks, which needed more battle damage repair than most vehicles (because they survived damage rather than simply being written off), placed a greater burden on the higher maintenance level. Typically the concept is that the field level replaces assemblies compared to repairing them at sustainment echelon. That in turn raises a need to estimate how many assemblies must be deployed forward so that replacement is possible.

¹⁶ The first class of 22 students was held on 10 December 2007, and the first formal class (64 students) on 7 January 2008.

¹⁷ According to a Congressional Research Service report produced in the latter half of 2008, the rollover problem was publicized when three Special Forces soldiers were killed on 29 June 2008 after their RG31 rolled over in Afghanistan. According to the report, more than half of accidents involving MRAP trucks since November 2007 had been rollovers, and that nearly 75 percent of them were in rural areas. At this time the Defense Department stated that the rollover risk was greatest in Afghanistan, where there were few roads, and the ones that existed were poor.

¹⁸ Memo from Director, Capabilities Development Directorate to MRSP JPO, 3 November 2008. It responded to a UUNS raised by I MEF on 2 October 2008 specifically for breathing apparatus. By this time MRAP vehicles in theater had suffered 114 accidents, of which 59 involved a rollover producing blackouts and spatial disorientation to those inside the vehicle. Of those, seven involved a need to get out of the MRAP truck while under water, and there had been five drownings. The Marines in theater were already using a helicopter aircrew-breathing device as their MRAP emergency breathing apparatus.





CHAPTER 14

MRAP INTERNATIONAL PROGRAMS

The United States transfers military equipment to other countries in several ways, and these transfers benefit the United States in several ways, as well. The most important is that they provide allies and coalition partners with the means to operate effectively alongside U.S. forces. For example, any troops that did not have MRAP vehicles in Iraq and in Afghanistan were in greater danger, and they were likely to operate far less effectively, than MRAP-equipped forces. That applied to the Iraqi and Afghani governments as much as to other coalition partners. The second is that foreign sales extend production runs and thus reduce unit prices paid by the United States for its own equipment. Similarly, foreign sales help maintain the U.S. production base.

The MRAP experience revealed a third advantage of Foreign Military Sales (FMS): foreign governments learned operational lessons that directly benefitted the United States. For example, the British changed their seat belts well before the United States

did and provided information to the U.S. program. Another example was Cougar. The British discovered an axle problem the U.S. program had missed. Again, critical information was shared. The U.S. program discovered that British driver training in some areas was superior to the U.S. curricula, and some British practices were adopted. Every foreign customer put its own twist on the vehicle, and had its own unique government-furnished equipment (GFE), for which the JPO had to make the necessary allowances and plan the necessary modifications.

The British, who were the first foreign users, also had the idea of holding an international MRAP vehicle users' conference. At first the U.S. program saw it as an opportunity to pass on U.S. operating experience. The users' conference grew into a two-year series of conferences to exchange hard-learned experience from all users, not just in the United States.

In the case of the MRAP program, full production capacity was generally already urgently needed to meet U.S. military requirements. The issue was typically not whether to extend U.S. production to support partners' needs, but rather how to allocate it in the best way. Allocation involved not only vehicles but also spare parts and sustainment resources such as field service representatives (FSRs) and even manuals and training. In theory, allocation might have been simplified by providing allies and coalition partners with vehicles not being produced for U.S. forces, but scarcities, such as of tires and of armor, applied to all MRAP vehicles; the vehicle makers were not really the bottlenecks whose capacity had to be allocated. As the MRAP program ran down after 2010, the situation changed, and allocation was simplified. In 2013, the only expanding part of the MRAP program was foreign sales, and it seemed likely that they might warrant new production of some vehicles. The policy issue shifted to whether customers were suitable for post-retrograde and whether sales or transfers were in the continuing interests of the United States, not whether transfers would impact U.S. military operations in Iraq and Afghanistan.

The most usual means of transfer is FMS, under agreements that are reported formally to Congress. FMS sales may involve U.S. financial assistance. Most FMS customer requests become FMS cases, which have to be developed by the organization responsible for the equipment, in this case the MRAP JPO. The case has to be staffed within the

Joint Chiefs of Staff and the Department of State. It generally begins with a Letter of Request (LOR); and JPO files include numerous informal contacts preceding such letters. An FMS transfer generally includes a cross servicing agreement, and the customer gains access to the U.S. military logistics system and to vehicle upgrades. Because the United States was buying large numbers of MRAP vehicles, a customer also benefitted from U.S. economies of scale. Additionally, if the coalition partner pursued a FMS case and it was approved, the FMS customer inherited the Defense Priorities and Allocations System (DPAS) Rating of DX, the same rating as U.S. forces, thereby allowing them the same level of priorities when ordering vehicles and parts. Under FMS rules, foreign orders were put into the queue with first come, first served. This is as opposed to buying through Direct Commercial Sales (DCS), which dropped their DPAS rating from DX to D0.

The advantage of buying a U.S. MRAP vehicle, as opposed to a foreign-developed mine resistant vehicle, included commonality and interoperability with the large number of U.S. vehicles. That must have been particularly important given the need to refurbish vehicles after they suffered attacks. FMS customers also benefitted from U.S. modifications to MRAP vehicles. That was more important for a spiral development program like MRAP than for most vehicles and weapons.

Once the United States proved that it had vehicles that could protect troops from roadside bombs and IEDs, its coalition partners wanted MRAP vehicles of their own. The British were buying their version of Cougar even before JPO MRAP was created, but once it had been set up, production for the United Kingdom was folded into the MRAP vehicle program. Before 2012 the British were the single largest MRAP vehicle export customers.¹ Canada also bought vehicles from General Dynamics Land Systems-Canada outside the MRAP vehicle program, but later became an FMS customer. Country requests were prioritized at the Joint Chiefs of Staff (JCS) J-8 level.

Thus, FMS and other transfer mechanisms provided coalition partners with the vehicles they needed to fight effectively alongside U.S. forces in both Iraq and in Afghanistan. A 2012 summary of the MRAP program showed the flags of eight partner countries that had obtained MRAP vehicles under FMS: Canada, France, Italy, the Republic of Korea, Singapore, the United Kingdom, Romania, and the United Arab Emirates (UAE).²

JPO International

At the outset, the Marine Corps Systems Command (MCSC) International Programs Office (MCSC IP) was the Service's Foreign Military Sales (FMS) Case Manager. The JPO's International Programs Assistant Program Manager coordinated with an MRAP Case Team lead in the Marines' MCSC IP organization, whose director in turn reported to the Navy International Programs Office (IPO). Navy IPO was the connection to the Defense Security Cooperation Agency (DSCA). It assigned case numbers to LORs from foreign countries, it approved schedule and threshold funding, and it finalized Letters of Authorization. MCSC notified Congress based on funding thresholds.

MRAP international sales were considered a minor part of the MRAP JPO because most of the office's energy was concentrated on producing enough vehicles for U.S. forces. The international programs team worked with MCSC IP, which developed cases, managed them, reconciled requirements, and closed them out. The IP team within the JPO assisted in defining requirements (which meant liaising with customers), executed the validated case requirements, developed acquisition and contract strategies, awarded and administered contracts, and coordinated with the JPO, with the customers, and with the manufacturers. Nearly every case required visits to the requesting country, as well as arrangements for its representatives to visit the OEM, with participation of the JPO in order to see and inspect the vehicles.

That made for a highly stressed lean team within an already lean JPO. In August 2007 the team totaled just four people: an IPO officer ultimately responsible for decisions and three contractors (one of whom had not yet been appointed). The Army was expected to contribute another three, for logistics, contracts, and finance, but they were not yet on board.³ At this stage the program was relatively simple, involving only the ongoing British purchase of Mastiffs (and their supporting publications and training) and a Canadian LOR. With their vehicles, the British had received the support of seven FSRs—the JPO's logistics went with its vehicles to an FMS customer. A further unofficial request had been received from Italy. Once it was formalized as an LOR, an FMS case would have to be developed.

Ultimately the FMS cases were handled within the JPO. It had to execute the cases, because it was responsible for overall MRAP vehicle production (including spares). It coordinated with foreign governments to define requirements, because it understood

exactly what was available and how the vehicles could be expected to operate. It investigated cost and received price quotes, again because U.S. manufacturers were the contractors for the vehicles. It also developed the RFPs issued to manufacturers to obtain price quotes. Finally, because it was responsible for moving U.S. MRAPs to theater, it was the logical organization to follow through the FMS vehicles to their end destination, unless the FMS customer wanted to pursue their own transportation, usually due to costs.

Once it had matured, the MRAP International Programs team pursued new FMS cases and also tried to identify risks inherent in existing ones. Thus an October 2012 IP briefing gave the situation in March 2012 as 30 FMS cases involving 15 countries and 923 vehicles. The Risk Recon element of the team had identified eight risks (unspecified). By October, there were 34 active FMS cases, and the team was pursuing four more. It was dealing with 21 countries and 1074 vehicles. Of the eight risks identified in March, three had been mitigated and closed, three new risks had been identified, and two active risks were being mitigated. Projects included modifications to existing vehicles, such as the addition of bar armor.

The MRAP IP office dealt with more than FMS, as there were other ways to provide the vehicles to foreign users. It also dealt with hardware cases for additions to vehicles such as mine rollers and anti-RPG measures, MRAP Egress Trainers, and with provision of support services (such as FSRs and manuals).

In that, foreign customers were as affected as U.S. forces by the lack of configuration management. Planning for spares was a problem for them, too, and it took time to bring the problem under control. The JPO's spares allocation "pain" had to be (and was) shared with the international customers whose vehicles operated alongside U.S. vehicles in the same theaters. Some spares were shared in-theater.

MRAP FMS Cases

The MRAP FMS program grew steadily. In 2006 it involved a single manufacturer (Force Protection Inc.), a single customer (the United Kingdom) and 30 vehicles. Others had been bought before the program was created.⁴ In 2007 a second customer, Canada, was added.⁵ In 2008 France and Italy joined, but the United Kingdom was by far the largest customer.

In 2009 a second manufacturer (Navistar) was added, and there were five new MRAP FMS customers, including Singapore, South Korea, Poland, the Czech Republic, and Romania. More new customers were added the following year, but MRAP vehicle demand declined because the largest customer, the United Kingdom, had largely filled its requirements. In 2011 a third manufacturer was added, Oshkosh, for M-ATVs.

As of 1 September 2011, the International Programs portfolio amounted to \$825 million for 924 vehicles from three different manufacturers for 14 countries: 25 cases, with 16 different vehicle configurations.⁶ In October 2012, MRAP represented 28 percent of open Marine Corps FMS cases, and 45 percent of total Marine Corps FMS dollars. During the next seven months, the MRAP IP Portfolio increased by eight cases (27 percent growth). Probably the largest single sale through mid-2013 was 750 M-ATVs through direct commercial sale to the UAE, for delivery between January and August 2013.⁷

Other International Mechanisms

In the case of MRAP vehicles, several other mechanisms were developed to provide coalition partners with the vehicles they needed in order to participate effectively in Iraq (Operation Iraqi Freedom) and in Afghanistan (Operation Enduring Freedom). There were direct Presidential Determinations (Rice Letter) and Sections 1202, 1206, and 1208 (of the National Defense Authorization Act) authority.

Section 1202 envisaged transfers to partner nations (actually loans) on a reimbursable or like-kind exchange basis. At least initially Section 1202 referred only to operations in Iraq and in Afghanistan, and it was under the authority of the Secretary of Defense with the concurrence of the Secretary of State. This authority was delegated to the CENTCOM commander. These are about 900 vehicles bought under the National Defense Authorization Act and lent—not sold—to foreign governments. These governments operate the vehicles as though they own them. Foreign governments, some of which were not the original operators, later acquired some of the 1202-loaned vehicles.

Section 1206 was direct sales (up to \$300 million when approved by the Department of State). Section 1208 was transfers and loans for Special Operations, arranged through SOCOM. As of 2007, Section 2006 was a pilot program using operations and maintenance funds, requiring 15-day prior Congressional notification. Section

1208 (FY 2005 Act) involved only FY 2006 and FY 2007 funds, and entailed 48-hour congressional notification.

An additional mechanism was developed to support partners in Afghanistan: Combined Security Transition Command-Afghanistan (CSTC-A). Under this designation, FMS cases were signed in June 2007 for a total of 258 CAT I and 86 CAT II vehicles. These transfers were soon cancelled (cancellation was requested on 17 August 2007), but they suggest the scale of coalition partners' needs.⁸

There was also a European Command Coalition Readiness Support Program (CRSP), begun in 2010, of vehicles loaned to some coalition partners. CRSP bought 30 Cougar CAT I A2 (4x4) to support Marine Corps Central Command (MARCENT), delivered October 2010 and 70 MaxxPro Dash to support Army Central Command (ARCENT), delivered February 2011. A CRSP II (follow-on) program was being developed in the fall of 2012, involving more than 100 vehicles and several countries.

As operations in Afghanistan wound down, there was another MRAP-transfer mechanism: disposal of Excess Defense Articles (EDA).

Excess Defense Articles

In 2012 the United States began selling MRAP vehicles as excess defense articles. These were vehicles that were made surplus by the establishment of Enduring Requirements (ER)—each of the Services and SOCOM's steady-state requirements for MRAP vehicles post-conflict. By October 2012, the Joint MRAP Vehicle Program (JMVP) had conducted EDA workshops with 12 governments that were interested in acquiring MRAP EDAs.

The EDA process was manpower-intensive, as the individual vehicle had to be inspected to determine whether it was serviceable. Visual inspections of vehicles in Kuwait were conducted in April and May 2012 to determine which of them were suitable for EDA transfer. That year EDA dwarfed foreign sales of new vehicles. Only three newly built FMS MRAP vehicles were delivered, compared to 151 vehicles transferred as EDAs.⁹ In October 2012 the IP Assistant Program Manager characterized EDA complexity as the worst of a series of four underestimated workloads. From October 2012 to mid-2013, representatives of 13 countries attended EDA workshops.

Handling the new EDA market for MRAP vehicles was complicated because in 2012-13 the Services had not yet publicized the Enduring Requirements, which would define how many vehicles they could release as surplus. The EDA market was further complicated in that non-Defense U.S. government agencies, such as Homeland Security, also expressed some interest in obtaining MRAP vehicles.

Continuing International Interest

Due to the high priority of the U.S. program, the U.S. Government initially limited sales to coalition partners in Iraq and Afghanistan. However, by mid-2013 there were major exceptions. Nine countries were obtaining MRAP vehicles for training. Many envisaged enduring requirements, such as riot control, presidential guard duties, oil field defense, border patrol, and mobility. African countries engaged in peacekeeping in Mali were interested, as were those involved in similar operations in Somalia. The continuing international requirement led to new production, as some of the countries were interested in significant numbers of vehicles. There is also interest in licensed-production overseas.

In theory foreign governments can buy MRAP vehicles outside the FMS system, because they are not on the limited-sale list, but most governments prefer FMS because it links them to the U.S. sustainment system, and it also provides access to U.S. modifications to the vehicles.

No one in the JMVP realized how rapidly the international side of the program would grow. No one outside the international program's community took it seriously enough to assign many personnel to FMS cases. As a consequence, the JPO's two FMS representatives found themselves travelling constantly. In March 2012, there were 30 FMS cases covering 15 countries and 923 vehicles; by October, the number of cases had grown to 38, and 1,074 vehicles had been delivered, including EDAs.¹⁰ The total for international customers was well more than 1,700 by early 2013.¹¹ In addition to vehicle sales, there were significant upgrade support packages.

By September 2013, when JMVP stood down, international sales were expanding. Many allies and coalition partners realized that, for insurgents, the important lesson of the wars in Iraq and in Afghanistan was that the most effective weapons were IEDs of various types. MRAP vehicles were the best antidotes, because they could deal

with IEDs however they were triggered. This combination of facts probably ensures continued interest in the MRAP vehicles by many governments. As retrograde operations progressed, MRAP manufactures were allowed to market to the foreign governments more aggressively and with more opportunity to sell to the interested foreign customers.

The wars in Iraq and in Afghanistan were coalition operations. MRAP vehicles became indispensable to all the partners because they and their occupants could survive attacks to which other vehicles would succumb. It followed that the MRAP transfers, particularly but not only via FMS, were crucial to maintaining full coalition participation, without which the operations would have failed. Participation included that of the Iraqi and Afghani government forces, which used both MRAPs and (in the case of Iraq) related vehicles. Under such conditions, the International Programs element of the JPO had a vital strategic role, more like that of the Lend-Lease offices, which helped arm World War II allies, than the usual FMS organizations, which support allies in peacetime.

End Notes

¹ British purchases amounted to 619 vehicles out of the total of 1,074 (including Excess Defense Articles) listed in October 2012: six USMC Cougar A1; 15 Cougar A1; 171 Ridgeback A1; 108 Mastiff Mk I/Cougar JERRV; 198 Mastiff Mk II (Cougar A2); 23 Mastiff Mk III (Cougar A2/EOD); 64 Cougar A2 (C-IED); 15 Cougar A2 (EOD); five Buffalo A1; and 14 Buffalo A2 (FAT).

² Unclassified slide dated 30 June 2010, presented in the unclassified Mine Resistant Ambush Protected (MRAP) Vehicle Overview, October 2011.

³ MRAP JPO International Program Briefing, 30 August 2007. This was a very small operation. To give a sense of scale, an August 2008 briefing described the Navy International Programs Office, whose “front office” alone required eight billets; it had a total of 166 billets and a \$17.8 million budget. Among other things, it had administered an average of 6083 FMS actions in FY04-06, and 1430 cases were still pending closure (probably when the slides were initially created in 2006). As an indication of the place of the IPO within the JPO, it was not even included in JPO program manager reports. The 25 October 2012 Program Management Review of International Programs showed a much larger organization headed by a Assistant Program Manager supported by a staff of seven, with three functional leads (lead engineer, lead program, and configuration management) and a staff including four Project Officers. This staff was being downsized despite a constant increase in case workload.

⁴ A British Letter of Request was received on 21 July 2006, before the MRAP vehicle program was created, for Mastiff (CAT II) vehicles. The case was developed, accepted, implemented, and on contract by 10 August 2007. It was described in a JPO presentation dated 30 August 2007. By that time 108 Mastiffs were on order.

⁵ The Canadian LOR was received in October 2006, just as the MRAP vehicle program was beginning. Contract development was accelerated, so that a contract was awarded on 3 May 2007. The program was for five Cougars (CAT II) and five Buffaloes. To get Buffaloes to the Canadians, vehicles planned for the Marines were diverted. The Canadian vehicles were Cougar JERRVs. At this point the only FMS contractor was FPI.

⁶ As described in the Transition Support Plan dated October 2011. At the time it was estimated that the program might involve as many as 4,000 vehicles by late 2012, and that the value of the program might then be \$2.75 billion, including about \$50 million in follow-up support such as work by FSRs and the provision of technical manuals.

⁷ Yasmin Tadjdeh, “Middle East MRAP Sales Give Hope to Truck Manufacturers,” *National Defense Magazine*, October 2012, provides this information. According to the article, the UAE approached Navistar directly. Navistar has advertised its MaxxPro and other vehicles that appear to reflect its MRAP experience. It is not clear to what extent such vehicles would come under the authority of the JPO, because, although they reflect the MRAP experience, in many cases they were not bought by the JPO. Apparently MRAP-like vehicles are not on the controlled weapon export list.

⁸ This was described by a slide in the International Programs summary of 30 August 2007. The recipients were not indicated.

⁹ Most EDAs were CAT IIs (HEV, JERRV EOD, JERRV ENG, Cougar Surge, and RG-33).

¹⁰ “Program Management Review: International Programs,” 25 October 2012, *op.cit.*

¹¹ FMS cases were approved for six countries (about 1,000 vehicles) in 2007-2011.





CHAPTER 15

MRAP VEHICLES AND M-ATVs FOR AFGHANISTAN

Afghanistan imposed very different warfighting requirements than Iraq. For the region, Iraq was a well-developed country with considerable paved mileage.¹ More or less conventional trucks could operate there. Afghanistan was almost completely unpaved. In a territory about the size of Texas, there are only about 11,000 miles of roads, so vehicles operated mainly off-road. They had to be smaller and more agile than those used in Iraq. Trucks had to be far more maneuverable.

The enemy in Afghanistan used primarily under-belly improvised explosive devices (IEDs). In response, the first MRAP vehicles were deployed from Iraq to Afghanistan in October 2007, and the first new MRAP vehicles reached Afghanistan in February 2008. Given the difficult terrain and the lack of roads, in 2008 all RG31s, the then lightest MRAP vehicles, were assigned to Afghanistan. The enemy's use of under-body IEDs accelerated, with IED attacks increasing nearly fivefold between 2007 and March 2009.²

Ultimately the two major MRAP vehicle users found themselves operating in very different areas of Afghanistan. The Army operated in the mountains, where it was channeled so that an enemy could predict where its vehicles would go. It had to deal with the most powerful under-body IEDs, because the enemy could take the time to set them up. The Marines operated mostly in flat desert, where their movements were unpredictable. These different conditions were reflected in different decisions as to which vehicles to retain postwar, because the Services' experience of combat was so different.³

The RG31 was one of the lightest and most maneuverable of the early MRAP vehicles, and as such, was the initial choice to support operations in Afghanistan. Even so, they were not sufficiently mobile to meet requirements in that theater. Once the decision had been made to use only RG31s in, the search immediately started for other options. To meet demand for a smaller and shorter version to improve mobility in Iraqi cities, Navistar developed the Dash. This lighter-weight vehicle (49,000 pounds) was delivered explosively formed penetrator (EFP)-protection-ready (the kit was different from that of the MaxxPro Plus). With the same engine as the MaxxPro Plus, it could do 67 mph and had a turning diameter of 55.5 feet, better than that of the lighter RG31. Compared to MaxxPro, MaxxPro Dash was also shorter and narrower, for better maneuverability in confined spaces. The improved suspension used a 23,000-pound capacity front axle and a 26,000-pound capacity rear axle. As with the Plus, Navistar produced an ambulance version, 250 of which were delivered. It turned out that the same characteristics that made the Dash more attractive for Iraqi cities also provided the required improved off-road capability for the challenging terrain of Afghanistan.

MaxxPro Dash deliveries amounted to 2,272 vehicles. DXM (a Navistar designation) was a follow-on version with independent suspension, of which 1,050 vehicles were delivered (LRIP 17). It had the same engine, but axle capacity was 21,000 pounds front and 23,000 pounds rear. Maximum speed was 67.9 mph, and turning diameter was 55 feet. Coil springs and shocks were upgraded to accept an EFP armor kit. Compared to Dash, DXM featured fully independent coil over shock suspension front and rear, larger wheels and tires (16.00R20), improved mobility and ride quality, and central tire inflation system (CTIS). The latter improved control over the pressure in each tire to improve performance on bad surfaces.

Existing vehicles were also modified. Thus the 4x4 Cougar also substituted independent suspension instead of solid axles.

Third-Gen MRAP Vehicle

The Joint MRAP Vehicle Program (JMVP) issued an entirely new specification for what it considered a third-generation vehicle: The MRAP All-Terrain Vehicle (M-ATV). The lightest of the earlier MRAP vehicles weighed 38,000 pounds.⁴ For Afghanistan, Joint Task Force (JTF) 101 specified a maximum weight of 25,000 pounds, the first time an MRAP vehicle was limited by a specific weight requirement. In effect, an explicit requirement for mobility was added to survivability. The latter requirement was very difficult, as sheer mass helped vehicles survive explosions. The weight crept up slightly during the requirements process, so that the M-ATV weight threshold for offerors was 25,000 pounds. After completion of the source-selection process, the threshold was raised initially to 27,500 pounds, to accommodate add-ons that the Special Operations Command (SOCOM) wanted and additional protection, and ultimately raised to 32,000 pounds.⁵

At the outset there were 25,000 Americans in Afghanistan, but it was clear that the number would soon increase sharply, as attention turned from Iraq to Afghanistan. Ultimately more than 8,000 special Afghan vehicles were needed.⁶ Initially it seemed that most of them would be adapted MRAP vehicles. A special Afghan vehicle was wanted for mountain roads and in relatively small numbers (the first estimate was for about 2,000 vehicles).

The requirement was formally framed in November 2008 and the request for proposals (RFP) issued on 8 December. It was intended to meet an approved Joint Urgent Operational Need Statement (JUONS) for an all-terrain vehicle specifically for service in Afghanistan.⁷ As with previous MRAP vehicle contracts, the contract called not only for vehicles but also for initial spares, services, and supporting equipment. The RFP envisaged a production range of 370 to 10,000 vehicles, to be produced at a rate of 100 to 1,000 per month.

Evaluation and source selection followed between January and June 2009, with a contract award in June. The process was very different from that used for the original MRAP vehicles. To ensure quick fielding and to respond to the Warfighter's strong request for a single variant in Afghanistan, the JPO adopted a winner-take-all procedure. It was aware that such awards often engendered protests, which would badly delay production, so instead of the less formal process adopted for the original MRAP

vehicle RFP, the source selection team, led by then-Deputy Program Manager David Hansen, chose a traditional process shaped precisely by the usual acquisition rules. In this particular case, going by the book promised a quicker result than the informality of the past—not because anyone in or out of the program had changed, but because there was now much more production capacity and protection was far better understood by all potential bidders (and by the JPO itself). The traditional process did cost time (about six months), but it saved time by precluding effective post-contract challenges. Traditional elements included sequestering the source selection evaluation board (SSEB), whose members were cut off from Internet access at their desks. This was the first (or very nearly the first) peer-reviewed source selection, a technique now widely used.⁸

In 2009 the M-ATV source selection received the highest Defense Department award for acquisition, the David Packard Award, for the innovative method of source selection. The previous year the overall JMV Program Office had been awarded this prestigious honor.

MRAP Program Epitomizes Acquisition Excellence

There was a two-stage down-select. First, anyone who could offer two trucks for tests received \$1 million to defray costs. The trucks were put through a safety test at Aberdeen Test Center (ATC) to confirm that they could undergo more exhaustive tests. The second down-select was for production. Nine companies responded to the RFP, and five ID/IQ contracts were offered to manufacturers whose vehicles passed the test and evaluation process.

This competition differed from the 2007 process, in that the JPO chose a single vehicle for quick production instead of its earlier practice of encouraging each manufacturer to test, fix, and test again and then produce limited quantities leading to larger awards. By 2008, the JPO had gained considerable experience. It was also well aware of the logistical problems of a mixed fleet. Although the 2008 process was fast, it was more like a traditional one, in that it was winner-take-all.⁹

There was some question as to whether a single manufacturer could produce enough trucks sufficiently rapidly. Secretary of Defense Gates wanted to form a production pool,

2009 David Packard Award

The Mine Resistant Ambush Protected All Terrain Vehicle Source Selection Evaluation Board (M-ATV SSEB) is presented the David Packard Excellence in Acquisition Award for its innovative acquisition practices and accelerated selection process leading to the optimal selection and rapid deployment of a vehicle system that satisfied a Joint Operational Need Statement. The M-ATV SSEB responded with inspirational speed, tenacity and dedication to a joint Warfighters' need in Afghanistan for protection against mines, improvised explosive devices and small arms fire. Never before has such an abbreviated timeline requirement for initial contractor paper evaluation, Government capability testing and limited user evaluation been levied on an evaluation team. The team developed new evaluation processes and then evaluated almost 400 requirements and over 1,500 Items for Discussion, leading to an extensive testing process that delivered over 1,200 Test Incident Reports to the competing offerers, all in just a few short months. The team's extraordinary professionalism and proficiency enabled them to overcome multiple challenges and award to the original schedule. The M-ATV SSEB's efforts resulted in the selection of a low risk solution and accelerated delivery of thousands of M-ATVs to leverage the existing MRAP fielding base for quick theater deployment that will save countless lives.

as had been done with aircraft during World War II; production pooling was often discussed during the Cold War in connection with possible U.S. mobilization. That was not how the Department did business in 2008-2009, but it could be done. All five MRAP original equipment manufacturers were told that the Department was close to making an award, but that it wanted two questions answered:

1. If you win, will you allow license production?
2. If you lose, will you build a competitor's truck?

And, all were promised that the anti-trust laws would not be applied.

Contenders

Eight companies offered vehicles.¹⁰ For all of them, the M-ATV must have looked as promising as the original MRAP vehicle competition. Although the initial requirement was only about 2,000 vehicles, that was likely to grow considerably. Ultimately the M-ATV winner, Oshkosh, produced slightly more vehicles than the largest original MRAP vehicle builder, Navistar. This was a prize worth fighting for. The scale of possible production was indicated by the terms of competition: each company was asked

for a base unit price based on 1,035 vehicles and for an option unit price based on 4,209 vehicles. Each was also asked for an average production rate of about 200 vehicles.

Requirements included a maximum curb weight of 25,000 pounds, a maximum height of 102 inches, maximum width of 96 inches, and a turning diameter of 54 feet. The latter was exceeded by two of the five final contenders: BAE Santa Clara (63.3 feet) and Oshkosh (62.7 feet). No contender exceeded the maximum height, but three of the five somewhat exceeded maximum width: 98.1 inches for BAE Santa Clara; 100.1 inches for Force Dynamics; and 98.1 inches for Oshkosh. These differences seem not to have been very significant, compared to weight, and did not rule anyone out.

The contenders were, in alphabetical order: ¹¹

- American LaFrance (ALF), which normally built fire engines, working with retired Army Colonel Garth Barnett, formerly of Protected Vehicles Inc. (PVI). Its 22,948-pound vehicle was withdrawn at the stage at which the company had to deliver a production ready vehicle (PRV).
- BAE Tactical Vehicle Systems (TVS), the Caiman producer, offered a 24,884-pound vehicle, reportedly a Caiman derivative, with a suspension based on the firm's Family of Medium Tactical Vehicles (FMTV) logistics truck.
- BAE Santa Clara (BSC) offered a 20,032-pound vehicle, the lightest of the contenders. This vehicle seems to have been based on the RG-33.
- Force Dynamics Ltd (FDL), a team of Force Protection Industries (FPI) and General Dynamics Land Systems (GDLS), offered a 23,000-pound vehicle. This was the Cheetah, in effect a next-generation lightweight Cougar. Cougar had previously been proposed for the Joint Light Tactical Vehicle (JLTV) program, but was rejected in August 2008. FPI built 13 prototypes. An earlier version of Cheetah might have been submitted as a CAT I entry in the original MRAP vehicle competition.
- FPI. It withdrew its separate 30,771-pound proposal that greatly exceeded the 25,000-pound limit.
- GDLS-C, which made the RG31. This 24,780-pound vehicle failed to meet one of the criteria for the production vehicle award. This vehicle was reportedly based on the RG31. GDLS-C announced that it was dropping out of the competition on 30 March 2009.

- Navistar offered a 24,625-pound vehicle, reportedly a version of its MaxxPro Dash, which it called MXT. On 30 March 2009 Navistar filed a protest against what it called an “unspecified technicality in the government’s evaluation of its proposal,” but it withdrew the protest early in April after the contract was amended by the JPO.
- Oshkosh (OTC) offered a 24,500-pound vehicle. Ultimately it won the competition.

This was very much on the scale of the original MRAP vehicle competition, although this time the rules were considerably more refined.

The eliminations indicated reduced the field to five contenders: BAE SC, BAE TVS, FDL, Navistar, and OTC. (Only the first four had significant experience delivering MRAP vehicles, however.) Each received a three-vehicle ID/IQ contract. All the vehicles were 4x4s, and capacity in each case was four occupants and a gunner. Details of their vehicles show sophisticated forms of protection, usually multi-layered to deal with both IEDs and small-arms (up to heavy machine gun) fire.¹²

M-ATV Contract Award

The contract award was announced on 30 June 2009, after the stock markets closed. When Oshkosh won, they had tremendous capacity and were willing to risk \$120 million to \$150 million. The company was willing to take these risks even though its commercial business was ailing, so it had fewer resources to absorb any losses it might incur. It had also been forced to lay off some of its veteran workers. In effect, they bet the house. This time, however, the Army’s Tank Automotive and Armaments Command (TACOM) let the low-rate initial-production (LRIP) contract for the JPO, a fixed-price purchase of 2,244 vehicles with an option for up to 6,644, with additional orders in the following months. So, the company did not have to go “on risk” as had been the case for MRAP vehicles intended for Iraq. Oshkosh produced more than 8,000 M-ATVs in 18 months.¹³

The day after the award there was a DoD press conference. Normally the losers in a major competition go to the press in attempts to overturn the results. Brigadier General Michael Brogan sought to forestall that, showing confidence in the winner and pointing to the urgent need for the vehicles. He was hoping for a protest question. When it came, he pointed out that the losers certainly had the right to protest, but that the 100-day delay involved would cost lives. In the end, there were no protests.

Navistar, which thought it had finished second, did go to Congress, but only to ask to be allowed to build the Oshkosh truck under license. In fact, however, Oshkosh always exceeded its production goals. Initially the theater thought it could absorb only 500 trucks per month; Oshkosh reached a monthly rate of 1,100. That made it possible to spread vehicles to a continental U.S. (CONUS) training base and also to pre-position them in theater. No production pool was needed.

When Oshkosh began work on its M-ATV proposal, it was focused on the Army's JLTV program, which the company expected to be considerably larger than M-ATV.¹⁴ The cocoon capsule embodied in the M-ATV had been designed for the JLTV project. The other element was an off-road suspension derived from the company's Marine Corps Medium Tactical Vehicle Replacement (MTVR) truck. Unlike many tactical trucks, this one was designed for the same combination of 75 percent off-road and 25 percent on-road operation that was required for the M-ATV.¹⁵ Its TAK-4 independent suspension was installed not only on M-ATVs but also on some MRAP vehicles destined for Afghanistan.¹⁶ The night Oshkosh discovered that it had missed the down-select for the JLTV, it decided to push for the M-ATV contract. They had already blast-tested their JLTV, so Oshkosh knew that its capsule would survive. It was already light enough to meet the M-ATV requirement, and it was easily developed into a more survivable design with a vee-bottom.

By the time of the M-ATV competition, Plasan and Navistar had parted company. Oshkosh bought a kitted armor design from Plasan, giving itself the same sort of production advantage that Navistar enjoyed in the earlier MRAP vehicle program. The contact between Oshkosh and Plasan had begun with the Oshkosh work on JLTV. The view at Oshkosh was not so much that kittable armor made possible production by semi-skilled labor, as that it made possible fast production, because bolting was much quicker than welding a large structure.

Oshkosh considered itself unique in combining a capsule with blow-away automotive elements. In its view, its competitors risked having axles and other heavy automotive elements blown into the troop compartment. Moreover, given the stringent weight limit on an M-ATV, it could not absorb blast energy the way a heavier MRAP vehicle did. Because M-ATV would be so much lighter, it had to have some other way to absorb the energy of an explosion. Oshkosh focused on absorbing the energy by blowing apart elements of the vehicle outside the troop capsule, preserving the capsule. Other MRAP

vehicles often lost parts in explosions, but they were not designed specifically to do so. Oshkosh conceived its M-ATV as a vehicle that would in essence die to save those inside.

Because the JLTV had a more stringent weight limit than the M-ATV, Oshkosh knew that it could meet M-ATV specifications. Knowing that the capsule would survive and that the suspension would meet the M-ATV's off-road requirement, Oshkosh felt that it had a good chance of winning.

The timing of the M-ATV submission was very tight. Work began in October 2009, and two pre-production vehicles had to be ready for tests in February 2010. They had to be fully equipped and fully armored, because the tests would begin with both the critical safety and blast tests. All five of the companies that had built MRAP vehicles in quantity were already competing. M-ATV had not really been on the company's scope until it failed the JLTV down-select. The decision to exploit the JLTV and MTRV designs was made quickly. Ironically, a few years after it won the M-ATV program, Oshkosh came back into the JLTV program by becoming one of the three down-selects for the engineering and manufacturing development (EMD) phase. This time it was exploiting the technology it had developed for M-ATV, which in turn evolved out of its earlier failed JLTV work.

Three Factors

Oshkosh credited its success in the M-ATV competition to three separate factors. One was the kitted-armor ballistic capsule derived from that it had developed for the JLTV competition. A second was the MTRV suspension and power train, which gave the excellent off-road performance required in road-less Afghanistan. The third was production capacity. It was critical to produce a high production rate. Because it had been producing trucks in such volume, Oshkosh had already developed a strategy of standardized procedures in its core defense plant, and also in its JLG Industries' factory at McConnellsburg, PA (whose main product was aerial work platforms, e.g., large "cherry pickers"). Oshkosh launched production simultaneously in both plants, more than doubling production.

Oshkosh used two facilities, one of which they had long owned. When it received the contract, the company was in the throes of a severe downturn, many of its long-time

workers having been let go. After June 2009, the company brought back 600 of them, with an average tenure of 11 years. The JMVP was more than satisfied with their product.

Oshkosh was already deeply involved in Marine Corps programs; it made the Marines' standard medium (7-ton) and heavy (22-ton) trucks, the MTVR and the LVSr. It also made their supplemental armor, and the armor designs clearly reflected the improving understanding of explosions that the JMVP was gaining using live-fire tests. The up-armor experience surely contributed to the company's successful Afghan design. The successful Oshkosh design combined elements of the MTVR and the new TAK-4 independent suspension.

The M-ATV reflected several years of MRAP vehicle experience. For example, by this time manufacturers were doing some pre-outfitting, and M-ATVs came to Charleston with wiring harnesses already installed. In addition to the basic truck variant, there were ambulance and Special Operations Command (SOCOM) variants.

Once more the MRAP JPO managed to produce the needed quantities quickly.

That said, fielding the M-ATVs in Afghanistan was more difficult than in Iraq. Time could not be spared to drive the M-ATVs to their users. Instead, drivers took their Up-Armored Humvees (UAHs) to distribution centers. There they turned in the UAHs to pick up M-ATVs that had been brought up on flatbeds. Then they drove back to their units, usually off-road, because there were so few roads: on the job training!

The M-ATV weighed 24,925 pounds and was powered by a 370-HP Caterpillar C-7 7.2 liter diesel. It was credited with a speed of 65 mph. Like earlier MRAP vehicles, it had provision for an explosively formed penetrator (EFP) protection kit, this time with doors corresponding to the four side doors of the vehicle. Compared to a CAT I MRAP vehicle, the M-ATV had a smaller capacity, just five personnel, including the gunner.

The JMVP felt that initial operational performance could be improved upon so there were safety and blast protection upgrades. An Underbody Improvement Kit (UIK) roughly doubled survivability against under-belly explosions. Its introduction was somewhat controversial within the JPO, however.¹⁷

Underbody Improvement Kits (UIK) were produced for 8,011 M-ATVs in Army and Marine service, with a different kit for SOCOM vehicles. The last group of M-ATVs

was built with UIKs already installed. The initial UIK upgrade production goal was 400 vehicles per month, raised by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L) to 750 per month. The UIK added a new slab of under-body armor and raised the vehicle by changing to larger-diameter tires. In addition, new stroking seats, better able to absorb blast acceleration, were installed. With the UIK 2 survivability upgrade, an M-ATV weighed 32,500 pounds; turning circle radius was 61.7 feet.¹⁸

Given its success with M-ATV, Oshkosh applied that experience to the JLTV program and won one of three EMD contracts with a vehicle it called Light Armored Tactical Vehicle (LATV)—in effect a scaled-down M-ATV using the same TAK-4 independent suspension and kitted armor, but with a considerably lighter capsule.

M-ATV Production

John Young, who at the time headed the OSD MRAP Task Force, signed an 11 December 2008 memo defining the desired M-ATV for Afghanistan, and in a 19 June 2009 memo the JPO stated that it had a material solution that could be produced in a timely manner. Three pre-award test vehicles had already been bought (30 April 2009). They were followed by a series of purchases under LRIP 15 (2,244 on 30 June, 1,700 on 31 July, 352 on 11 August, and 923 on 9 October 2009), under LRIP 16 (1,000 on 10 November and 400 on 9 December 2009), and LRIP 17 (1,039 plus 421 for SOCOM on 22 February 2010).¹⁹

Smaller numbers were bought under LRIPs 18 through 22: four test articles under LRIP 18 (15 July 2010); 46 for SOCOM under LRIP 19 (30 November 2010); 177 under LRIP 21 (20 May 2011); and 400 under LRIP 22 (27 June 2011). The latter purchase brought the total of M-ATVs to 8,371. M-ATV procurement included UIKs to increase resistance to more powerful under-body IEDs. A UIK consisted of additional armor (additional belly plate), structural enhancements (ladder, tie rods), blast mitigating seats, seat integration (floor mounted front, wall mounted rear), gunner stand improvements (Skydex, quick-pull pin), integration of larger 16R20 tires, improved wheel zone deflectors, and blast-mitigating floor mats. The UIK was directly tied to increased and more effective IED activity in Afghanistan. The kits were produced by Oshkosh.

The first trucks delivered in September 2009 and were fielded in November and December, a year after the RFP was issued. These were entirely new trucks. The

manufacturers had learned a great deal by this time and understood that there would be a large order. They had some latitude for trade-offs because there were only the two key performance parameters of survivability and mobility. For example, the trucks had to be able to brake on an incline in off-road Afghanistan. There were more than 300 tradable requirements. As with the original MRAP vehicle program, the question was always what was essential versus what was desirable; the great lesson of the MRAP vehicle program was that focusing only on what was essential made for a fast effective program. That was not easy. By 2009 everyone in Iraq and Afghanistan had MRAP vehicles, so senior flag and general officers wanted to add their own requirements. Normally no one at the level of a program manager could have denied them. The OSD Task Force could and did. It kept senior officers out of testing and procurement.

The JPO could produce M-ATVs remarkably fast, but as President Obama ordered a surge in Afghanistan in 2009, those on the ground doubted that they could absorb the vehicles as rapidly. General Petraeus thought 500 per month was the limit his force could absorb. Dr. Carter, who was then in charge of acquisition (USD AT&L), and hence in charge of producing M-ATVs as fast as possible, rejected that. Every M-ATV absorbed into Afghanistan was saving U.S. troops and making them more effective. He said that 500 per month was not nearly good enough: the program would be shipping 1,000 vehicles into theater each month. Initially there was some resistance from the Army, which recalled problems at the beginning of the program.³⁰ But that soon dissipated.

End Notes

¹ A February 2009 JPO analysis of the rollover problem and of the likely problem in Afghanistan tabulated data on the two countries. Iraq had 37,851 km of paved roads and 7,049 km of unpaved ones. Afghanistan had 2793 km of paved roads and 18,207 km of unpaved ones. Mountains and hills accounted for 79 percent of the area of Afghanistan. Iraq was 80 percent desert, compared to less than five percent in Afghanistan. Total land area was comparable: 437,162 sq km for Iraq, 647,500 sq km for Afghanistan. Slopes in central Iraq were less than 15 percent, compared to more than 45 percent in Afghanistan. Elevation extremes were 0 to 3,611 m in Iraq, compared to 258 to 7485 m (24,550 feet) in Afghanistan. In Iraq, 9,472 vehicles had suffered 77 rollovers, a ratio of 1:123. The corresponding figures for Afghanistan were 1,272 vehicles and 24 rollovers (1:53).

² Andrew Feikert, CRS report “Mine-Resistant, Ambush-Protected (MRAP) Vehicles: Background and Issues for Congress,” 3 August 2009, *op.cit.* On page 3 the report cites a JIEDDO report that in March 2007 there were 163 IED incidents in Afghanistan, including devices found and disarmed. They resulted in 8 successful attacks causing 16 U.S. and coalition casualties. In March 2009 there were 361 incidents (27 effective attacks) that killed 19 troops and wounded another 56. According to the report, the enemy was building larger IEDs and finding better ways to conceal them. This report dates interest in a new MRAP-type vehicle for Afghanistan to the summer of 2008.

Department of the Army, Justification and Approval for Other than Full and Open Competition (CMO Control No. 2011-134) for 177 Underbody Improvement Kits (UIKs) for M-ATVs, dated 25 April 2011. At this time, M-ATVs were one of the most widely used vehicles in theater; with UIK they would be more capable and more survivable. Funding had already been approved by the JPO. The memo continued by pointing out that the enemy had become aware that he could overmatch M-ATV protection with IEDs (it cited memos from

CENTCOM and from Deputy Commander of U.S. Forces-Afghanistan dated 30 September 2010 and 28 October 2010, documenting the deficit in M-ATV survivability). Most of the memo was devoted to justifying the sole-source award of the UIK contract, citing the cost in blood of the delay inherent in a competitive contract.

³ Colonel John Rooney, who knew more about survivability than anyone else in the program, commented that the Marines loved their Cougars; their experience in southwest Afghanistan showed that the Cougar met their needs. The Army chose to retain the M-ATV and the MaxxPro Dash. Rooney felt that the Cougar's main virtue was its excellent hull. While it initially had the worst seats and the worst floor, the M-ATV was, in his view, far more mobile, much lighter, and more versatile. Rooney interview.

⁴ The objective curb weight was 17,000 pounds; the 24,000 pounds was the maximum acceptable. This was about two tons less than the lightest MRAP vehicle, but also over three tons more than a JLTV. Unlike JLTV, M-ATV was not to have helicopter air mobility, but it was to be transportable by a C-130 or C-17 (MRAP vehicles could not be transported by a C-130). Width was not to exceed 96 inches (106 inches with add-on EFP protection). Height would be limited to 102 inches, including an Overhead Gunner's protection kit. Other requirements were the ability to maintain up to 75 mph on a paved level road, and 45 mph on a 5 percent grade. M-ATV should accelerate to 30 mph in 12 seconds, and travel 300 to 400 miles without refueling. It should be able to ascend a 40 percent grade on a paved surface at 10 mph or safely ascend a 60-degree grade at a minimum of 2 mph. It would also have to maneuver safely over a 40 percent side slope on a paved surface at 5 mph. These rather elaborate requirements were intended to insure that the M-ATV could operate freely in Afghanistan; it had to be capable of operating in areas denied to MRAPs. The requirements also contrast with the almost total lack of explicit automotive requirements in the original MRAP solicitation.

⁵ An 8 February 2011 information paper announced that the Joint Requirements Oversight Council (JROC) had modified the previous weight limit of 27,500 pounds, as stated in its memorandum JROCM 029-10. A JUONS (CC-0326a) of 30 September 2010 required increased underbody protection up to 2x(T) for 4,546 M-ATVs in Afghanistan. The solution was UIK 2, whose estimated weight was 2,853 pounds; it was to be applied as an engineering change proposal (ECP). The first 800 kits were placed on contract on 23 December 2010, with another 2,080 projected as of February 2011. It turned out that the additional weight did not significantly degrade vehicle performance or maneuverability. The reason for changing the formal weight limit was that otherwise M-ATV procurement had to cease. The 2011 memo proposed increasing the current 27,500-pound curb weight by another 4,500 pounds to allow for affordable improvements in survivability without degrading cross-country mobility or reliability. It would not affect speed on grade, braking, acceleration, etc. Vehicle curb weight was not an accurate reflection of mobility or how vehicles operated in theater; they were typically tested at gross vehicle weight (GVW). With UIK2, curb weight would be 29,053 pounds. With the information paper, the JPO proposed another 10 percent allowance for ECP growth, for example for EFP protection, to a total of 32,000 pounds. The JROC approved the increase to 32,000 pounds in a memo dated 25 March 2010.

⁶ The JROC target approved in June 2009 was 5,244 vehicles; in September that grew to 6,644; and in 2010 (JROCM 001-10) it came to 8,104 vehicles.

⁷ According to the March 2009 *Defense Update* article, the Department of Defense DoD had been seeking an all-terrain MRAP vehicle equivalent since the first MRAP trucks were deployed in Afghanistan. The British had reached much the same conclusion after deploying Mastiffs (modified Cougars). By 2009 the British were operating several less heavily protected vehicles in Afghanistan: Supacat, the all-terrain wheeled Jackal, and the Swedish BvS10 tracked articulated vehicle. The only U.S. alternatives, according to the article, were the RG31 and UAHs. It is not clear why MaxxPro Dash was not included.

⁸ Richard Ginman, who in mid-2013 was director of acquisition for the DoD, was the peer reviewer. The concept was to attach two or three successful retired program managers, engineers, and contracting officers to a program to give it the benefit of their experience without reporting back to USD (AT&L). That morphed into a means of standardizing "best practices." Policy on peer reviews was promulgated by a 29 September 2008 memorandum from USD AT&L. Section 808 of the FY 2008 defense authorization established a requirement for post-award independent management reviews of contracts, and for sharing lessons learned from those reviews. A 2010 briefing on the peer review concept included the idea that such reviews would allow for taking time to improve quality, the opposite of the 'time is of the essence' concept integral to the MRAP vehicle program.

⁹ This time specifications were more elaborate. Version 4.0 (8 December 2008) of the draft Performance Specification ran to 108 pages. This document specified the maximum curb weight of 25,000 pounds (17,000 pounds objective) and the maximum width of 96 inches (84 inches with mirrors, etc. folded); maximum width with an EFP kit was 106 inches. Maximum height of 102 inches included the OGP kit on the vehicle. Actual protection remains classified, but the unclassified part of the draft included the requirement to be able to drive 1 km after a single 7.62 mm perforation in any of the following systems causing a fluid leak: engine; cooling system; or fuel storage. Operation would be on primary roads (10 percent of the time), secondary roads (40 percent), trails (30 percent), and cross-country (20 percent). M-ATV was expected to ascend a 40 percent paved grade at 10 mph and a 60 percent paved grade at 2 mph without losing stability; or maintain 45 mph on a 5 percent grade. Driving a sinusoidal path along a road tipped up 30 degrees at 5 mph, it had to remain stable, with no tire lift—a reaction to the rollover problem. On the flat, M-ATV was to exceed 65 mph (75 mph objective). The specification went on to describe performance over various obstacles.

¹⁰ Lockheed Martin reportedly planned to offer a vehicle based on its JLTV submission and was the ninth, but it withdrew before submitting anything. It is not clear which the tenth was.

¹¹ M-ATV candidates were described in a March 2009 *Defense Update* article. The data given here include descriptions from the article.

¹² Designs had to allow for four types of protection: mine/underbody, IED (side)/direct fire, fire suppression (in the event of a hit), and RPG/ EFP protection. By this time it was well understood that the vee-bottom alone was not enough to deal with mines; there also had to be a sufficient gap between mine/IED and vehicle. Some vendors offered a suspension that could raise the crew capsule to increase the air gap. Drive trains and their tunnels were still a point of vulnerability; the cavity could be armored so that it would survive an explosion. Armor against side attack IEDs and direct fire (by up to heavy machine guns) had to include overhead protection. Soldiers and Marines inspected and operated the vehicles, observing points of vulnerability (in one case they considered the suspension susceptible to incapacitation by small arms or shrapnel).

¹³ The initial contract, under LRIP 15, amounted to 5,151 operational vehicles and 93 test vehicles, the number of the latter reflecting the greater emphasis on automotive capability. This number of test vehicles moved M-ATV closer to a conventional vehicle program. LRIP 16 (June 2009) bought another 1,400 vehicles, and LRIP 17 (January 2010) another 1,460. In addition LRIP 18 bought four more test vehicles, and LRIP 19 bought 82 vehicles for SOCOM and 250 ambulances. Of the total of 8,440 in the M-ATV fleet, the Marines received 1,454, the Army 5,804, the Air Force 277, the Navy 154, and SOCOM 501, plus the 250 ambulances.

¹⁴ According to an article by David Axe in the July 2010 issue of *Automobile Magazine*, Oshkosh had a particular competitive advantage because it began work on M-ATV even before the government requested it, because the company could see the need for such a vehicle. That may actually be a reference to the company's work on JLTV. See, "Oshkosh M-ATV Military Vehicle in Afghanistan—Battle Ready," http://www.automobilemag.com/features/news/1007_oshkosh_m_atv_military_vehicle_afghanistan/viewall.html.

¹⁵ Typical practice, for example in Army tactical trucks, was the opposite. The Marines were the only Service that demanded 75 percent off-road performance in tactical trucks. Oshkosh considered itself fortunate to have been the developer of the Marine truck.

¹⁶ MRAP vehicles with solid axles had conventional leaf-spring truck suspensions, and as the vehicles became heavier the ride, which had never been very good, became much worse. The independent suspension adopted for Afghanistan solved that problem.

¹⁷ The upgrade was the source of significant debate, even within the JPO leadership. There was a natural tension between what might be better and what might be produced more rapidly. Program improvements were generally made in response to changing requirements. That applied to a variety of changes. For example, the ISS was under test for nearly a year before it became a requirement and thus had to be introduced into the program. The question was always what was good enough versus what might be desirable.

¹⁸ This is the only vehicle in the JMVP March 2012 "Smart Book" program summary for which a training requirement was listed: 40 hours of OPNET training course plus a 6.5 hour UIK course.

¹⁹ A 29 January 2009 memo from the USD AT&L (John Young, who headed the MRAP Task Force) reported a 24 December request from CENTCOM for MRAP vehicles to fight in Afghanistan during the coming summer, and also to train US and Coalition troops before deployment. The ultimate requirement was unknown, but Young asked for 1,460 M-ATVs plus 1,050 MaxxPro Dashes with independent suspension, 250 RG31A3s with independent suspension, and 58 RG-33s.

²⁰ Paul Mann interview. Between about October 2009 and December 2010 Mann was being berated for logistical problems, his callers not thanking him but instead attacking him for delivering so many problems. Army leaders' perception seemed to be that the MRAP vehicle program was out of control, not handling its problems. The program spent January through March 2010 supporting the operation to field 1,000 vehicles each month, and by March the Army was back on board.





CHAPTER 16

PROCUREMENT SUCCESS!

The Joint MRAP Vehicle Program (JMVP) bought a flood of vehicles in a time span that most observers considered astounding, something not seen since the procurement miracles of World War II. Many had doubted that the United States even retained this kind of capacity, and the loss of capacity was often blamed on a dysfunctional procurement system. Yet the JMVP operated, not as a special small rapid acquisition program outside the rules, but within them. And in this way it is an important pointer to a new kind of agile procurement demanded by the kind of circumstances that led to the wars in Iraq and Afghanistan.

The DOD Procurement System

To see why this might be so, it helps to look back at the logic that produced the current system, a logic integrally associated with the Cold War the United States

fought and won during the half-century after World War II. Initially it seemed that the Cold War demanded heavy investment in a series of radical new technologies, such as nuclear weapons and jet aircraft. No one had any idea of what the new technology would or should cost. That was relatively unimportant as long as new weapons and associated systems were in the development stage. By the late 1950s, they were entering production. It turned out that cost estimates were wildly wrong. The Services could not afford what they had paid to develop, at least not in anything remotely like the desired quantities. The country could not afford enough of a defense budget to pay for the desired numbers. This problem led to a new approach to defense procurement, which is essentially that currently in force, the Department of Defense (DOD) Planning, Programming, and Budgeting System (PPBS), later adding an important “E”—as the Planning, Programming, Budgeting and *Execution* System (PPBES). Note the emphasis on planning and execution, particularly to ensure programs remain affordable.

PPBES is designed to ask, again and again, whether a projected system is affordable and is meeting operational requirements established for it. A program has to pass a series of milestones and “gates” before it is released for production.¹ Some of those milestones are intended to check whether whatever the program offers is worth what it is likely to cost. The intent is that budgeters can see what they are likely to have to pay early enough to adjust resources to meet requirements.

None of this is well adjusted to surprise requirements or to crash programs—to accommodating disruptive technologies that change the balance between accepted types of weapons. In order to do its work of evaluation without being rushed, PPBES does not take time into account.

The reason why can probably be found in the context. As PPBS was being created from 1961 on, Secretary of Defense Robert S. McNamara was coming to understand that nuclear deterrence made global war extremely unlikely. He needed the new technology, but he could afford to wait for a lot of it. Temporary gaps in U.S. capability were unlikely to have disastrous consequences. That was the opposite of the feeling a few years earlier, that unless radical new weapons were instantly developed the results would be horrific. For McNamara, a defense *budget* disaster was significantly worse than waiting a few years for a better strategic missile. The need to control the budget became stronger as the country fought the Vietnam War. It happened that President Eisenhower had drastically cut the Army budget during the 1950s (in favor of the Air Force and the

Navy), and successor Administrations needed defense money to rebuild the Army in order to fight in Southeast Asia.

The impact of stretched-out programs with numerous reviews was subtle. If a program took a long time to reach production, some of its technology might be outmoded before it got there. There was an implicit pressure to insert the most advanced possible technology so that some of it would still be advanced by the time a new weapon reached production. For that matter, a system that placed obstacles in the way of starting a program provided program managers with a strong incentive to offer radical performance improvement at the outset.

The reviews intended to weed out programs had their own effect. These reviews always involve extensive staffing outside the program itself, for example by the DOD Joint Requirements Overview Council (JROC), which figures greatly in this history. Those doing the review have every reason to try to improve a program, and they often seem unaffected by the need to keep it affordable. It is difficult to imagine how those on these staffs can resist that temptation. The result is twofold. First, requirements grow (“requirements creep”). Second, the staffing itself slows the program dramatically, because it happens in multiple stages. Program managers complain that everyone has a brilliant idea to add, but only they have to find the funding to pay for it. The solution to escalating unit cost often is to stretch out the execution of the program.

There is no countervailing pressure to keep systems simple and affordable. The budget process often seems to be disconnected from the requirements process, as though choices of requirements are not also choices of what something is likely to cost. Worse, once requirements have been chosen, it is extremely difficult for anyone to pull back a validated requirement in order to cut cost. Quite aside from cost, the effect of requirement creep is usually to stretch out a program, usually by many years. As in any other bureaucracy, early warnings of problems are unwelcome, and those punished are often the program managers least responsible for the problems. Everyone involved in the JMVP was well aware of these facts.

As more than half a century has passed since the beginning of PPBS, many more participants have been fed into the staffing process, among them joint staffs overseas, who have a stake because they will use whatever is being developed. The more staffing, the more “improvements” fed into a program, the longer it takes to reach fruition.

Time is not a parameter, although sometimes procurement experts speak of “Schedule as an Independent Variable.” Much more frequently cost is the key issue, and the problem is how to control requirements creep. A program that breaks its budget damages many other programs that are also needed. There is a reason for budget controls. It is also important to keep in mind what aspect of cost is most important. The DOD budgets (“programs”) on an annual basis, although in extraordinary circumstances it makes multi-year purchases. What counts is how much has to be spent each year. If unit cost escalates, the program can be stretched out. In the end, the total expenditure might be far higher than what was originally envisaged, but if annual expenditure is controlled, that may be good enough.

There are too many “cooks,” even though all of them are excellent and well intentioned.² They are symptomatic of the hope for ideal solutions to tactical problems, rather than the “good-enough” solutions that were quickly mass-produced in the past. Even having so many contributors makes for a lengthy process of deciding what an ideal system has to do.

Taking a New Course

The JMVP was different. It embraced one key performance parameter—survive IEDs—and a supplementary requirement for automotive performance. The latter was based on standard considerations; an MRAP truck was not some new creation. The MRAP performance parameters were rapidly developed and then used with little additional review. It turned out that the result was good enough to make an immense difference in combat. The JMVP is thus a good illustration of how too many cooks really do spoil the broth and how a very smallish team can do exactly what is needed.

The JMVP is interesting in retrospect because its managers, who guessed that it would grow to enormous proportions, did not seek a way out of the normal procurement system. They certainly took advantage of every allowance for tailoring, but they never broke the rules. Critics might argue that they succeeded because they enjoyed highest-level support, but the character of the program was set long before Secretary of Defense Gates became aware of it. Because their program was propelled through the system very rapidly, it received far less staffing than the usual large defense program. In effect, the JMVP was a test of what would happen to a program that was not subject to much staff input at any stage. All of the Assistant Secretary of the Navy for Research,

Development, and Acquisition (ASN RD&A) “synchronization meetings” and Office of the Secretary of Defense (OSD) MRAP Task Force efforts were in effect a way of forcing the system to reach decisions with minimum staff input.

Putting limits on staffing means accepting imperfections from the outset. It also means concentrating on what the originating Service wants. The great experience of the U.S. defense procurement community seems to be requirements creep which undermines initial cost estimates (or limits) and which protracts programs. The current approach is to add more supervision to correct matters. The alternative is to achieve self-discipline by forcing the prospective buyer to understand what can be traded off at what cost. That may not be obvious in the case of the JMVP. However, at the outset there was a conscious trade-off, to accept prototype vehicles of different types in order to achieve rapid fielding, despite the considerable cost in logistics and in other complications. In the JMVP case it was time, not cost, that counted. The self-discipline approach using minimal staffing is associated with spiral development. The reader should not imagine that it is without its own costs and problems, but the JMVP offers a case study of what it can do.

Defense programs are lengthy, and the staffing necessary to start a new program contributes to delays. Clearly some technology is worth inserting rapidly. To do that, the DOD has developed a variety of rapid-acquisition techniques, the object of which is to produce limited numbers of items very quickly, bypassing the system. This kind of bypass works as long as programs are small; often a short production run is handled as though it is a research and development (R&D) exercise rather than a procurement project. One major down side of this kind of practice is that it develops no sustainment tail to keep the new items in service. Examples from the Iraq and Afghanistan wars include many of the unmanned aerial vehicles (UAVs) and also the jammers developed on a crash basis by the Joint Improvised Explosive Device Defeat Organization (JIEDDO).

The conventional path to deployment is acceptable in a world of deterrence, because slowly developing programs do not really endanger the country. The assumption has been that if there is a war, whatever is now being made can be made in greater quantity—that whatever is already being made is the right equipment for the war. Things become more difficult if the character of war changes. In a way, Secretary of Defense Donald Rumsfeld found himself on the cusp of such a change—“Transformation” as he called it. He saw new technology, mainly for command and

control, as a way of transforming the U.S. military into something more affordable yet capable of meeting daunting operational requirements. However, he did not (or was unable to) transform the procurement system into something agile enough to deal with the sorts of changes he had in mind. That is why his counter to IEDs in Iraq, which were a disruptive enemy technology, was to field relatively small numbers of high-technology items, such as jammers, which could be bought outside the normal procurement system. The requirements for and production of MRAP vehicles were a different proposition. The JMVP was the single largest Defense program in FY 2010, three years after its inception. It could never have been built up to that size within the usual deliberate defense environment.

The JMVP is a creature of a radically new environment. Nuclear deterrence still protects the United States from global war, but 9/11 showed that we could not deter a class of terrorists capable of attacking the United States directly. Instead of a protracted Cold-War competition, the United States faced frequent crises and hot wars. Worse, there was no sense that winning one hot war in, say, Iraq would necessarily protect the United States from another one. There was also a sense that the enemy might field disruptive technology, meaning technology against which existing *kinds of systems* were ineffective. IEDs were not new when the United States invaded Afghanistan and Iraq, but the enemy used them on a much larger scale than before, so that previous countermeasures, such as specialized anti-mine vehicles, no longer seemed to be enough.

When the DOD plans 20 years ahead, planners are assuming that they know the kinds of things we will need—such as more advanced submarines, tanks and fighter aircraft. Although they do not know exactly what these future systems and platforms will look like, the planners can say that, for example, the Army will need enough tanks for “X” number of units. In a disruptive world, defense suddenly needs a lot of something currently unexpected. That happened in World War II with the sheer number of aircraft and aircraft-supporting installations (including aircraft carriers) required for global conflict. It happened again in the 1950s with the revolution in strategic weapons: who in 1940 would have imagined the Polaris submarine-launched ballistic missile in 1960? It has not really happened since, until the first IED exploded and killed U.S. personnel.

The environment of the Iraq and Afghan wars was a lot more like World War II than the Cold War. Time and quantity both matter enormously. Budgets can be, and

are, expanded as needed by “Supplementals,” which in this case reduced the friction between new urgent procurement (like MRAP vehicles) and existing programs. But keep in mind that although everyone might have enough money, other resources can still be limited. When the MRAP program received its DX industrial rating, which gave it highest-priority in obtaining resources it needed, it took things like armor steel from other programs. Other managers were not at all willing to give up such resources. Money could not simply be translated into more steel production, or more run-flat tires, or more heavy-duty axles. The perfectionism that one might associate with the long review process of conventional programs is not very relevant: better to have something that works fairly well *right now* than something a lot better when it is no longer needed. The JMVP was shaped to that new reality.

Agility and disruptive technology have other implications relevant to the JMVP experience. In a world of more or less steady categories of weapons, sustainment over decades is very important. Weapons have to be designed so that new technology can be inserted as it appears. There is a reason that fighter aircraft conceived during the 1970s, like the F-15 and F-16, are still viable 40 years later. The aircraft look the same, but they are filled with technology not imagined when they were designed, and they deliver new kinds of weapons. The United States has been very successful in building such adaptable platforms, and they fit U.S. procurement style. Disruption means that for some reason the platform itself is no longer viable and that steady technology insertion is no longer a viable strategy. In this sense stealth was a disruptive technology, in that its advocates considered previous non-stealth airplanes obsolete (just as jet engines made most piston-engine aircraft obsolete).

In the Iraq and Afghan experience, as long as just add-on armor kept a Humvee survivable, the usual procurement model made sense. The immense investment in Humvees and in their support was exactly what the forces in Iraq and Afghanistan needed to remain fully mobile. Once under-body IEDs became common, the Humvee itself was no longer viable, no matter how much armor was added to it. It had to be discarded in favor of something else. That is why the quick development of MRAP vehicles was so important and why the JMVP solution turned out to be viable for the remainder of these wars.

If disruption becomes the rule, then no platform or weapon or system will remain viable for very long. The Services will find themselves seeking quick production of

new kinds of platforms and systems to stay in action. When the JMVP was rapidly assembled, the most significant gap turned out to be in sustainment, which advocates of more conventional programs pointed to as the vulnerability of a quick unconventional program. If the Services find themselves in a world of more disruptive problems, there will be less interest in keeping a program alive over decades. Deliberately not investing in sustainment might turn out to be the way to keep such programs affordable, and agility will become the paramount requirement, not the exceptional one as in the JMVP.

Spiral Development

As it happens, procurement professionals have been told for years that it is better to adopt the kind of spiral development exemplified by the JMVP: begin with something adequate or acceptable, an 80-percent solution, then progressively develop it into something a lot better. The reality is that in order to make a new program look worth buying, the program has to offer something really exceptional. The system has been designed to avoid wasting money on anything else. Program managers want to develop something that will make it all the way to production, and those staffing the reviews are also inclined to add rather than to pare away what is wanted. Any paring down comes as it turns out that revolutionary capability comes with an unacceptable cost.

The alternative to spiral development is concurrent development: go for something entirely new, and develop whatever is needed to make it work, all at the same time. Procurement professionals are taught that concurrency is risky, but it has been the rule in the Army and the Air Force. Generally, the Navy and Marines have favored spiral development, though not always. As procurement regulations were written and re-written, they accepted this dual possibility. As the cost of concurrent (revolutionary technology) programs rose, the regulations more and more pointedly stated that 80-percent solutions available sooner were preferable to apparently better solutions available later on. However, program managers have tended to prefer what looked like better solutions to their problems. The entire system was not designed for urgency, and that alone discouraged anyone who took the 80-percent route seriously. That is why urgent problems invariably led to solutions outside the system. For that reason, the program in 2008 received the David Packard Award for acquisition excellence (and again in 2009 for the “innovative acquisition practices and accelerated selection process of the M-ATV Source Selection Evaluation Board”).

2008 David Packard Award for Acquisition Excellence

The Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program (JMVP) is presented the David Packard Excellence in Acquisition Award for the rapid development, acquisition, and fielding of the MRAP family of vehicles. An initial Joint Urgent Operational Needs Statement in October 2006 for 1,185 vehicles set the stage for an astounding acquisition effort in 2007. Using competitive prototyping; astute industrial base analysis and management; and flexible, creative, and accelerated fielding and sustainment, the JMVP placed 11,904 vehicles on order and fielded over 1,500 vehicles during the year. While meeting statutory requirements, the Joint Program Office (JPO) simultaneously budgeted, contracted, tested, produced, integrated, fielded, and sustained the highly survivable MRAP vehicle fleet. Additionally, the JPO embarked on major upgrades to vehicle protection, load capacity, and mobility in response to warfighter feedback and evolving threats. This accelerated acquisition program has saved many lives and made an exponential contribution to combat effectiveness in the Global War on Terrorism.

Once time becomes the key parameter, the situation changes radically. The JMVP exemplifies this kind of change. From the outset, those running the program understood that time was of the essence. Every day without enough MRAP vehicles was a day troops were being killed by IEDs. Even an 80-percent MRAP vehicle would save lives, perhaps many more than a 100-percent MRAP vehicle (if one could envisage such a thing) that would not be available for a few years. The secret of the JMVP's success was that the philosophy of the spiral solution and “the best is the enemy of good enough” was effectively transmitted throughout the team running the program. It was important, too, that the JMVP team was very lean, because decisions could be made rapidly on a face-to-face basis. It also helped that the key performance parameter was so clearly defined: an MRAP vehicle had to protect its occupants from a defined threat. There were actually numerous requirements, such as automotive ones, but the key parameter—Save Lives!—defined the program.

Procurement Courage

Quick execution made the JMVP an agile organization, well equipped to meet changes in requirements rapidly. Even without actual warfare, the United States appears to be entering an era in which we have to be more agile in what we field. Much of our technology is now provided by industry, in the form of commercially available items, and recent reports of cyber-espionage suggest that enemies are able to steal a lot of what

is not commercial. An enemy might be able to gain access to U.S. technology and field it before we do. To make matters worse, extensive U.S. reliance on the Internet and various defense intranets is an important factor in keeping up the rate of U.S. defense innovation. An enemy with a small industrial base and small forces may be able to exploit this kind of information very quickly. The JMVP exemplifies a massive agile and successful program, which looks to be the right pattern for a future of sophisticated enemies with access to too many of our secrets.

In this regard the JMVP had an advantage over other means of countering IEDs. Jammers had to adapt to changing enemy technology, and they could not deal with non-electronic means of triggering IEDs, such as pressure pads. Because MRAP vehicles were effective no matter how the enemy triggered his IED, they changed the measure-countermeasure situation. To defeat a generation of MRAP vehicles, an enemy had to field either much more effective IEDs (such as explosively formed penetrators (EFPs)) or much larger ones. In either case, that imposed much higher costs on the enemy, including tactical ones, than changing from one kind of trigger to another. The enemy needed much more time to make such changes, if indeed they could be made at all, and the necessary changes also exposed the enemy to other kinds of counterattack (moving a much heavier IED required a lot more effort, and more visible effort, for example). Moreover, simply knowing that MRAP trucks existed did not help the enemy counter them. The JMVP was unusual in combining quick fielding *and* long effective lifetime (before the enemy managed to defeat the vehicles).

The success of the JMVP, which was run within the “lifelines” of the current procurement system, suggests that PPBES is far more flexible than had been imagined. Properly handled, it can yield results previously considered impossible. It is not clear whether the JMVP proves that the system can be repaired, or whether it only shows that it takes extraordinary talent and courage and very high-level support to make it work. The JPO took all the required steps. It created all the required documentation. In some cases documentation was prepared while the program ran, but that was permissible. Sometimes documentation lagged delivery of MRAP vehicles in theater. The great difference was in the way in which the JMVP interacted with external DOD organizations. Their role was greatly reduced. That in turn made it possible to run the JMVP extremely fast. Removing staff layers meant that those within the program could be held personally responsible for problems. Someone higher up had to back their courage.

For the JMVP, the Marine (and Navy) view of procurement (and of regulations in general) was key: missions were to be accomplished without violating the rules, the emphasis being on rapidly executing the desired mission, hence on finding a way that comported with the rules, but was not necessarily dictated by them. That was an attitude more toward operations than procurement, but in the case of the JMVP it carried over. In effect, the attitude was that the rules offered a variety of opportunities, and that a commander (or, in this case, a program manager) was there to find some way to exploit them. A saying in the Navy was that “commanders are given orders and told not to violate the book; the Army simply followed the book.” As written, the procurement rules might allow considerable tailoring, but most of those in procurement seemed to take them at face value. The only part of the rules normally ignored was the injunction not to seek perfection.³ DoD 5000 has a large number of “thou shalls” but very few “thou shall nots.”

Another way to look at the regulations as a guide was that they were a way of avoiding risk. Those involved in the JMVP sometimes talked about “procurement courage.” Often that meant being willing to risk failure in one way or another. That was possible only if the program leadership was willing to trust subordinates and to back their decisions—for which they had to take full responsibility. That in turn was possible only within a small, handpicked group.

The JMVP team was much smaller than in most such programs. For a time it was staffed at 80 percent of what might be considered a minimum staffing model. In one early case, when the MRAP vehicle program had to seek approval for initial production, it was told flatly that its staff was too thinly manned to manage the size of program involved. In response, the top MRAP vehicle program staff created an organization chart which, they later said, included everyone they had consulted over the previous three months. The team leaders were confident that their handpicked subordinates could do what was necessary. In some cases that included completing key paper work in days rather than the usual months. To do that, everyone on the team had to work very long hours and forego weekends. The team was inspired to work that way both by the leadership of its chiefs and by an understanding of how critical the need was.

Responsibility was deliberately pushed down to the lowest possible level. Managers could always see who had made each key decision. They could assign responsibility and assess how well those involved had done. The team members in turn enjoyed

that responsibility and looked for ways to make the program run better. This lean-team approach is often associated with “skunk works” programs functioning outside the procurement system, but the JMVP demonstrated that a lean team could operate effectively within the rules. What mattered were how management functioned and the extent to which it trusted the others in the team.

In the case of the JMVP, what also mattered—enormously—was the goal. Everyone in the team understood that every day without an effective MRAP vehicle meant troops in Iraq killed by IEDs. On that basis an 80-percent solution was quite attractive compared to a more distant but (theoretically) better solution. The goal automatically favored a policy of early production to a reasonably good standard plus continuing tests for improvement, in essence, spiral development. The goal in turn was relatively easy to visualize, and it was easy to rate alternative vehicles. The JMVP team deliberately avoided most requirements other than explosion resistance and the minimal automotive characteristics.

Ultimately the explicit strong backing of Secretary of Defense Gates protected those in the program who had taken risks at an early stage, and who were pushing the program much more rapidly than conventional practice might have dictated. However, the operating practices that shaped the JMVP were established well before it rose to the Secretary’s attention.

Aegis Provenance

Other counter-IED programs did not produce similar results. In theory they had similar motivations, but they seem not to have been run on the same lines. The difference was surely leadership within the JMVP. Because the program originated with the Marine Corps, it drew on the larger Navy procurement community. One striking feature of the Marine’s MRAP vehicle program (which would evolve into the JMVP) was that PM Paul Mann, who set the tone of the program, was a veteran, not of Marine vehicle programs, but of the Navy air defense (mainly Aegis) program. Others in the JMVP also came from Aegis. It seems clear in retrospect that much of the shape of the JMVP can be traced back to the Aegis program, which was for a radically different threat and forces. The JMVP showed how important the existence of an acquisition community could be. The key people understood the acquisition system well enough to envisage the potential inherent in the regulations.

Aegis, and by extension the entire Navy theater air/ballistic missile defense program, epitomized spiral development. A single line of development could be drawn back from the latest anti-ballistic missile Standard Missile 3 (SM-3) to the Tartar designed in 1954-56 and even further back to the immediate post-WW II years. The Navy had sought concurrent development solutions, and generally they had not worked (the most spectacular was Typhon, in 1957-65). By 2006 it is unlikely that those in the program were aware of its early history, but they certainly understood that spiral development worked. Their motto, and Rear Admiral Wayne E. Meyer Jr.'s mantra, was "build-a-little, test-a-little, learn-a-lot." They also well understood the larger idea that something more or less good enough was a lot better than a nonexistent though apparently ideal system, which anyway might not work at all in the end.

Aegis also had a sense of urgency, though not on anything like the scale met in the JMVP. It was conceived during the Cold War as a way of meeting an escalating Soviet anti-ship cruise missile threat, and its first leader, Rear Admiral Meyer, entered the Navy during its first big (and terrifying) "guided-missile" experience, the Japanese Kamikazes during World War II. He never forgot that "his" missile system was what stood between the fleet and something similar. The missile problem survived the end of the Cold War, and so did the sense of urgency.

The JMVP showed that individuals were extremely important. It might be argued that the regulations-as-guide approach is designed to work reasonably well despite personnel choices; the old adage, according to Herman Wouk, was that "the Navy is a master plan designed by geniuses for execution by idiots."

The implication of the JMVP is that procurement can work a lot better if it is organized in small teams of very carefully selected professionals, rather than in larger teams organized on a much less selective basis. Because procurement is a non-combat role, it lacks the prestige attached to other parts of the military. On the other hand, the military head of a procurement program comes out of a combatant branch, and considerable prestige attaches to successful development of an important weapon system.

A spiral development program is fundamentally different from a concurrent development program because different phases of the project are always in different stages of procurement. That was a new experience to many in the program. Joint

Program Manager (JPM) David Hansen marveled that on one day the program was in every stage of the usual cycle at the same time: developing a requirement for the next iteration, conducting development and operational testing, running current production, fielding and maintaining vehicles, and planning for their disposal. That was the whole life cycle of a program, conducted in parallel. It sounds a lot less bizarre if the program is simultaneously responsible for different phases of a complex weapon system like Navy surface-to-air missiles—a program from which some in the JMVP team came. They were hardly surprised by the way spiral development played out.

Normally a program is structured for purchasing and logistics efficiency. A requirement is framed and approved after review, usually at the DOD level. It might be refined by asking potential bidders for information as to what they can offer, using requests for information (RFIs). Then a request for proposals (RFP) is circulated. Bids are received and reviewed. There may be comparative tests (as in a fly-off). The winning bidder receives the contract. Losing bidders sometimes appeal, and production begins only after that issue has been resolved. After prototype tests, a low-rate initial-production (LRIP) contract is let. For example, a new vehicle typically first goes through a series of protracted tests to see whether it meets its specifications. Once it has passed, a few are made and given to a chosen organization for operational tests. Only after it has passed does it go anywhere near the field. Remarkably in this regard, a typical MRAP vehicle ran directly from factory to outfitting to transportation to the Warfighters in theater.

Even for something as simple as a truck, the normal process can be lengthy. For example, the MRAP vehicle was conceived some time after work had begun on a new standard light truck, the Joint Light Tactical Vehicle (JLTV), which was intended to replace the existing Humvee. In mid-2013, as the JMVP was being wound down, the JLTV prototypes were still in the test phase. Their program followed the normal process.⁴

The JMVP collapsed these stages by conducting several in parallel. The irony was that it was a spiral-development program conducted in a concurrent framework—something completely new to modern defense procurement. The process of preparing a request for bids was pared down drastically in hope that manufacturers would offer producible vehicles immediately. Test articles would need to accompany company proposals, or follow shortly after their submission. “PowerPoint” briefings were not good enough: industry had to have hardware. The intent clearly was that building a blast-resistant

vehicle was a relatively simple proposition and that companies already knew what was needed.

Each MRAP vehicle original equipment manufacturer (OEM) was told that the only requirements were usable vehicles, available quickly, which could survive a standard blast test. Surviving the blast test was the key to further orders. And, early on, it was the bottleneck in the test process, because the Aberdeen Test Center (ATC) initially had only limited instrumented facilities.

Manufacturers were told that the program was likely to grow, and they were offered open-ended, ID/IQ contracts. That gave them an incentive to develop a production base, but it also complicated programming, because the program wanted to buy as many trucks as possible as soon as possible. Even so, none of the big carmakers bid. The numbers were not large enough to interest them. Without them, it was obvious at the outset that none of the bidders could produce enough trucks rapidly enough, so there had to be parallel procurement. Unlike many defense contracts, there could not be a single bidder. Since the initial vehicles had to be taken off the shelf, there could be no single design. The Program Office understood from the outset that accepting several different designs would cause problems, but they were less important than the problem the IED presented.

The incentive the program held out was that the sooner a manufacturer produced an acceptable vehicle, the sooner he would get production orders. Initially blast testing was a bottleneck. Trucks were tested at ATC, using an instrumented facility that could handle only one truck at a time. Trucks had to wait for tests. Any truck not ready when its turn came would have to wait until later, with the unspoken possibility that its manufacturer would miss out on production. The JPO was well aware of the importance of blast testing, and of the way in which test capacity would speed the program, so it invested heavily to expand ATC's capacity.

From the outset, too, the JMVP anticipated that logistics would be a problem, since parallel pipelines had to be established for all the different types and since each would require its own training. It turned out that manufacturers did not enforce tight configuration management. The same brand of truck might use several types of battery, for example, and wiring might be in different places. That is not normally a major issue,

but it became important when trucks had to be outfitted with sophisticated equipment on an assembly-line basis.

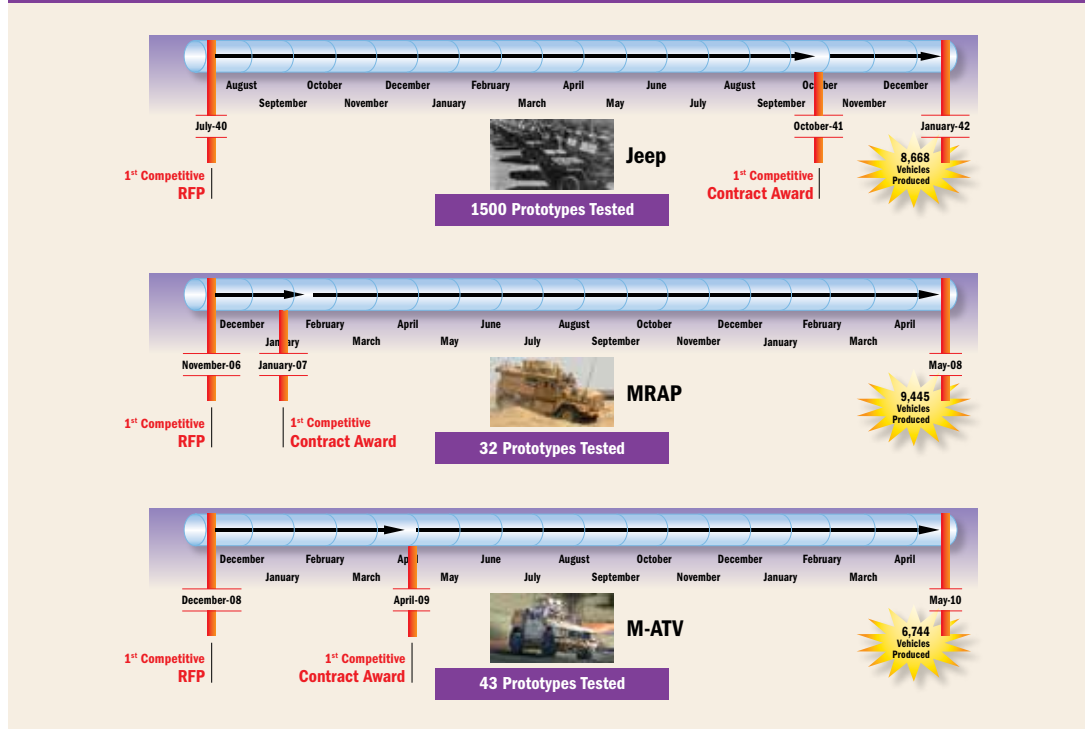
An important Aegis tenet, probably inherent in spiral development, was that government and manufacturer formed a team. They shared knowledge of the problem the program was intended to solve. In the JMVP, parallel procurement helped ensure this sense of teaming, because there was never a sense that the government side wanted to squeeze out any of the producers. All were given the sort of test data the government usually holds back, because the intent was for them to use that data to improve their designs. Normally the point of holding back test data is that it is the basis for a competitive choice; a manufacturer might use it to protest a contract award. Such protests are now common, and they are a typical drag on program schedules. The JMVP never had to face a protest, although it regularly rejected some truck manufacturers' offerings. The program's view was that even a manufacturer who lost out on one round of contracts might improve his product to the point where he would win later on, as the program could not afford to lose his capacity.

The trust built up with the manufacturers had other consequences. They were willing to risk their own money on the assumption that the program would keep its promises to keep buying trucks. They were also willing to make modifications as needed before terms were formally agreed. More generally, trust made the program work. Much of the delay programs encounter is due to the need to meet legal requirements, in terms of assembling formal contracts before any work can begin. Too often something goes wrong between agreement and contract. The JMVP showed that when it was accepted that the project's word could be taken completely, the legal work could follow.

World War II Parallels

The closest parallels to the JMVP are many World War II programs, which are remembered for their shared sense of purpose and their camaraderie. They were usually very much 80-percent programs. Anyone looking back sees multiple parallel designs put into production while problems were still being solved. Everyone knew that was wasteful in financial terms. But the terms that mattered, and the terms that mattered in the JMVP were measured in time and lives saved. It was perfectly acceptable to spend money on designs that ultimately failed, because it was quicker to put as many designs as possible into production than to sift them out at an early stage. Moreover, it

–Figure 6–
COMPARED TO THE “LEGEND”



was acceptable to field systems that were not the best, but which could be produced in quantity; as Stalin said, “quantity has a quality of its own.” That was evident in tank design and production, for example. The Germans offered an alternative approach that emphasized technical sophistication, and as a result often did not field weapons at all, or fielded them too late in the war. Sophistication in engineering also often made for poor reliability and maintainability.

Thinking of the JMVP “deliverable” as a truck, albeit a highly capable truck, members of the program often compared it to early stages of the World War II Jeep program, which accelerated remarkably quickly.⁵ However, Jeeps were relatively simple vehicles even for their time. Figure 6 illustrates the parallels between Jeep and MRAP/MRAP All-Terrain Vehicle (M-ATV) production.

By way of contrast, an MRAP truck was a protected vehicle intended to support offensive operations. The truck technology might have been well known, but not the protective technology, once it began to develop. Thus a better parallel in overall

thinking might be the Army's World War II medium tank program, which began with a clearly inferior vehicle (M-3 Grant, derived on a crash basis from the even worse M-2) and quickly developed it into the M-4 Sherman—an 80-percent solution, but available in sufficient numbers to overwhelm its enemies. Compared to the World War II tanks, MRAP vehicles evolved much more rapidly to deal with changes in its environment and the threats it faced. The proof of program adaptability was that an entirely new M-ATV was developed and produced so quickly specifically for Afghanistan, when U.S. attention returned to that theater. Without sufficient numbers, even the best conceivable MRAP vehicles would have had little impact on the war, not to mention on casualties.

The great difference from World War II program was computers, which made it relatively easy for managers to track progress at all levels of the program, and to do so nearly in real time. Those in the JPO remember weekly (or even more frequent) reports in partly graphic form, for clarity. Tracking revealed bottlenecks on which efforts should be concentrated. Those involved remember weekly meetings at which the Pipeline Charts were always passed around: how many vehicles were in what stages of completion...how many were ready for shipment...how many were in different stages of shipment. Equivalent efforts were certainly made in the past, but information was almost inevitably some weeks or months late, and even the most urgent programs had to allow considerable slack to make up for that.

Time and money were, in effect, traded off. That made sense: a successful MRAP vehicle not only saved lives, it made effective action in Iraq and Afghanistan much more feasible.

A critic later charged that MRAP put far too much emphasis on estimates of lives saved, articulated as a particular dollar value placed on a life.⁶ The first counter-argument was that any such calculation was obscene. Moreover, to prevent the enemy from guessing how often his IEDs worked, no figures were released as to how many explosions had occurred and how many troops owed their lives to MRAP vehicles. The number far exceeded the critic's, but no accurate estimate was releasable. Those in the program were acutely aware of how many, because they tracked every explosive event and its consequences. That was aside from receiving numerous personal letters from troops riding in MRAPs, who survived large explosions because their vehicles worked.

No one describing other counter-IED programs later talked in terms of lives saved due to IEDs that failed. Perhaps the reason was that the connection between MRAP trucks and survival was particularly clear. That connection in turn contributed heavily to the high morale of the JMVP team, both military and industrial.

The MRAP vehicle program began with an urgent need, so it was made an ACAT II program to produce a limited number of vehicles for the Marines.⁷ When the JROC identified a much greater need, the program blew past the ACAT II threshold and justified the ultimate ACAT ID designation. The vehicle designs were never sufficiently stabilized to justify the move from LRIP to full-rate production (FRP) characteristic of a more conventional program. Instead it produced a series of LRIP production runs—a logistical nightmare, to be sure, but one that was considered acceptable as long as the vehicles protected the troops riding them.

Many vehicle modifications were developmental items not part of the vehicle proper, such as anti-rocket-propelled grenade (RPG) armor and active anti-RPG measures.⁸ If they had not been part of the JMVP, each would have been a separate ACAT program. The MRAP Transfer Fund made it possible to pay for this subsystem R&D work as needed to counter the evolving threat. The same applied to improvements such as doors and seat belts. Some of these programs did roll through the DOD 5000 framework without formal documentation. They were treated as modifications to existing systems. The *vehicle* documentation was updated, however, and the leadership was always kept briefed.

All of this was possible because sustainment was not a high priority for vehicles needed to fight the war, not for the long term. Roughly halfway through the program (2010), it became clear that all Services and SOCOM would be retaining some of their MRAP vehicles, and configuration management became much more important. In effect, each Service chose the configuration it liked best.

The Key to Success

To an MRAP program participant, the key to early success was the small size of the JMVP team. That made it possible for gifted leaders like Paul Mann, and Dave Hansen his original deputy who would succeed him as JPM, to communicate effectively with

everyone involved, inspiring and unifying them. Students of psychology argue that there is a natural limit to the number of individuals who can be unified in this way.⁹ Beyond that face-to-face communication dissipates. The ideal is probably much smaller. The small number in the JPO could easily come to a shared understanding of priorities and trade-offs. The absence of clear understanding of goals and methods and trade-offs makes larger programs complicated and slow moving. It helped that the goals were clear, but once the program ballooned past a certain size that did not preclude all sorts of disagreements. Decisions had to be forced through. It was impossible to keep running an unstructured program—unstructured for suppleness and agility—when it grew to 600 people, however. Compare Figure 3 (in Chapter 5), the initial USMC MRAP program organization in November 2006, with the JMVP organization (Figure 5 in Chapter 10) at the height of program activities in August 2009.

End Notes

¹ Programs are intended to pass through Milestones A, B, and C before entering low-rate production (the MRAP vehicle program began, in effect, just before Milestone C). Milestone A is the Analysis of Alternatives (AOA) to meet stated requirements. Milestone B is the Engineering Management Development (EMD) phase, the parallel tests of prototypes. Milestone C is to approve Low-Rate Initial Production (LRIP) of the selected system.

² The procurement system was further considerably complicated by the Goldwater-Nichols Act of 1986, which greatly empowered the Joint Staff compared to the staffs of the individual Services. The Act also interposed the regional combatant commanders (COCOMs) between Service commanders in the field and their Service chiefs. For example, when a Marine commander in Iraq developed an Urgent Operational Needs Statement (UONS) for a mine-resistant vehicle, that requirement had to be endorsed by the ground component commander (Army and Marines) and by the regional command (CENTCOM) to become a Joint Urgent Operational Needs Statement (JUONS). At least in theory, once the Marines developed an operational requirement for such a vehicle, it was subject to review at the outset by the Joint Operational Requirements Oversight Council (JROC). In theory, these levels of oversight are good things. Jointness within CENTCOM should have ensured that both ground Services would share any valuable new development, and that both would make sure that it was applicable to them. Jointness within the JROC should have ensured that the new program did not duplicate something already in development. Both levels make excellent sense, except in a wartime situation in which time is more important than avoiding all waste. The centralized joint system also makes it difficult for any Service chief who disagrees with the joint staff or with the Office of the Secretary of Defense (OSD) to get what he feels he needs. Too, the process tends to invite participation in the requirements process by those who have at best a marginal stake in the outcome, i.e., the system that enters production.

³ In his interview for this history, Brigadier General Brogan recalled a group chartered by the House of Representatives to examine means of rapid acquisition. There were four witnesses. He represented the JMVP. The others were Dr. Dov Zakheim, representing the Defense Science Board chaired by Dr. Jacques Gansler; the DoD Inspector General (DODIG); and Thomas Dee of the Joint Rapid Acquisition Cell (JRAC). Zakheim and Gansler both recommended creation of a three-star post for rapid acquisition. The committee allowed Brogan to speak first. He argued that the issue was not regulations or organization, but rather it was mind-set. Regulations are not prohibitions. If they are taken as permissive, a program can move rapidly. Money and support help, but willingness to take some risk is the key.

⁴ The JMVP is sometimes compared to the Army-managed JLTV program, which is intended to offer protection somewhat similar to that offered by MRAP vehicle but to be much lighter and more expeditionary. It was conceived as a way to regain the mobility and load capacity of the Humvee with better protection. However, because of the emphasis on mobility, it is unlikely to match MRAP vehicle survivability. The M-ATV approaches the JLTV requirement for mobility, but it offers MRAP vehicle survivability. That raises the question

of whether a quick spiral program can do as well as a more conventional and more deliberate one. JLTV is expected to be less expensive per vehicle than an MRAP vehicle, but it in mid-2013 it did not yet exist, so no one can say for sure. By then, JLTV had been running competitive prototypes for some six years. It was a conventional defense program designed to mitigate risk by producing and testing multiple different prototypes. JLTV was moved back from Milestone C to Milestone B (more testing required) about 2007, apparently partly because at that point it was obviously so much less survivable than the first MRAP vehicles.

⁵ The comparative chart, produced in 2010, showed the first competitive RFP for the Jeep issued in July 1940. Between then and the first competitive contract award (October 1941), 1,500 prototypes were tested. By January 1942, 8,668 vehicles had been produced. The comparable time scale for MRAP vehicles stretched from the first competitive RFP in November 2006 to May 2008, by which time 9,445 vehicles had been produced. The first competitive contract award had been made in January 2007, which would have corresponded to a Jeep award in September 1940, when the Army was buying prototypes. The comparable span for M-ATV was from December 2008 to May 2010, by which time 6,744 vehicles had been produced. In this case the first competitive contract award was made in April 2009, which would have corresponded to December 1940 for the Jeep. There were 43 M-ATV prototypes.

⁶ Chris Rohlfs and Ryan Sullivan, “The MRAP Boondoggle,” *Foreign Affairs Spotlight* (electronic edition), 26 July 2012. Rohlfs had previously written a paper, “The Government’s Valuation of Military Life-Saving in War: A Cost Minimization Approach” (2006), and his critique of the JMVP seems to have been based on the methodology he developed in it. The initial Rohlfs and Sullivan paper was “The Cost Effectiveness of Armored Tactical Vehicles for Overseas U.S. Military Operations,” a Naval Postgraduate School working paper (2011). Those in the program pointed out that Rohlfs and Sullivan had been denied access to the classified IED attack and casualty figures they wanted for this paper.

⁷ The initial size of the program, about \$365 million, would have made it ACAT III. It was Dr. Etter’s decision, as ASN (RD&A), to advance it to ACAT II to reflect the amount she thought it would need.

⁸ James Williamson interview.

⁹ Donel R. Forsyth, *Group Dynamics*, 4th Ed., Thomson Wadsworth 2006, http://www.cengagebrain.com.mx/content/forsyth68220_0534368220_02.01_chapter01.pdf.





CHAPTER 17

HOW DID THE PROGRAM SUCCEED?

In Chapter one, three key questions were posed: (1) Why did the MRAP vehicle program matter? (2) How was it such a success? And (3), Can it be replicated in the future?

This history of the Joint MRAP Vehicle Program (JMVP) provides insight into answering the first question. It mattered because lives were saved and operations otherwise frustrated by roadside bombs and improvised explosive devices could be carried out successfully and safely. The MRAP vehicles were “game-changers.”

To Dr. Ashton Carter, Under Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L), who led the OSD MRAP Task Force after John Young, the answer to the third question is a resounding “Yes!” The JMVP is an excellent illustration of the limitations of the business-as-usual process and of the ways in which

it can be shaped to meet critical requirements. It can be a model for future urgent-need programs.

This chapter focuses on the “how” of the MRAP program success and draws lessons for the future.

Acquire, then Require

The DOD procurement system normally pays great attention to cost, which is natural, as defense policy begins with finding out what is affordable within the available funds. Indeed, the great surprise to anyone interested in strategy and enters the defense profession is that resources—money—come first, many times even before strategies and doctrine have been hammered out.

Unfortunately, the system also does not explicitly take time into account. It is well understood in the procurement profession that there is generally a choice between cost and schedule, and that it is far easier and more acceptable to let a schedule slip than to demand a great deal more in the way of immediate and always constrained resources. There is another consequence of drawing out defense programs. Technology and circumstances can and do change dramatically over time, so that what seems to be cutting-edge when it is ordered might be obsolete when it is delivered. That problem in turn leads to continuous changes in requirements as a weapon or system goes through its lengthy adolescence, and none of those changes come cheap.

That is the opposite of a spiral program like the JMVP, in which the emphasis was on getting a vehicle that met the minimum essential requirements into service as soon as possible in sufficient numbers to make a tactical—if not strategic—difference. There was never any question that a better vehicle could have been produced had the program been willing to take time to do so. The better vehicle would have been less vulnerable, less expensive to procure and operate, and easier to maintain. But the delay would have been costly in a vastly more important currency, Warfighters’ blood.² What is interesting, looking back, is that accepting an 80-percent solution, and then improving it as production continued, allowed the Joint Program Office (JPO) to deliver a good enough solution quickly, and then develop the better vehicle through modifications, upgrades and additional vehicle designs.

Carter's way of expressing what had to be done by the JMVP was "acquire, then require," because otherwise the process of assembling detailed requirements would make it impossible to get anything to the troops on the ground quickly enough. In Carter's and Gate's perspectives, the "business as usual" defense procurement system is risk-averse. The era of huge crash programs whose leaders were celebrated for their extraordinary achievements seemed to end in the 1950s or early 1960s. That earlier time was perceived as close to a possible war, and it seemed that unless the United States embraced revolutionary military technology, it would be defeated.³ Crash programs were conducted during the Vietnam War, but on a relatively small scale. None of them assumed anything like the proportion of the defense budget devoted to MRAP vehicles, which in Fiscal Year 2010 was the single largest item in the budget.

Risk aversion means that the system is designed so that it need not embark on a program until it knows exactly what that system will do, and how it will do it. That is the meaning of the usual layers of review prior to approving the series of milestones. To Carter, the phrase "acquire, then require" captured the 80-percent solution idea: once the program got started it could feel its way along. "Risk aversion" is actually an ironic phrase, because it does not take into account the risk to troops in the field. There is just too much distance between those acquiring weapons and other systems and those who use them. It is possible that the Marines did so well with MRAP vehicles precisely because there is so much less distance between the field and the acquisition system in their relatively small Service.⁴ Defense Secretary Gates remarked that he was constantly frustrated by the ponderousness of response to the real-world demands of war in Iraq and Afghanistan. He understood that the JMVP should be the highest priority during the surge in Iraq, but it was difficult to enforce that priority.

Supple Agility

It was also important that the program was supple enough to deal with fast-changing requirements. Carter particularly remembered the transition from a flat Iraqi landscape in which massive MRAP trucks could move effectively to the road-less mountains of Afghanistan. That brought forth both major changes to the existing MRAP vehicles, such as independent suspension, and the new M-ATV. The JMVP demonstrated its suppleness when it went from need to fielding M-ATVs in eight months, ultimately producing 8,000 of them in 18 months.

The counter-improvised explosive device (IED) JMVP was not the only crash program Secretary of Defense Gates and his team pushed through to fight the wars in Iraq and Afghanistan. Others were the necessary improved intelligence/surveillance and better and much quicker treatment for wounded troops. They were part of his holistic approach to the war. For example, Gates dramatic improvement in care for wounded troops not only encouraged U.S. forces, but it also demonstrated U.S. resolve to the Iraqis and to the Afghans. Better surveillance hobbled the enemy by forcing him to think first about evading it and second about attacking. Before his intervention, there had certainly been interest in surveillance, but as a direct means of finding IEDs and, to an extent, their makers—not as a strategic means of changing the enemy’s focus from attack to survival.

Although neither Secretary Gates nor Dr. Carter said so directly during interviews for this history, it seems reasonable to say that both saw the existing procurement system as an obstacle to any new strategy. The system is well designed to buy things that fit into previously defined slots, with well-understood rationales. The rationales in turn decide how the system should balance different requirements for any given new system or weapon. The underlying strategy is unstated, but it is reflected in what is bought and in what quantities. The reality is that from time to time circumstances change or some potential enemy changes the situation sufficiently to demand something really new. In the late 1990s and early 2000s there was official interest in defense transformation, in the way that new technology and new ways of using it could have a disruptive effect on war. The examples were taken from the interwar period of the last century, things like blitzkrieg and the aircraft carrier. When Donald Rumsfeld became Secretary of Defense, he promised to cut costs through “transformation,” and even established a special office, headed by retired USN Vice Admiral Arthur Cebrowski, to channel and accelerate change. Rumsfeld’s particular blend of transformation did not seem to work; and it was sometimes said that “transformation died at Fallujah,” meaning that the Iraqi insurgency could find ways to defeat Rumsfeld’s favored high-tech programs.

But that did not mean that radical change was wrong, only that the particular transformation championed by Secretary Rumsfeld had not worked (partly, perhaps, because it was not yet mature or particularly well-defined).

Secretary Gates’ holistic approach to war in Iraq seems to have been far more successful. The JMVP was part of that approach. It did not fit the pre-war or even the pre-Rumsfeld

procurement system. Neither did the other new approaches that he adopted. But, taken together, they were a key part of a new approach to Iraq and Afghanistan, which seems to have been quite successful. They were also radical breaks with the usual procurement system. It is distressing to envisage a defense acquisition system that works only when someone insightful, who brings an effective team of top subordinates into play, leads it.

In that regard, the “top cover” offered by SECDEF Gates should not be discounted. By the time he was involved, the program had grown far beyond the small initial team inspired by the initial risk-takers. Many of those involved had spent their careers staying as far as possible from risk, living within the regulations. The strong cover offered by the Secretary of Defense emboldened them and encouraged them to seek creative solutions to the problems the program met. Indeed, the key lesson might be that such programs can succeed only if there is cover, and that missteps do not ruin a career. On that basis members of a small team can be expected to take responsibility and run with it.

Leadership mattered enormously to the success of the program, and not just in the Office of the Secretary of Defense. Those in charge of the JMVP were clearly willing to do anything they demanded of everyone else in the program—the brutal hours, the continuous effort, the personal sacrifices. They also remember the camaraderie and the sense of personal achievement. Again and again, JMVP team members describe the program as the best years of their lives. That was partly because they felt personal responsibility for their lifesaving achievement, but there must have been a lot more. The atmosphere of the program shows in the universal feeling that no other, more conventional, program could ever be so rewarding.

A “Victory Program” in All-But Name

Everyone on the government-industry JMVP understood exactly where the program was supposed to go, and because all of them considered the objective—saving American and coalition lives—was worth every effort they could exert. Saving lives was a simple version of the victory towards which World War II programs were oriented. As with the JMVP, that clear goal made extraordinary exertion worthwhile. Few current programs have so clear a goal. However, during World War II the overall goal of victory sufficiently motivated workers in many programs that did not have obvious or easily visualized goals of their own.

Perhaps the JMVP seems different because after 9/11 there was a deliberate attempt on the part of the administration *not* to put the United States on a wartime footing. The wars were too complicated, and popular pressure would have demanded measures that might not have been acceptable, or which might not really have been in long-term U.S. interests. Thus the JMVP might have been one of the few military programs of its era to be pressed as a victory program.

The victory-program atmosphere justified extraordinary personal sacrifices on the part of those inside the JMVP. People burned out. When the demand for a new program (M-ATV) materialized, some were unable to continue at the pace that had created MRAP vehicles in the first place. The larger lesson is that although vital programs can run at “MRAP speed” for a time, the JMVP *as run* cannot be a model for sustained procurement. The MRAP vehicle program on a somewhat slower basis *can* be a model. The program certainly did show that much of the currently required documentation could be created much more rapidly and more efficiently than anyone imagined. It might be that running rapidly at very high pressure at the beginning of a program guarantees a much quicker and better outcome by ensuring that 80-percent solutions will be accepted.

Other historical examples can help. Perhaps the faster schedule can become the norm, given successes. The program might be an excellent demonstration that what is now widely accepted as time from concept to reality is not necessarily what *should* be accepted. History suggests that until about 1960—when the current acquisition system was created—defense programs really did run a great deal faster than they now do. Not all of them were MRAP-style crash efforts. In fact almost none of them were, yet they were completed in much more quickly than now.

Lean, Courageous Outsiders

One essential point not often mentioned is that the program worked as it did because it was largely run by outsiders to the military vehicle world. They did not know what they could not do, or how long a program should take before it produced a flood of vehicles. Obviously it is neither possible nor desirable to begin each important program with outsiders. But perhaps it is possible to say that the insiders (in this case, in the vehicle world) have been unduly affected by the slow schedules that are now the norm. Perhaps

the expertise of the insiders can be and should be tempered by examples, such as that given by the JMVP, of how rapidly and efficiently a program can run.

The JMVP set a standard for how lean a program team could be. It managed to survive with so few people because all of them were skilled and extremely dedicated—and accustomed to working extreme hours. Many of them burned out in the process. That would not be an acceptable cost in a less urgent program. However, simply showing that a large program could be conducted as quickly as the JMVP should be inspiring.

The JMVP *did* enjoy special support, including the DX rating, but it achieved remarkable results in its early days, before it had any of the special benefits of Secretary Gates' support. That performance should still be inspiring. We live in a world in which it is accepted as normal that a new aircraft, for example, should take well over a decade (even two decades) to progress from prototype to service. Most of those buying today's and tomorrow's aircraft are unaware that aircraft of the past, which seemed just as complex to contemporaries, were fielded far more quickly because the need seemed more urgent. That lack of urgency applies to the full range of weapons and support systems.

Procurement courage and the idea that regulations are opportunities rather than a template for slow deliberate procurement are another matter. Those in a program can be courageous only if they know that they can take risks without suffering disproportionate punishment. The JMVP began with risk-takers who realized how important it was. They accepted a great deal of risk, but also understood that the risk was mitigated by the funds available—someone in the program remarked, “money was the hydraulic fluid of acquisition”—and the high profile of the program ensured that money *would* be available. To many outsiders, the flow of money explained the program's success. But the money did not just appear magically. The sustained high-level support that provided it had to be earned and re-earned through two administrations and through several turnovers in Congress.

Explicit Priorities

A second vital point is that there has to be a strong sense of priorities in requirements.⁵ Too often a list of requirements is just that, without any sense of what matters. There also has to be a sense of stability over the likely length of development, both in the high-level officers in charge and in the team of development managers. It is uncertain whether these ideals will be approachable in reality. Above all, those inside the program

must be able to point to an objective with which they can identify. Making future amphibious operations work by providing a new vehicle has an obvious vital objective; making more efficient use of printing facilities, say, is unlikely to generate similar dedication.

Procurement practices are designed to limit risk, which is inherent in any high-technology enterprise. And it should not be assumed that the MRAP “trucks” were low technologies, only. That is why the usual process is sequential: once one stage has been ironed out, it is sensible to proceed to the next, from setting requirements to buying competing prototypes, to testing them and solving their problems, to selecting one and then to move to limited and then full production. All of that takes years, and the JMVP was designed to move a lot faster. To do that it collapsed many of these stages. It limited risk by giving itself considerable maneuverability. Building vehicles in parallel but in limited numbers made it possible to abandon any one type which turned out to be unacceptable, as several did before the reductions to five manufacturers. Wherever possible, decisions were broken down into phased decisions that could be made more quickly, but which also would not scuttle the program if they turned out badly. Generally the joint program managers (JPMs) accepted risk that would not be fatal, such as financial risk and the risk of automotive problems and concentrated on the potentially fatal risks—survivability and schedule. They were also able to separate out elements of infrastructure that could be built up independently of production choices, such as the development of the integration facility at Charleston and the preparations for transportation and for reception and maintenance in theater.

These are not surprising lessons. Everyone in procurement knows the dangers of requirements creep and of unrealistic scheduling and of dispersed authority, usually without responsibility. It may be that the most important reason that the JMVP succeeded was that the number of cooks making its broth was dramatically limited by the mechanisms of the OSD Task Force and Dr. Etter’s (ASN RD&A) “synchronization meetings.” It might be that the most important effect of these meetings was to compress decision-making and in that way to reduce the number of inputs. Requirements creep is a lot less likely if no one outside a very lean program has the time or opportunity to think through a way the program can be improved, without a clear feeling for the cost of improvement.

If this analysis were correct, then the widespread perception that the JMVP succeeded because it enjoyed an (perhaps) unrepeatable level of funding, priority, and high-level support is wrong. It may have succeeded largely because the attention was applied to limit tinkering at every level. Almost certainly the JMVP could have been better (although probably not faster). But speed of execution was the most important attribute. Moreover, experience of many more deliberate programs must make an observer wonder whether all that deliberation was really worthwhile. It is possible that applying tight deadlines to review panels like JROCs might approximate this effect.

There is already some limited evidence that the JMVP is serving as a valuable example. The latest iteration of the DoD procurement regulation (DoD 5000.2) includes, for the first time, an urgent process. It sets up a “clear” procurement lane. Those using it can work first and worry later about detailed documentation. This new approach makes explicit reference to the success of the JMVP. It uses the JMVP, not some rapid acquisition program, as its reference because the others were permitted and admitted breaches of the entire regulatory structure. The JMVP was entirely legal; it operated within the regulations, taking every advantage of permissible tailoring and accelerated decision-making. It always applied for (and received) specific waivers. That can be done again.

Another lesson was the value of computer technology for tracking the program and making agile management possible. The program was always tracked in detail, so that anyone could see how it was progressing and what bottlenecks had to be addressed. Leadership meant that this kind of tracking was a positive means of pushing the program rather than a way of spying on those involved to find out whom to punish. The computer tracking could perform either function; it was the people involved who decided which way it was used. For example, the computer description of the current state of the program could be (and was) used to decide whether to install something in theater or in SPAWAR Charleston—which would cause the least delay? This type of tracking was considered rare.⁶

The key was the aggressive use of a few well-designed metrics that directly supported decisions, and the discipline to continue to use those metrics despite the difficulties involved in creating them and reviewing them regularly.

Lessons Learned

In September 2008 the JMVP assembled a list of lessons learned since the fall of 2006, some of which paralleled changes in the DoD 5000 procurement regulations, and all of which are apparent looking back from the vantage of September 2013:⁷

- The use of multiple firm fixed-price contracting (with some caveats) and ID/IQ contracts combined with a tiered price structure to provide volume discounts. Contracts of this type were considered highly scaleable, they could be executed very rapidly, and they minimized the risk of protests. On the other hand, the program accepted some difficulty in responding to changes in program requirements and vehicle configuration.
- The use of a small number of performance-based requirements rather than the usual detailed specifications, giving the JPO great flexibility in selecting vehicles. The JPO welcomed a test-analyze-test-fix approach in which the manufacturer was encouraged to solve technical problems revealed by testing. This approach focused procurement decisions on performance rather than compliance with a long list of specifications. In order to speed fielding, requirements considered not essential were not initially included, but were picked up later as add-ons, such as increased armor and load. In addition, there was Admiral Giambastiani's edict that no one could change a key performance parameter or a knowledge, skill, and ability requirement without his approval.
- Extended competition: by buying a few vehicles initially from the widest range of manufacturers, the program could evaluate as many as possible and identify and fix deficiencies in cooperation with the manufacturers. Instead of choosing one or two winners, the JPO was able to evaluate more vehicles and quickly move them into the field to gain, among other things, operational experience. Purchases gradually necked down to the most suitable vehicles; there was no initial neck-down apart from that imposed by basic survivability. The inherent risks were insufficient depth of testing and the loss of economies of scale. This was frequently offset by increasing the number of test articles and doing more testing simultaneously.
- The use of mature technology to achieve rapid fielding, using requirements designed to avoid untested technologies such as protection against EFPs and RPGs, which

might have delayed fielding (but it was probably more important that the Marines, who began the program, faced under-bottom IEDs rather than EFPs). But much of what was not tested initially was added later. This was the essence of a spiral program: get something giving real value as a beginning, then improve it later. The value of an evolutionary approach was clearly demonstrated.

Other lessons had not yet been incorporated into proposed new regulations, but contributed greatly to the program's success:

- Focus, achieved by limiting program objectives. In this case they were simply: (1) field survivable mission-capable vehicles; (2) field them quickly; and (3) concurrently build the necessary industrial base.
- Use smaller, more frequent reviews and decision points. The weekly “synchronization meetings” worked because they made for quick, supple decision-making. Other meetings were also frequent and targeted.
- Active involvement of the most senior decision-makers.
- High-level participation by all involved decision-makers, with the emphasis on fixing responsibility to solve problems uncovered at the frequent high-level meetings.
- The use of a centralized integration facility (SPAWAR Charleston) that could apply any lessons learned with one type of vehicle across all vehicle types and variants.

These lessons might become even more compelling for today's and tomorrow's systems and platforms, particularly as funding is squeezed as a result of across-the-board cuts mandated by sequestration.⁸

End Notes

¹ Carter interview.

² Carter remembered that when he was hired, Dr. Gates told him, “the troops are at war, but the Pentagon is not, especially the part you will run.”

³ The best case in point is the Polaris missile system. Neil Sheehan’s biography of General Bernard Schriever USAF, who was responsible for the parallel Air Force ballistic missile program, indicates that Schriever encountered considerable obstacles from an Air Force leadership which preferred to continue to rely on manned bombers, and from an Air Force procurement bureaucracy absolutely averse to fast, risky programs. President Dwight D. Eisenhower’s leadership was crucial. Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York: Random House, 2009).

⁴ The Navy is obviously a lot larger than the Marine Corps, but traditionally most naval officers spent most of their time in line rather than staff assignments, and the Navy filled many acquisition slots with officers who had just come from the fleet, hence represented the users’ views and needs. That probably explains the success of many naval programs, such as Aegis, whose orientation informed the MRAP program.

⁵ Defense programs have the essential requirements identified as Key Performance Parameters, or KPPs. These parameters are defined in terms of thresholds and objectives, the former of which cannot be traded. The programs are supposed to be funded to the objective level, allowing the PM to trade down to the threshold level in order to maintain performance and schedule within cost. Unfortunately, none of these practices are regularly followed. Many programs have too many KPPs; the objective—threshold range, if there is an objective—is often not meaningful; and the programs are usually funded to the threshold level that removes all trade space. As often seen in the MRAP vehicle program, the problem is not always the system, it was the execution of the system.

⁶ Ward interview. The system, at least the one used by Charleston, was Vehicular Integrated Solutions (VIS). It began with white board spreadsheets. Using it, the program could tap into other databases, for example the DLA cost list. It could validate the configuration of each vehicle delivered. VIS seems to have been an example of the computer program tracking that began with Dr. Etter.

⁷ JPO MRAP, “MRAP Vehicle Program History and Lessons Learned; Main Report: Lessons Learned,” 17 September 2009.

⁸ “Defense Spending: Squeezing the Pentagon,” *The Economist*, 6 July 2013, pp. 25-26. It is interesting to note the *The Economist* editors chose an image of an underway column of MRAP vehicles to illustrate the article.





CHAPTER 18

TRANSITION

In 2008-2009, as the Joint MRAP Vehicle Program seemed about to wind down, Deputy Joint Program Manager (JPM) David Hansen mused on where the program should go. It seemed to him that the point of the Joint Program Office (JPO) had been to produce and field the required flood of vehicles, but that the Services should be responsible for maintaining them, as they maintained all of their other equipment.¹ No JPO could forever be in what he called the “car rental” business, providing vehicles, waiting for them to be returned beaten up in service, and then refitting them for further service. That had always been—and should be—the business of the Services who used the vehicles. Anything like the JPO ought to embody a plan for transition after fulfilling its central job of production and fielding. At first Hansen found few supporters. Gradually, however, the logic of his position won people over. They realized that special arrangements, such as the Transfer Fund, could not be allowed to continue indefinitely.²

An MRAP vehicle was one among many, and however successful it was, it could never be fully integrated into the Services until they took responsibility for it.³

Hansen's vision had another implication. As an acquisition professional, he saw the JMVP as one among many possible applications of innovative and effective acquisition practices. The JPO that Paul Mann and he had honed was in effect a center of acquisition excellence. Surely it was worth preserving as such, not to keep developing MRAP trucks, but to carry out other urgent defense projects. Surely it was worth keeping together for the next project.

As it happened, half of Hansen's vision has been realized. JPO responsibility for MRAP vehicles officially ended on 19 December 2013 when USD AT&L Frank Kendall signed the final transition ADM, and the Services have developed plans for the transition to more conventional management and funding. Moreover, they have decided just how important MRAP vehicles were compared to other vehicle projects. Many of the considerations that precluded developing something like the MRAP vehicle program seven years earlier were still valid.

Hansen's other vision, that the JPO should be recognized as a center of procurement excellence and preserved as such, did not do as well. One of the challenges was that no one outside the JPO seems to have been able to articulate the reasons for its success. Many have argued that it was sufficient for Secretary of Defense Gates to have backed the program to the hilt and that with so much money flooding in the JMVP could hardly have failed. They ignore the fact that the program was succeeding well before it came to Dr. Gates' attention and well before it expanded much beyond the Marine Corps. Something was working well at the outset. Part of the JMVP success can certainly be laid at the door of the Secretary of Defense, but another part explains Hansen's idea of a continuing center of procurement excellence, a sort of procurement "skunk works" operating within the framework of existing regulations, but using them as opportunities rather than as restrictions.

Four COAs

The first attempt to move from the JPO to a service-oriented MRAP vehicle program was an April 2008 plan to move the JPO to the Army, on the basis that the Army operated the large majority of the vehicles.⁴ Secretary of Defense Gates vetoed this plan, but planning for transition from a Marine Corps managed JPO revived in 2009.⁵ Nothing was done that year, but on 7 June 2010, Dr. Ashton Carter, Under Secretary of Defense (AT&L) issued a memorandum asking the Department of the Navy (which was responsible for the JMVP) to describe and evaluate four possible courses of action (COAs), which he would review. Once a decision had been reached, an Integrated Product Team (IPT)/Planning Group would be formed to pursue the chosen COA. The MRAP Task Force met on 18 October 2010 and addressed four COAs:

1. Strengthen the JPO, with three sub-options: an Army Service Acquisition Executive (SAE), a PEO (Program Executive Officer) and JPM; a Navy Department SAE, PEO, and JPM; or SAE, PEO, and JPM from different Departments. It had to be admitted that this COA was not a permanent solution, since it postponed the necessary transition to the Services. In particular, the Services might find it burdensome to keep supporting the JPO with both personnel and money. Against that, the JPO had a proven track record and it offered valuable economies of scale.
2. Make the Marines the lead Service, with the Services and Special Operations Command (SOCOM) standing up their own internal organizations to coordinate with the lead Service (as in the Humvee program).⁶ However, it was not clear that all the Services would have sufficient structure or interest to stand up the required program managers/cells to work with the lead service.
3. Make the Army the lead service, otherwise as in CoA #2.
4. Have the Service Components each manage their own assets (as in the way combat uniforms were managed).

The MRAP Task Force recognized that the existing JPO was very much an ad hoc organization living mainly on Overseas Contingency Operations (OCO) funding, which would evaporate as operations in Iraq and Afghanistan wound down. It coordinated and integrated all the required Theater Provided Equipment (TPE) (such as on-board command, control, communications, computers and intelligence

equipment), and it provided “one-stop shopping” for the Services’ MRAP vehicle needs. The focus was on quickly delivering capability to Warfighters, with the Departments of the Navy and the Army sharing management roles under Marine leadership in the JPO in Stafford, VA.

The evaluation of the COAs listed transition objectives: (1) seamlessly supporting the war effort while it lasted; (2) supporting the Services’ enduring MRAP vehicle requirements; (3) ensuring good stewardship of resources; (4) supporting sustainment; and (5) providing personnel structure to support the effort. COA #1, which was an extension and strengthening of the existing JPO, scored highest. Splitting the program among the Services—COA #4—was the worst, although still rated as “good.”

In fact none of the COAs was cost-free. In order to strengthen the JPO to the point where it could continue to function after the war, each Service would have to establish permanent billets to support it. At the very least, the Services would have to allocate funds from their own budgets, since without OCOs there would be no Transfer Fund financing the JPO and the MRAP vehicles and their sustainment. Making either the Army or the Marines lead Service would require increased headquarters staff; for example, an Army-led program would require a Marine financial support staff to close out the existing work and establish an acquisition and financial support structure either at Warren, MI, or at Fort Belvoir, VA. The Army would have to establish billets to replace those lost with the dissolution of the JPO. If the program were split up among all four Services and SOCOM, the OSD Comptroller would have to coordinate the five components of the program, in the way that most cross-service programs are managed.

With OCO funding, the JPO reconditioned vehicles upon their return from theater. That would be simplest under COA #1 and most difficult if the work had to be split up among the Services COA #4. On the other hand, changing from the current TPE to unit ownership by the Services would be relatively simple, and did not have to be a transition issue.

It was likely that both production and major hostilities would soon end, at which point all vehicles would have been retrofitted and enduring requirements would be met. The Army would be the largest stakeholder (with with an enduring requirement of 8,585 MRAP vehicles, compared to an enduring requirement of 1,231 MRAP vehicles for the Marines). They would necessarily have a large existing management, logistics, and test and evaluation support structure. After all, it was the Army that had established

the sustainment structure in theater. Once production ended, that part of the program would be far more important than the production element that the JPO had managed.

Making the Army lead Service (COA #3) might be best for supporting enduring requirements, and also for stewardship of resources and for providing sufficient personnel. The strengthened JPO (COA #1) would be better (not best) at these roles, and only “good” at supporting enduring requirements and maintaining support capability. In this evaluation, COA #4 was worst in every category.

Phases might be envisaged, beginning with the phase in which vehicles were still being produced. At some point production would be complete; that could be envisaged in 2010, with only M-ATVs still being made as the COA assessment proceeded. At some point after that the OCO funds would vanish, to be replaced by funds from the Services’ budgets. Once production ended, vehicles would be retrofitted or scrapped. It appeared that major hostilities would end some time after that had been done. As operational tempo in Afghanistan declined through these phases, COA #3 (Army lead) replaced COA #1 (strengthened JPO) as the best course of action. It seemed to follow that transition should be driven by the occurrence of milestones, rather than by a fixed schedule.

By late 2010 responsibility for vehicle lines had been split within the JPO offices, so that Stafford, VA (Marines) was responsible for Buffalo, and Cougar. Warren, MI (Army) was responsible for M-ATV, Caiman, MaxxPro, RG-33 and RG31. JPO (Forward) operated the MRAP Sustainment Facility (MSF) in Kuwait and Regional Support Activities (RSAs) in Iraq and Afghanistan.

From the point of view of maintaining a future MRAP vehicle force, there is little question that COA #1 would have been best, with COA #3 and COA #2 somewhat distant second. The Services had other priorities. COA #1 and to a lesser extent COA #2 and COA #3 earmarked particular resources, both human (billets) and fiscal, which the Services might wish to deploy otherwise. The question of designing a transition merged into the question of how important (and how active) an enduring fleet of MRAP vehicles would be.

The JPO report on Courses of Action was briefed to the OSD MRAP Task Force on 18 October 2010.

USD AT&L Direction

Under Secretary of Defense AT&L Ashton Carter established the transition plan in a 12 May 2011 Acquisition Decision Memorandum (ADM). The existing JPO would remain under the Secretary of the Navy to support Operation Enduring Freedom (OEF) operations in Afghanistan. Planning would focus on two program offices, a Marine MRAP Vehicle Program Office as the lead Service to manage Cougar variants (mainly used by the Marines and the Navy) and an Army MRAP Vehicle Program Office as the lead Service to manage the others.⁸ The other Services would also have program offices to manage their own vehicles, in coordination with the lead Service for the vehicles. Although production had ended (except for possible foreign sales of new vehicles), the surviving vehicles required life-cycle management. In many cases the basis for long-term sustainment, in terms of identifying parts and producing maintenance manuals, was incomplete. In effect, Carter chose a combination of the proposed approaches. He merged COAs #2 and #3, which allowed the Marine Corps to retain the responsibility they already had for the vehicle they would retain in greatest quantity, the Cougar, with the Army becoming the lead Service for all others. It also took advantage of the greatest virtue of the centralized JPO, its ability to produce and update MRAP vehicles.

Once the war in Afghanistan was over, updating and retrofitting MRAP vehicles would no longer be urgent. In that sense the MRAP vehicle program would come to resemble a more conventional program, in which an initial configuration would be set and updated periodically rather than on a tight evolutionary schedule involving large numbers of somewhat varied vehicles.

The Secretary of the Army established a Transition IPT (TIPT) to develop an implementation plan. It was led by an Army civil servant from PEO Combat Support/Combat Service Support (PEO CS/CSS) and had representatives from all the Services and other key personnel. Meanwhile the JPO led an effort to explore the feasibility of transitioning the existing JPO-led theater maintenance support to the Army and Navy (Marine) support structures, to decide whether such a transition should take place ahead of the larger program transfer.⁹ It was assumed that the JPO would remain in place to support OEF until the “end of hostilities,” however that was defined. The 2011 ADM also defined the transition requirement that transition steps and criteria correspond to OEF events or conditions. The Defense Department had to notify the JPO specifically that OEF conditions were suitable for transition. The Services would

become responsible for life-cycle management beginning with FY 2014 (i.e., after 30 September 2013).

In June 2011 William King, the JPO Budget and Finance Manager (BFM), held a “BFM Summit” with the Services and SOCOM to arrange with them their FY 2013 OCO requests, so that they would take over financial responsibility for the MRAP vehicles and sustainment.

In December 2011 the Transition IPT submitted its plan for approval. It set minimum exit criteria for the transition:

- USD AT&L would approve an implementation plan developed by the Transition IPT.
- The program would provide adequate resources to ensure sustainment and approved requirements.
- Each component (Service, SOCOM) would have a designated management structure in place to execute or to coordinate execution with the lead Services of program management functions formerly provided by the JPO.
- The Department of Defense would determine and notify the JPO that conditions in Afghanistan were suitable for program transition.
- The Joint Staff would validate MRAP Baseline (as fielded) capabilities as threshold requirements, and the test community had to submit an assessment of the gaps, risk, and scope of testing required to certify that MRAP vehicles met these minimum requirements.

The President submitted FY 2013 OCO budget requests to Congress in February 2012. They reflected the agreements made at and after the BFM summit. King held another BFM summit on 11 June 2012 to finalize the roadmap to Service funding management for transition. That made it possible to end the Transfer Fund (which happened on 30 September 2012, the last day of FY 2012).

The transition and the end of the Transfer Fund were intimately linked. Without the Transfer Fund, there was no “colorless money” to sustain all the MRAP vehicles anywhere; there were only funds appropriated to the different Services. The projected date on which the JPO would end seesawed back and forth, but it became clear that the

JPO could not really survive the end of the Transfer Fund. Without it, it might still have coordinated Service programs, but it could not easily have maintained sustainment in the field, the one remaining trans-Service program element that would have justified its continued existence after the end of MRAP vehicle production.

USD AT&L Frank Kendall signed a further transition Acquisition Decision Memorandum (ADM) on 24 September 2012, approving a two-phase plan. In Phase I, the Joint Program Manager would report to the Army Program Executive Officer for Combat Support/Combat Service Support (PEO CS/CSS) as Joint Program Executive Officer (JPEO) no later than 1 October 2012. In Phase II, his functions would transition to an Army Product Manager within PEO CS/CSS no later than 1 October 2013, at which time the Joint Program Office would be dissolved. After the conclusion of Phase II, Kendall would consider delegating Milestone Decision Authority (MDA) to the Secretary of the Army, but with the Marines retaining management of Cougar variants and the Army all other MRAP vehicles (as had been envisaged in the earlier documents).

The Phase I transition of the Joint Project Executive Office (JPEO) from the Marines to the Army (under Kevin Fahey) was carried out on schedule, 1 October 2012. That day, Vice President Joe Biden joined Deputy Secretary of Defense Ashton Carter at a Pentagon ceremony marking the end of production of MRAP vehicles. The news accounts of the ceremony at the Pentagon did not refer to the shift in organization, or specifically to the JPO in connection with the remarkable production achievement.

The original JPO was created above all to produce the flood of vehicles, and with the end of production it was reasonable to move on to full Service responsibility for sustainment. Now it was necessary to divide up the large machine the JPO had built. In February 2013 JPM David Hansen, accompanied by William King, began visiting every continental U.S. activity still engaged with the JPO, more than 20 organizations. He briefed each on the history and logic of the transition, and also on their expectations as the Services/SOCOM would take responsibilities. These visits were completed in April 2013, and all briefed Fahey at a Transition Readiness Review (TRR) in June that they were ready for transition and were assuming responsibility for their own MRAP vehicles.

–Figure 7–
MRAP JOINT PROGRAM OFFICE – 2013

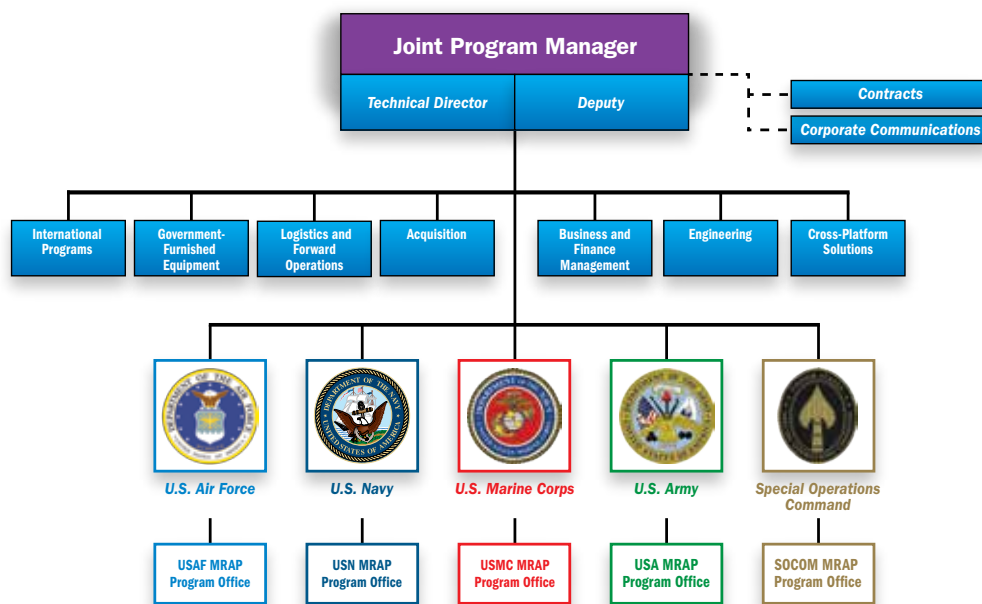


Figure 7 shows the structure that the JPM implemented for the transition period, with the Services' and SOCOM's program offices essentially integrated into the JPO structure in a way that would seamlessly allow their assumption of full responsibilities after the JPO stood down.

On 30 April 2013, King confirmed that the Services' spending plans for FY 2014 were complete. At this point the JPO was ready to dissolve, from a fiscal and programmatic point of view.

The Transition Readiness Review was held in June 2013 as planned.¹⁰ From this point on everyone involved was working through the various chains of command to develop an ADM. As of mid-September the memorandum was still being staffed, but it was assumed that the JPO would be dissolved on 30 September 2013, as planned. Figure 7 shows the post-transition MRAP program organization.

From the outset, the JPO had been a “coalition of the willing,” without any charter splitting functions between the Marine (lead) and Army offices. Because the Marines

were the lead Service, their JPO in Stafford, VA included the International Programs element and most of the program's finance and contracts support. Otherwise both offices were equipped with the full range of skills needed.

The Services have all had to face the fact that without the JPO and its funds, they would have to maintain their MRAP vehicles. These are complex, large, expensive vehicles, and it takes considerable resources to keep them going. Just as before the wars in Iraq and Afghanistan, there is considerable pressure to reduce the cost of U.S. defense. Each Service has had to think through its postwar priorities.

The end result is transition to a standard support organization, very similar to that which has always been in place for the Humvee fleet. The Army is lead service for the large majority of the vehicles, with the Marine Corps taking the lead only for the Cougars that are largely unique to that Service. Funding will come via Service appropriations. Each Service has established their own program office to coordinate support for their vehicles. In a final example of JMVP initiative, these organizations were established within the JMVP well before the disestablishment of the JMVP was final, providing time to work out their own management processes, and ensuring a smooth hand-off of management responsibilities.

End Notes

¹ Hansen produced and maintained a PowerPoint presentation, "JPO MRAP Program Overview: Transition Thoughts." This briefing was first produced on 14 March 2008, but the edition in hand dates from 2010, after Hansen had succeeded Paul Mann as JPM.

² The idea that the Transfer Fund had to be terminated at some point came, according to Dennis R. Dean, during a drive to Capitol Hill by Dave Hansen and William King. King suggested it and Hansen very much liked the idea. Note, however, that a Senate staffer thought the Transfer Fund could not have been accepted in the first place unless it had a sunset date. The two explanations may well describe the same reality: Hansen's view that the special process run by the JPO could not continue indefinitely might have made the Transfer Fund idea acceptable to the Senate staff.

³ Transition initially had a different meaning. An Army staffing form dated 12 March 2008 enclosed a proposed memorandum of agreement (MOA) between the Services to establish a small joint team to examine details, options, and timelines to transfer MRAP vehicle management from the Navy to the Army. Army procurement was to be completed in March 2009; the other Services' requirements would be met by August 2008. Secretary of Defense Gates vetoed this plan.

⁴ An IPT tasked with developing a transition plan was active between about March and October or November 2008. It was led by Elaine McCusker, who had been Dr. Etter's staff member for the MRAP program, and all the Services were represented. It was unable to come to any agreement as to a plan for transition to Service responsibility. The Army debated the options of simply transferring leadership of the existing JPO to the Army (the TACOM PEO to take over MRAP vehicles) or creation of two separate JPOs, one run by the Navy (for Marine Corps and Navy) and the other run by the Army (Army, Air Force, and SOCOM). This effort died when it became apparent that

MRAP production in some form would continue both to support all the Services and to support requirements for OEF (Afghanistan). The IPT did not consider the possibility of maintaining the existing JPO in any form.

⁵ Work in 2009 is referenced in the 7 June 2010 USD (AT&L) ADM that formally began the transition planning process.

⁶ At this time the Army had about 100,000 Humvees, the Marines about 25,000. The Army was lead service, and the Marines leveraged significant Army expertise. Each service maintained its own acquisition decision-making, and each reset and rebuilt its own vehicles. For example, the Marines had not initially bought M1114s when the Army did, deciding only later to do that.

⁷ The transition brief for USD (AT&L) included the JPO's estimate of the cost of the enduring requirement for MRAPs. At that time plans called for active, home station training (HST), hot storage (quick access), and cold storage vehicles. Grand totals were 13,630 MRAP vehicles and 6,747 M-ATVs plus 133 test MRAP vehicles and 93 test M-ATVs. Of these, the Army was expected to retain 2,781 active MRAP vehicles plus 1,224 HST and 6,820 in hot storage (none in cold storage) plus 850 active, 531 HST, and 2959 hot storage M-ATVs. In all, 4,332 MRAP vehicles and 1,675 M-ATVs would remain active. This was the enduring requirement as of 22 July 2010. It assumed that all MRAP vehicles would be brought home from theater for HST and storage and reset (brought up to date) in FY 2011. The active life of a vehicle was given as 7,000 miles (12,000 for SOCOM).

⁸ SOCOM had stated that it had no enduring MRAP vehicle requirement. It would rely on Service support for MRAP vehicle allocation, storage, and sustainment in future. The allocation of SOF-configured MRAP vehicles no longer required in Afghanistan and Iraq would be coordinated with each SOCOM Service component.

⁹ This was a follow-up to a 7 June 2010 memorandum asking the Navy (i.e., the JPO) for courses of action for the transition.

¹⁰ The Transition Readiness Review process was begun on 20 September 2012, and a location chosen on 18 October. The first JPM-JPEO Transition Status Meeting was held on 20 October, with others following on a monthly basis. The meeting announcement package was issued on 12 March 2013. The final Army report on the transition was completed in June 2013, the TRR itself having been held on 13 June.





CHAPTER 19

JMVP LEGACY

Winston Churchill remarked, “The further backward you can look, the further forward you can see.” The great question is whether the legacy of the JMVP will be a better way of acquiring future weapons to meet requirements that can be only dimly perceived in 2013. Would this remarkable wartime program, which saved so many lives, and which might have been decisive strategically, inspire changes in the way the Department of Defense develops and buys its weapons?

The Iraq and the Afghan wars were bruising, and it is tempting to imagine that their circumstances will not soon recur. As this history was written, however, the United States was contemplating the appropriate measures against Syria in response to Sarin-nerve agent attacks that killed some 1,450 civilians. “Boots on the ground” looked to be out of the question.

The prewar logic of expeditionary lightweight forces is still very attractive, and not only because it is likely to save a good deal of money. It corresponds to a reasonable view of U.S. commitments and responsibilities. It is tempting to imagine that U.S. forces will not soon face irregular forces whose main weapons will be improvised explosive devices (IEDs). Yet our enemies have certainly watched events in Iraq and in Afghanistan with great interest. They have seen how IEDs of various kinds dealt with the lightweight forces the United States initially deployed. They will surely understand the implications of discarding the MRAP vehicles that so blunted the IED threat.

As the war in Afghanistan wound down, and the Nation continued to bring home its forces in the region, MRAP vehicles and M-ATVs in country were no longer needed in great numbers. The vehicles were difficult to bring home, particularly since the roads to the north would not easily take them, and the road to ports in Pakistan for sealift home might be closed for political reasons.¹ “The U.S. military withdrawal from Afghanistan poses an enormous logistical challenges,” U.S. officials noted in mid-September 2013. “The landlocked country is halfway around the world, has few rail lines and poor roads, and is ringed by mountainous terrain. By the end of [2014]..., they need to pull out 24,000 vehicles and 20,000 shipping containers, one way or the other.” That left costly airlift—upward of seven times more expensive as the land route through Pakistan. In all, some \$7 billion was budgeted to ship everything home.

Certainly, some vehicles were left behind. But, they were very tough vehicles. Every MRAP vehicle or M-ATV left behind had to be reduced, laboriously, to unrecognizable scrap—unrecognizable so that anyone who felt that the U.S. withdrawal amounted to his own triumph would not have any “trophies” to display.

The unified Joint MRAP Vehicle Program Office (JMVP) closed on 30 September 2013, with ownership of the program transferred to separate Service and Special Operations Command (SOCOM) offices. In all, the JPO had procured a total of 27,702 vehicles against an approved requirement for 27,740 MRAP and M-ATV vehicles. From 1 October 2013 onward, each Service and SOCOM was responsible for its own fleet of vehicles, including maintenance, upgrade, storage, and disposals. The Navy and the Marines were responsible for legacy FMS cases and for all new Cougar sales; the Army, responsible for transferring all other MRAP vehicles and M-ATVs. The Services in 2013 identified the “enduring requirements” for MRAP vehicles and M-ATVs, that is, the number of vehicles each Service intended to retain after the hostilities ended.

SOCOM did not have a post-hostilities enduring requirement, and as this history was prepared was disposing of all remaining “spec-ops” vehicles. However, SOCOM Service components would retain, through their Service, the enduring MRAPs.

**MRAP Vehicle Enduring Requirements
(As of 31 December 2013)**

• U.S. Army:	8,585
• U.S. Marine Corps:	1,231
• U.S. Navy:	586
• U.S. Air Force:	754
• Total:	11,156

As of mid-2013, the Service MRAP program offices were engaged in transforming their programs into formal programs of record, with completion of the arrays of manuals and other arrangements necessary for an enduring program, all of which had been started, and most completed, by JPO MRAP. In some cases standard (M-series) vehicle

designations have been applied. The manufacturers are also advertising MRAP vehicle and similar vehicles to potential foreign buyers, and in the future those buyers may come to have many more protective vehicles than the U.S. Services.

Without doubt, the JMVP experience provides important lessons not only in procurement but also in how to build vehicles capable of surviving under-body and other attacks. Some of those lessons will be applied to the Joint Light Tactical Vehicle (JLTV) program for, in effect, a Humvee successor. Because the JLTV has to be air-transportable for future expeditionary operations, it cannot be as heavy as even the lightest M-ATV. Unfortunately a major lesson of the MRAP vehicle program has been that survivability requires mass as well as intelligent protective design. It is not clear that current materials can make a much lighter JLTV anything like as survivable as an M-ATV with underbody improvement kit (UIK)—but if the future is expeditionary, weight matters a great deal.

The argument against keeping many MRAP vehicles in service was that they are niche vehicles—excellent at what they do, but hardly what might be wanted as standard vehicles. Those who built the vehicles would argue that this niche is the future, because surely the United States will find itself engaging insurgents again and again, and because the wars in Iraq and in Afghanistan have taught adversaries that under-body mines and IEDs are among the most effective uses of their resources. Those fighting us in Afghanistan certainly seem to think so, and they are part of a larger network

of terrorists and insurgents who see the United States as their main enemy. Without doubt, too, lessons learned by the Taliban in Afghanistan are being communicated to others.

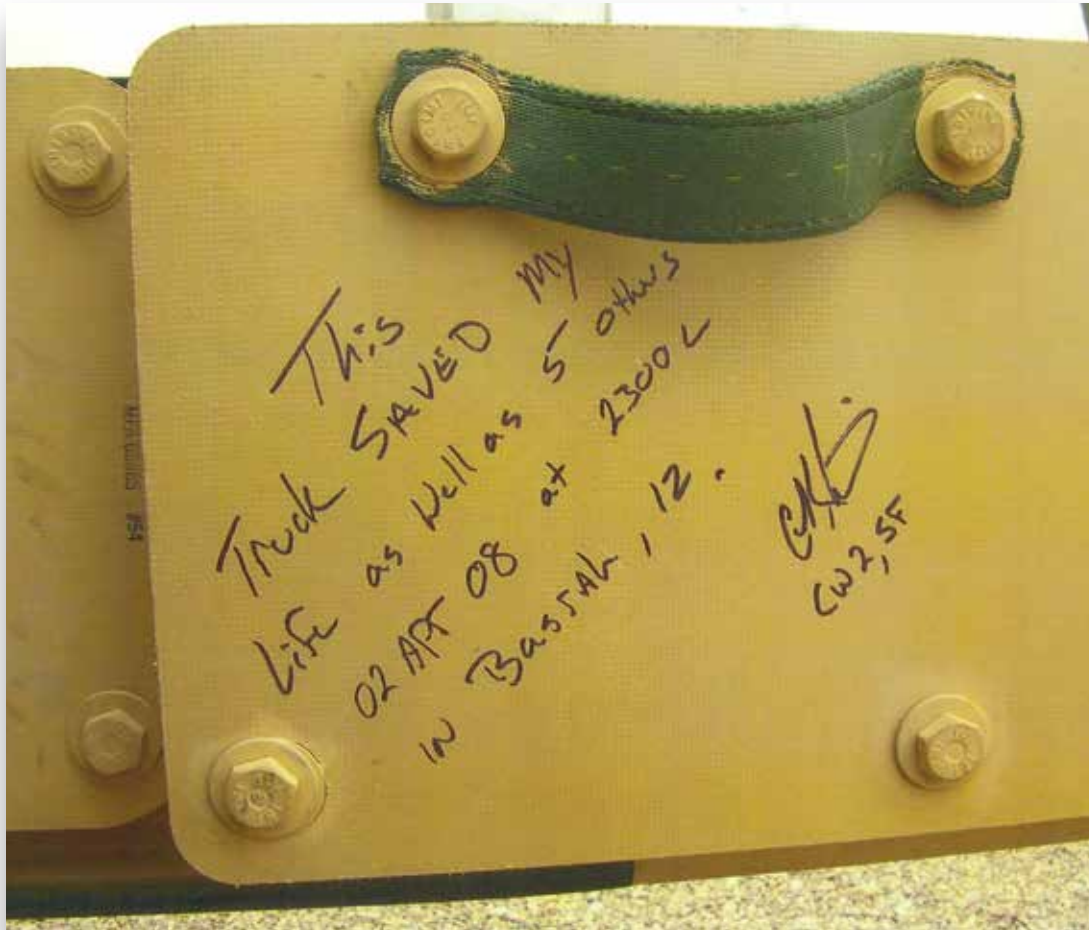
The JMVP taught a lot about how to arrange a vehicle internally and also how to make its troop capsule survivable, but there does not seem to have been enormous progress in materials science, which would produce a significantly lighter vehicle with similar survivability. Those in the program saw that sort of breakthrough as decades away. On the other hand, the JMVP developed many applicable survivability improvement technologies, from seats to floor mitigation. The bottom-protection science developed by the JMVP has been applied to the Army's Stryker vehicle, a double-vee hull and other improvements, giving it greater survivability against under-body IEDs even though it is low-slung.

Some of the MRAP vehicles will survive, many in cold storage against the possibility of another Iraq or another Afghanistan. Thus, some elements of the JPO "machine" built to keep them running will also have to remain.

That said, the operational fleet of vehicles would doubtless be weeded out if for no other reason than to reduce the variety that so complicated wartime maintenance. That will favor a combination of MaxxPros and M-ATVs for the Army, and Cougars and M-ATVs for the Marines. Other vehicles will survive in quantity because they have already been adopted for special roles such as EOD and route clearance. The Army retained the RG-33 and RG31 for this purpose, and at least some of the vehicles involved will be ex-MRAP trucks. The FPI Buffalo CAT III EOD vehicle will also remain in service with both the Army and the Marine Corps. Ultimately none of the Caiman vehicles were retained for the enduring requirement.

Again and again in the documentation of the JMVP the phrase "COTS" appears, to the extent that when asked initially about associated research and development (R&D), key JMVP actors recounted that there had been none. Yet this account shows an enormous amount of effort of exactly that type—of spiral development based on a massive investment in testing. As for the manufacturers, both Navistar and Oshkosh succeeded by applying a different technology to building the hulls of their vehicles. They certainly were not taking something off the shelf.

COTS or more, no one looking back should be under the illusion that the MRAP vehicles were “just trucks” plucked off a figurative shelf. They were rather special creations, and they should be remembered that way. They saved thousands of lives at risk from insidious, deadly threats, and they did so at “MRAP Speed.”



End Notes

¹ Craig Whitlock, “U.S. Forced to take Costly Route to Move Gear out of Afghanistan,” *Washington Post*, 13 September 2013, p. A7.





MRAP VEHICLES CHARACTERISTICS

MRAP Mission Categories

MRAP vehicle variants are a family of armored commercial-off-the-shelf (COTS) vehicles with blast-resistant underbodies and other features designed to protect the crew from land mines and improvised explosive devices (IED), fragmentary blasts, and direct-fire weapons. There are three categories of MRAP vehicles:

Category I (CAT I) vehicles support operations in an urban environment and other restricted or confined spaces including mounted patrols, reconnaissance, communications, and command and control.

Category II (CAT II) vehicles provide a reconfigurable vehicle that is capable of supporting multi-mission operations such as convoy lead and escort, troop transport, explosive ordnance disposal (EOD), casualty evacuation (CASEVAC), ambulance, and combat engineering (CE).

Category III (CAT III) vehicles support mine/IED clearance operations providing deployed commanders of various units and EOD/Combat Engineering (CE) teams survivable ground-mobility platforms.

In addition to these three MRAP categories, the primary mission of **MRAP-AII Terrain Vehicles (M-ATV)** is to provide protected, enhanced off-road mobility capable of operating in a threat environment involving ambushes employing the use of mines, IEDs, rocket-propelled grenades (RPGs), explosive-formed penetrators (EFPs), and small-arms fire (SAF). The M-ATV enhances the effectiveness of ground combat forces (including combat, combat support, and combat service support) with a focus on stability operations against unconventional enemy forces engaged in irregular warfare in a non-linear battlefield.

This appendix provides summary mission and technical information on MRAP baseline vehicles and variants produced by original equipment manufacturers (OEMs):

Sources: MRAP Joint Program Office and OEM background materials.

- BAE-Ground Systems Division (RG-33)
- BAE-Tactical Vehicle Systems (Caiman)
- Force Protection Industries Incorporated (Buffalo, Cougar)
- General Dynamics Land Systems-Canada (RG31)
- IMG/Navistar Defense (MaxxPro)
- Oshkosh Defense (M-ATV)

BAE GROUND SYSTEMS DIVISION

- RG-33 CAT I SOCOM BASE M1238
- RG-33A1 CAT I SOCOM ISS M1238A1
- RG-33 SOCOM ARMORED UTILITY VEHICLE (AUV) M1239
- RG-33L CAT II BASE M1232
- RG-33L CAT II HAGA AMBULANCE M1233
- RG-33L CAT II PLUS M1237
- RG-33L CAT II HAGA Plus AMBULANCE M1237A1



RG-33 CAT I SOCOM BASE M1238

<p>Mission Summary: Special Operations.</p> <p>System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.</p> <p>Manufacturer(s): BAE-Ground Systems Division, York, PA</p> <p>Number of Vehicles Delivered: 262</p> <p>Personnel Capacity: 8</p> <p>Gross Vehicle Weight (Pounds): 39,850</p> <p>Combat Vehicle Weight (Pounds): 46,000</p> <p>Payload Weight (Pounds): 6,150</p> <p>Kit Weight (Pounds): N/A</p> <p>Height (Inches): 134 (with Common Remotely Operated Weapon System)</p> <p>Width (Inches): 113</p> <p>Length (Inches): 262</p>	<p>Minimum Ground Clearance (Inches): 14.6</p>
	<p>Minimum Turning Diameter (Feet): L 66.2 / R 64.6</p> <p>Maximum Slope: 60%</p> <p>Engine (Type/Horsepower): Cummins ISL 8.9 liter / 400</p> <p>Transmission: Allison 3200SP 6-speed</p> <p>Configuration: 4x4</p> <p>Maximum Speed (Miles/Hour): 65</p> <p>Time to 50 mph (Seconds): 8</p> <p>Fuel Consumption Rate (Miles/Gallon): 6.6</p> <p>Range (Miles): 528</p> <p>Armor/Passive Defense: V-shaped hull to deflect blast, gunner protection</p> <p>Other Features:</p>

RG-33A1 CAT I SOCOM ISS M1238A1

Mission Summary: Multiple Special Operations.

System Description: US Special Operations Command variant, COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.

Manufacturer(s): BAE-Ground Systems Division, York, PA

Number of Vehicles Delivered: 128

Personnel Capacity: 7

Gross Vehicle Weight (Pounds): 51,500

Combat Vehicle Weight (Pounds): 52,340

Payload Weight (Pounds): 840

Kit Weight (Pounds): N/A

Height (Inches): 146

Width (Inches): 137

Length (Inches): 265

Minimum Ground Clearance (Inches): 14.9

Minimum Turning Diameter (Feet): L 66.2 / R 64.6

Maximum Slope: 60%

Engine (Type/Horsepower):

Cummins ISL 8.9 liter / 450

Transmission: Allison 3200SP 6-Speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 68

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 4.3

Range (Miles): 344

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features: TAK-4 independent suspension for increased mobility

**RG-33 SOCOM ARMORED UTILITY VEHICLE (AUV) M1239**

Mission Summary: Multiple Special Operations.

System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.

Manufacturer(s): BAE-Ground Systems Division

Number of Vehicles Delivered: 70

Personnel Capacity: 4

Gross Vehicle Weight (Pounds): 57,609

Combat Vehicle Weight (Pounds): 74,000

Payload Weight (Pounds): 16,310

Kit Weight (Pounds): N/A

Height (Inches):

147 (with Common Remotely Operated Weapon Station)

Width (Inches): 136

Length (Inches): 350

Minimum Ground Clearance (Inches): 13.1

Minimum Turning Diameter (Feet): L 95.5 / R 96.1

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-13 / 600

Transmission: Allison 4500SP 6-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 65.2

Time to 50 mph (Seconds): 9

Fuel Consumption Rate (Miles/Gallon): 3.4

Range (Miles): 272

Armor/Passive Defense: V-shaped hull to deflect blast, gunner protection

Other Features: Larger payload and 36,000-pound towing capacity, with front 5g/rear 5g walking beam suspension





RG-33L CAT II BASE M1232

Mission Summary: Multiple including convoy escort, EOD, and CASEVAC.

System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.

Manufacturer(s): BAE-Ground Systems Division, York, PA

Number of Vehicles Delivered: 731

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 50,835

Combat Vehicle Weight (Pounds): 52,000

Payload Weight (Pounds): 1,165

Kit Weight (Pounds): N/A

Height (Inches): 138.4

Width (Inches): 113

Length (Inches): 356

Minimum Ground Clearance (Inches): 14.4

Minimum Turning Diameter (Feet): L 76.9 / R 80.2

Maximum Slope: 60%

Engine (Type/Horsepower):

Cummins ISL 8.9 liter / 400

Transmission: Allison 3200SP 6-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 66.9

Time to 50 mph (Seconds): 8.7

Fuel Consumption Rate (Miles/Gallon): 6.9

Range (Miles): 552

Armor/Passive Defense:

V-shaped hull to deflect blasts, no EFP

Other Features: N/A



RG-33L CAT II HAGA AMBULANCE M1233

Mission Summary: Ambulance and CASEVAC, with additional missions including recon, convoy, troop transport, and EOD/CE.

System Description: Heavy Armored Ground Ambulance (HAGA) is a modified RG-33L vehicle enabling en-route care for 3 litter-bound or 6 ambulatory patients.

Manufacturer(s): BAE-Ground Systems Division, York, PA

Number of Vehicles Delivered: 128

Personnel Capacity: 9

Gross Vehicle Weight (Pounds): 52,000

Combat Vehicle Weight (Pounds): 52,362

Payload Weight (Pounds): 362

Kit Weight (Pounds): N/A

Height (Inches): 138 (w/OGPK)

Width (Inches): 113

Length (Inches): 333

Minimum Ground Clearance (Inches): 14.3

Minimum Turning Diameter (Feet): L 76.9 / R 80.2

Maximum Slope: 60%

Engine (Type/Horsepower):

Cummins ISL 8.9 liter Turbo Diesel / 400

Transmission: Allison 3200SP 6-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 66.9

Time to 50 mph (Seconds): 8.7

Fuel Consumption Rate (Miles/Gallon): 6.9

Range (Miles): 552

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features: Motorized litter-lift and folding ramp for loading patients

RG-33L CAT II PLUS M1237

Mission Summary: Multiple including reconnaissance convoy operations, troop transport, EOD/CE, and CASEVAC for maneuver units.

System Description: COTS vehicles with EFP protection designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.

Manufacturer(s): BAE-Ground Systems Division, York, PA

Number of Vehicles Delivered: 995

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 71,095

Combat Vehicle Weight (Pounds): 73,500

Payload Weight (Pounds): 2,405

Kit Weight (Pounds): N/A

Height (Inches): 137

Width (Inches): 134

Length (Inches): 333

Minimum Ground Clearance (Inches): 12.9

Minimum Turning Diameter (Feet): L 95.2 / R 86.4

Maximum Slope: 50%

Engine (Type/Horsepower):

Cummins ISL 8.9 liter / 450

Transmission: Allison 3200SP 6-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 65

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 400

Armor/Passive Defense:

V-shaped hull to deflect blasts, EFP protection

Other Features: Enhanced Automatic Fire Suppression System (AFSS)

**RG-33L CAT II HAGA Plus AMBULANCE M1237A1**

Mission Summary: Ambulance and CASEVAC, with additional missions including recon, convoy, troop transport, and EOD/CE.

System Description: Heavy Armored Ground Ambulance (HAGA) is a modified RG-33L vehicle with EFP protection enabling en-route care for 3 litter-bound or 6 ambulatory patients.

Manufacturer(s): BAE-Ground Systems Division, York, PA

Number of Vehicles Delivered: 53

Personnel Capacity: 9

Gross Vehicle Weight (Pounds): 72,592

Combat Vehicle Weight (Pounds): 73,500

Payload Weight (Pounds): 908

Kit Weight (Pounds): N/A

Height (Inches): 137

Width (Inches): 134 (with EFP protection)

Length (Inches): 333

Minimum Ground Clearance (Inches): 12.9

Minimum Turning Diameter (Feet): : 95.2 / R 86.4

Maximum Slope: 50%

Engine (Type/Horsepower):

Cummins ISL 8.9 liter / 450

Transmission: Allison 3200SP 6-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 65

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 400

Armor/Passive Defense:

V-shaped hull to deflect blast, EFP armor

Other Features: Motorized litter-lift system and longer folding ramp than baseline HAGA, along with modifications to increase patient survivability including vital signs monitors, oxygen concentrators, and suction hoses. Enhanced Automatic Fire Suppression System (AFSS)



BAE-TACTICAL VEHICLE SYSTEMS

- CAIMAN CAT I M1220
- CAIMAN CAT I PLUS M1230
- CAIMAN CAT I MTV M1248
- CAIMAN C20TM M1230



CAIMAN CAT I M1220

Mission Summary: Multiple including convoy escort, EOD, and CASEVAC

System Description: COTS vehicles designed from the Family of Medium Tactical Vehicles (FMTV) chassis to reduce casualties and increase survivability for personnel from land mines, IEDs and SAF.

Manufacturer(s): BAE-Tactical Vehicle Systems, Sealy, TX

Number of Vehicles Delivered: 1,170

Personnel Capacity: 7

Gross Vehicle Weight (Pounds): 38,000

Combat Vehicle Weight (Pounds): 40,000

Payload Weight (Pounds): 2,000

Kit Weight (Pounds):
6,500 MRAP Expedient Armor Program kit

Height (Inches): 143

Width (Inches): 98

Length (Inches): 309

Minimum Ground Clearance (Inches): 14

Minimum Turning Diameter (Feet): 62

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 / 330

Transmission:
Allison 3070SP automatic with integral transfer

Configuration: 6x6

Maximum Speed (Miles/Hour): 64.4

Time to 50 mph (Seconds): 9

Fuel Consumption Rate (Miles/Gallon): 5.5

Range (Miles): 401

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features:

CAIMAN CAT I PLUS M1230

Mission Summary: Multiple including convoy escort, EOD, and CASEVAC.

System Description: COTS vehicles designed from the Family of Medium Tactical Vehicles (FMTV) chassis to reduce casualties and increase survivability for personnel from land mines, IEDs, EFP, and SAF, with the Caiman Plus including numerous upgrades compared to the Caiman CAT 1.

Manufacturer(s): BAE-Tactical Vehicle Systems, Sealy, TX

Number of Vehicles Delivered: 1,694

Personnel Capacity: 7

Gross Vehicle Weight (Pounds): 52,000

Combat Vehicle Weight (Pounds): 62,000

Payload Weight (Pounds): 10,000

Kit Weight (Pounds): 11,055

Height (Inches):

143 (with Objective Gunner Protection System)

Width (Inches): 121

Length (Inches): 312

Minimum Ground Clearance (Inches): 14

Minimum Turning Diameter (Feet): L 61 / R 62

Maximum Slope: 55%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter with ACERT / 330

Transmission: Allison Type 1 3700SP GenIV

Configuration: 6x6

Maximum Speed (Miles/Hour): 58

Time to 50 mph (Seconds): 10.4

Fuel Consumption Rate (Miles/Gallon): 4.5

Range (Miles): 333

Armor/Passive Defense: V-shaped hull to deflect blast, gunner and EFP protection

Other Features: Caiman Plus includes 16 Unique Engineering Change Proposals to the Caiman CAT I, including: "MAMA Bear" EFP protection and chassis upgrades to the frame, 19K axels, brake wedges, door-assist system, rear and side steps, fuel-tank self-sealing and automatic cabin and engine fire suppression, crew seats improvements, backup alarm, aluminum wheels, and LED lighting.

**CAIMAN CAT I MTV M1248**

Mission Summary: Troop Transport.

System Description: COTS vehicle designed to reduce casualties and increase survivability for personnel from land mines, IEDs, EFP, and SAF, with the Caiman Plus including numerous upgrades compared to the Caiman CAT 1.

Manufacturer(s): BAE-Tactical Vehicle Systems, Sealy, TX

Number of Vehicles Delivered: 1,237

Personnel Capacity: 11

Gross Vehicle Weight (Pounds): 47,717

Combat Vehicle Weight (Pounds): 56,713

Payload Weight (Pounds): 8,996

Kit Weight (Pounds): 15,057

Height (Inches): 117

Width (Inches): 101.5 (without EFP protection)

Length (Inches): 325

Minimum Ground Clearance (Inches): 13.4

Minimum Turning Diameter (Feet): 58

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-9 / 450

Transmission: Caterpillar CX28

Configuration: 6x6

Maximum Speed (Miles/Hour): 65 (55 without EFP Protection)

Time to 50 mph (Seconds): 9

Fuel Consumption Rate (Miles/Gallon): 5.5

Range (Miles): 400

Armor/Passive Defense: V-shaped hull to deflect blast, monolithic underbody plate to increase survivability, gunner and EFP protection

Other Features: Caiman MTV includes approximately 20 ECPs to the Caiman Base and Plus vehicles including: Rear Combat Locks, Front Windshield Egress, Door Mirror Upgrades, Seat Upgrades





CAIMAN C20TM M1230

Mission Summary: Command and Control on the Move, with beyond line of sight communication capability.

System Description: Command and Control Mission Equipment Package (MEP), Digital Backbone and installation kit on a COTS vehicle, Caiman CAT I Plus M1230

Manufacturer(s): BAE-Tactical Vehicle Systems, Sealy, TX

Number of Vehicles Delivered: 9

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 52,000

Combat Vehicle Weight (Pounds): 62,000

Payload Weight (Pounds): 10,000

Kit Weight (Pounds): 13,387 (includes EFP, C2 equipment, and TARDEC Auxiliary System Power (ASP)

Height (Inches):
143 (with Objective Gunner Protection System)

Width (Inches): 131

Length (Inches): 313 (with rear step)

Minimum Ground Clearance (Inches): 12

Minimum Turning Diameter (Feet): 61.7

Maximum Slope: 55%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter with ACERT / 330

Transmission: Allison Type 1 3700SP GenIV

Configuration: 6x6

Maximum Speed (Miles/Hour): 59

Time to 50 mph (Seconds): 10

Fuel Consumption Rate (Miles/Gallon): 4.5

Range (Miles): 333

Armor/Passive Defense: V-shaped hull to deflect blast, side EFP protection

Other Features: Includes all Caiman Plus survivability and performance features. The C20TM capability allows beyond line of sight communication, both NIPR and SIPR. An auxiliary system power unit (generator) and clean power batteries were integrated into the hull to provide additional power to run the additional C2 equipment. Other ECPs include the Check 6 rear camera for increased situational awareness, the Overhead Wire Mitigation kit for navigating safely in urban conditions, 8 ton HVAC, and the IBIS-Tek 360 light kit.

Note: A kit was designed and produced by TARDEC to adapt the existing C20TM kit currently on the Caiman Plus CAT I vehicle and make it compatible with the newer MTV chassis. These kits were not installed due to the results of the MRAP III study which omitted the Caiman family of vehicles from the Army's enduring fleet requirement.

FORCE PROTECTION INDUSTRIES INCORPORATED

- BUFFALO CAT III MK2 A1
- BUFFALO CAT III MK3 A2
- COUGAR 4X4 HARDEND ENGINEER VEHICLE 4X4HEV
- COUGAR 6X6 HARDENED ENGINEER VEHICLE 6X6HEV
- COUGAR AMBULANCE
- COUGAR CAT I A1
- COUGAR CAT I A2
- COUGAR CAT I ISS A1
- COUGAR CAT I ISS A2
- COUGAR CAT I SABER TOW-ITAS
- COUGAR CAT II A1 MEAP
- COUGAR CAT II A1
- COUGAR CAT II A2
- COUGAR CAT II ISS A1
- COUGAR CAT II ISS A2
- COUGAR JOINT EXPLOSIVE ORDNANCE DISPOSAL RAPID RESPONSE VEHICLE JERRV 4X4EOD
- COUGAR JOINT EXPLOSIVE ORDNANCE DISPOSAL RAPID RESPONSE VEHICLE JERRV 6X6EOD

BUFFALO CAT III MK2 A1

Mission Summary: Route clearance.

System Description: Heavy category vehicle providing route-clearance capabilities and personnel protection against anti-personnel and anti-tank mines and IEDs.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 71

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 48,000

Combat Vehicle Weight (Pounds): 66,000

Payload Weight (Pounds): 18,000

Kit Weight (Pounds): N/A

Height (Inches): 150.6

Width (Inches): 106

Length (Inches): 343

Minimum Ground Clearance (Inches): 17 under front axel, 20 under transfer case, 14 under rear walking beam

Minimum Turning Diameter (Feet): 73

Maximum Slope: 25%

Engine (Type/Horsepower):

Mack ASET AI-400 Diesel / 400

Transmission: Allison HD-4560P 5-speed automatic

Configuration: 6x6

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): Not available

Fuel Consumption Rate (Miles/Gallon): 4

Range (Miles): 382

382Armor/Passive Defense: EFP medium protection

Armament and Active Self Defense: Not available

Other Features: 30-foot extendable boom with an attached claw, which, when combined with boom-mounted video camera, used to find/uncover concealed mines and IEDs with precision and operator stand-off/protection, automatic fire extinguishing system.



BUFFALO CAT III MK3 A2

Mission Summary: Route clearance.

System Description: Heavy category vehicle providing route-clearance capabilities and personnel protection against anti-personnel and anti-tank mines and IEDs.

Manufacturer(s): Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 8

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 53,250

Combat Vehicle Weight (Pounds): 66,000

Payload Weight (Pounds): 12,750

Kit Weight (Pounds): N/A

Height (Inches): 150.6

Width (Inches): 106

Length (Inches): 343

Minimum Ground Clearance (Inches): 17 under front axel, 23 under transfer case, 14 under rear walking beam

Minimum Turning Diameter (Feet): 73

Maximum Slope: 30%

Engine (Type/Horsepower): Caterpillar C-13 / 440

Transmission: Caterpillar CX31

Configuration: 6x6

Maximum Speed (Miles/Hour): 60

Time to 50 mph (Seconds): Not available

Fuel Consumption Rate (Miles/Gallon): 4.8

Range (Miles): 458Armor/Passive Defense: EFP medium protection, with automatic fire-extinguishing system

Other Features: 30-foot extendable boom with an attached claw, which, when combined with boom-mounted video camera, used to find/uncover concealed mines and IEDs with precision and operator stand-off/protection. Improved HVAC system and new seats and restraints.





**COUGAR 4X4 HARDENED ENGINEER
VEHICLE 4X4HEV**

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: A versatile heavily armored multi-purpose vehicle that was urgently needed by EOD/CE teams to increase their survivability against land mines and IEDs

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 14

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 38,000

Combat Vehicle Weight (Pounds): 44,000

Payload Weight (Pounds): 6,000

Kit Weight (Pounds): N/A

Height (Inches): 125

Width (Inches): 104

Length (Inches): 249

Minimum Ground Clearance (Inches): 13.7

Minimum Turning Diameter (Feet): 58.9

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 7 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features:



**COUGAR 6X6 HARDENED ENGINEER
VEHICLE 6X6HEV**

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: A versatile heavily armored multi-purpose vehicle that was urgently needed by EOD/CE teams to increase their survivability against land mines and IEDs

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 13

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 39,000

Combat Vehicle Weight (Pounds): 52,000

Payload Weight (Pounds): 13,000

Kit Weight (Pounds): N/A

Height (Inches): 128

Width (Inches): 104

Length (Inches): 269

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): 64.6

Maximum Slope: 60%

Engine (Type/Horsepower):

Transmission: Caterpillar C-7 7 liter / 330

Configuration: 6x6

Maximum Speed (Miles/Hour): 64.5

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 350

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features:

COUGAR AMBULANCE

Mission Summary: Transport and conduct emergency care in an armored ambulance on multiple critical battlefield casualties (up to two patients) while in close proximity to enemy troops.

System Description: A converted Cougar ISS CAT II A2, this variant has the ability to transport "walking wounded" and/or two litter patients. There is a unique ballistic blanket (washable), as well as, a mounting/bracket device that allows the medical equipment to be securely attached.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC
Amb Kit: BMI Defense, Inc.; Shock-Ride; Ferno; SPAWAR

Number of Vehicles Delivered: 53 Kits

Personnel Capacity: 7 + 1 supine / 4 + 2 supine

Gross Vehicle Weight (Pounds): 51,500

Combat Vehicle Weight (Pounds): 57,600

Payload Weight (Pounds): 6,100

Kit Weight (Pounds): N/A

Height (Inches): 148

Width (Inches): 107

Length (Inches): 296.2

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet): 90

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 7 liter / 330

Transmission: Allison 3500SP 5 speed

Configuration: N/A

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 300

Armor/Passive Defense:

No welding required to install kit.

Other Features: Four Armor Works seats have 5-point restraint, energy attenuators and the ability to fold up/down. Ferno wall-mounted plate allows medical equipment to securely attach for easy accessibility and maneuvering. BMI ballistic blanket and blackout curtains are washable.



COUGAR CAT I A1

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 1795

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 34,000

Combat Vehicle Weight (Pounds): 38,000

Payload Weight (Pounds): 4,000

Kit Weight (Pounds): N/A

Height (Inches): 128

Width (Inches): 106

Length (Inches): 249

Minimum Ground Clearance (Inches): 13.7

Minimum Turning Diameter (Feet): 58.9

Maximum Slope: 60%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense: V-shaped hull to divert blast

Other Features:





COUGAR CAT I A2

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 204

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 38,000

Combat Vehicle Weight (Pounds): 42,000

Payload Weight (Pounds): 4,600

Kit Weight (Pounds): 4,600

Height (Inches): 135

Width (Inches): 107

Length (Inches): 250

Minimum Ground Clearance (Inches): 13.5

Minimum Turning Diameter (Feet): 58.9

Maximum Slope: 60%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense: V-shaped hull to divert blast

Other Features: 7" raised roof height



COUGAR CAT I ISS A1

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: Delivered as a kit for already fielded vehicles

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 37,500

Combat Vehicle Weight (Pounds): 44,600

Payload Weight (Pounds): 7,100

Kit Weight (Pounds): N/A

Height (Inches): 148

Width (Inches): 106

Length (Inches): 249

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet): 68

Maximum Slope: 60%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense: V-shaped hull to deflect blast,

Armament and Active Self Defense: Crew-served .50 cal machine gun

Other Features: Independent suspension system (ISS) upgrade to baseline variants

COUGAR CAT I ISS A2

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: Delivered as a kit for already fielded vehicles

Personnel Capacity: 6

Gross Vehicle Weight (Pounds): 41,500

Combat Vehicle Weight (Pounds): 44,600

Payload Weight (Pounds): 3,100

Kit Weight (Pounds): N/A

Height (Inches):

148 (with Objective Gunner Protection Kit)

Width (Inches): 107

Length (Inches): 250

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet): 68

Maximum Slope: 60%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 400

Armor/Passive Defense:

V-shaped hull to deflect blast, EFP protection available

Armament and Active Self Defense:

crew-served .50 cal machine gun

Other Features: Independent suspension system (ISS)
upgrade to baseline variants

**COUGAR CAT I SABER TOW/ITAS**

Mission Summary: Supports small unit combat operations and combined anti-armor team (CAAT) unit tactics, techniques and procedures (TTPs).

System Description: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 64 kits

Personnel Capacity: 4

Gross Vehicle Weight (Pounds): 37,500

Combat Vehicle Weight (Pounds): 44,600

Payload Weight (Pounds): 1,500

Kit Weight (Pounds): 1,500

Height (Inches): 135

Width (Inches): 106

Length (Inches): 249

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet): 68

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 7 liter/ 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense: V-shaped hull to deflect blast

Armament and Active Self Defense: M41 SABER
tube-launched, optically sighted, wire-guided (TOW) missile
with improved target acquisition system (ITAS)

Other Features:





**COUGAR CAT II A1 MEAP
(MRAP Expedient Armor Protection)**

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 278 kits

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 49,640

Combat Vehicle Weight (Pounds):
76,000 (with MRAP Expedient Armor Program)

Payload Weight (Pounds): 26,360

Kit Weight (Pounds): 6,486

Height (Inches): 127 (with Marine Corps Transparent Armor Gun Shield)

Width (Inches): 139.5

Length (Inches): 296.8

Minimum Ground Clearance (Inches): 13

Minimum Turning Diameter (Feet): L 70.3 / R 64

Maximum Slope: 30%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 63

Time to 50 mph (Seconds): N/A

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 350

Armor/Passive Defense: MEAP

Other Features:



COUGAR CAT II A1

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 603

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 40,000

Combat Vehicle Weight (Pounds): 52,000

Payload Weight (Pounds): 12,000

Kit Weight (Pounds): N/A

Height (Inches):
128 (with Objective Gunner Protection Kit)

Width (Inches): 106

Length (Inches): 295.8

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): L 70.3 / R 64.6

Maximum Slope: 60%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 350

Armor/Passive Defense:
V-shaped to deflect blast, gunner protection

Other Features:

COUGAR CAT II A2

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 191

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 43,000

Combat Vehicle Weight (Pounds): 64,000

Payload Weight (Pounds): 21,000

Kit Weight (Pounds): 6,500

Height (Inches): 135

Width (Inches): 107

Length (Inches): 295.8

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): L 70.3 / R 64.6

Maximum Slope: 60%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 6X6

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 350

Armor/Passive Defense:

V-shape hull to deflect blast, EFP protection available

Other Features: 7-inch raised roof height



COUGAR CAT II ISS A1

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):

Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: Delivered as a kit for already fielded vehicles

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 47,500

Combat Vehicle Weight (Pounds): 57,600

Payload Weight (Pounds): 10,100

Kit Weight (Pounds): N/A

Height (Inches): 135

Width (Inches): 106

Length (Inches): 296.2

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet): 90

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 7 liter/ 330

Transmission: Allison 3500SP / 330

Configuration: 6x6

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): N/A

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 350

Armor/Passive Defense: V-shaped hull to deflect blast, EFP protection available

Other Features: Independent suspension system (ISS)





COUGAR CAT II ISS A2

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, and command and control.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: Delivered as a kit for already fielded vehicles

Personnel Capacity: 10

Gross Vehicle Weight (Pounds): 51,500

Combat Vehicle Weight (Pounds): 57,600

Payload Weight (Pounds): 6,100

Kit Weight (Pounds):

Height (Inches): 148

Width (Inches): 107

Length (Inches): 296.2

Minimum Ground Clearance (Inches): 15.5

Minimum Turning Diameter (Feet):

Maximum Slope: 60%

Engine (Type/Horsepower): Caterpillar C-7 7 liter/ 330

Transmission: Allison 3500SP / 330

Configuration: 6x6

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): N/A

Fuel Consumption Rate (Miles/Gallon): 5

Range (Miles): 300

Armor/Passive Defense: V-shaped hull to deflect blast, improved internal ballistic protection, EFP protection available

Other Features: Independent suspension system (ISS), increased capacity axels and springs, improved seats/seat mounting



COUGAR JOINT EXPLOSIVE ORDNANCE DISPOSAL RAPID RESPONSE VEHICLE JERRV 4X4EOD

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, ambulance, command and control, and EOD/CE missions for maneuver units

System Description: Versatile heavily armored, multi-purpose vehicle equipped that was urgently needed by EOD/CE teams to increase their survivability against land mines and IEDs. JERRV has adequate armor protection and can carry all required EOD equipment.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 13

Personnel Capacity: 4-6

Gross Vehicle Weight (Pounds): 31,750

Combat Vehicle Weight (Pounds): 36,000

Payload Weight (Pounds): 4,250

Kit Weight (Pounds): N/A

Height (Inches): 124

Width (Inches): 106

Length (Inches): 245

Minimum Ground Clearance (Inches): 13.7

Minimum Turning Diameter (Feet): 58.9

Maximum Slope: 60%

Engine (Type/Horsepower):
Caterpillar C-12 7 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62

Time to 50 mph (Seconds): 8.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 420

Armor/Passive Defense:

Other Features:

**COUGAR JOINT EXPLOSIVE ORDNANCE
DISPOSAL RAPID RESPONSE VEHICLE
JERRV 6X6EOD**

Mission Summary: Small-unit operations in urban or confined areas such as mounted patrols, reconnaissance, communications, ambulance, command and control, and EOD/CE missions for maneuver units.

System Description: Versatile heavily armored, multi-purpose vehicle equipped that was urgently needed by EOD/CE teams to increase their survivability against land mines and IEDs. JERRV has adequate armor protection and can carry all required EOD equipment.

Manufacturer(s):
Force Protection Industries, Inc., Ladson, SC

Number of Vehicles Delivered: 109

Personnel Capacity: 4

Gross Vehicle Weight (Pounds): 40,000

Combat Vehicle Weight (Pounds): 52,000

Payload Weight (Pounds): 12,000

Kit Weight (Pounds): N/A

Height (Inches): 120

Width (Inches): 108

Length (Inches): 294

Minimum Ground Clearance (Inches): 13.7

Minimum Turning Diameter (Feet): L 70.3 / R 64.6

Maximum Slope: 60%

Engine (Type/Horsepower):
Caterpillar C-12 7 liter / 330

Transmission: Allison 3500SP 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 9.6

Fuel Consumption Rate (Miles/Gallon): 6

Range (Miles): 350

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features: There is also a JERRV 6x6 Engineer variant. The biggest difference is personnel capacity increases to 10.



GENERAL DYNAMICS LAND SYSTEMS-CANADA

- RG31 CAT I A2
- RG31 CAT I A2 M1 RTR
- RG31 CAT I A3 MK5EM



RG31 CAT I A2

Mission Summary: Multiple including reconnaissance, convoy escort, EOD/CE, troop transport, ambulance and CASEVAC.

System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF. The RG31 A2 is 95% in common with the RG31 A2 MK5.

Manufacturer(s): General Dynamics Land Systems, Canada; Canadian Commercial Corporation, Ottawa, ON

Number of Vehicles Delivered: 1,379

Personnel Capacity: 7

Gross Vehicle Weight (Pounds): 33,033

Combat Vehicle Weight (Pounds): 37,485

Payload Weight (Pounds): 4,452

Kit Weight (Pounds): 1,386

Height (Inches):

138 (with Objective Gunner Protection Kit)

Width (Inches): 96

Length (Inches): 277

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): 58.2

Maximum Slope: 60%

Engine (Type/Horsepower): Cummings / 275

Transmission: Allison 250SP

Configuration: 4x4

Maximum Speed (Miles/Hour): 65

Time to 50 mph (Seconds): 8

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 335

Armor/Passive Defense:

V-shaped hull to deflect blast, MEAP EFP protection

Other Features:

RG31 CAT I A2 M1 RTR

Mission Summary: Multiple including reconnaissance, convoy escort, EOD/CE, troop transport, ambulance and CASEVAC.

System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF. The RG31 A2 MK5 (short cab) is 95% in common with the RG31 A2

Manufacturer(s): General Dynamics Land Systems, Canada; Canadian Commercial Corporation, Ottawa, ON

Number of Vehicles Delivered: 105

Personnel Capacity: 4

Gross Vehicle Weight (Pounds): 33,500

Combat Vehicle Weight (Pounds): 46,300

Payload Weight (Pounds): 12,800 (compared to 4,452 in RG31 A2)

Kit Weight (Pounds): 1,386

Height (Inches): 134

Width (Inches): 97

Length (Inches): 237

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): 50

Maximum Slope: 60%

Engine (Type/Horsepower): Cummings / 300

Transmission: Allison 3000SP

Configuration: 4x4

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 8

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 385

Armor/Passive Defense: V-shaped hull to deflect blast, MEAP EFP protection

Other Features:

**RG31 CAT I A3 MK5EM**

Mission Summary: Multiple including reconnaissance, convoy escort, EOD/CE, troop transport, ambulance and CASEVAC.

System Description: COTS vehicles designed from ground up to reduce casualties and increase survivability for personnel resulting from land mines, IEDs and SAF.

Manufacturer(s): General Dynamics Land Systems, Canada; Canadian Commercial Corporation, Ottawa, ON

Number of Vehicles Delivered: 105

Personnel Capacity: 4

Gross Vehicle Weight (Pounds): 29,434

Combat Vehicle Weight (Pounds): 46,300

Payload Weight (Pounds): 15,436 (compared to 4,452 in RG31 A2)

Kit Weight (Pounds): 1,430

Height (Inches): 134

Width (Inches): 97

Length (Inches): 237

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): 50

Maximum Slope: 60%

Engine (Type/Horsepower): Cummings / 300

Transmission: Allison 3000SP

Configuration: 4x4

Maximum Speed (Miles/Hour): 55

Time to 50 mph (Seconds): 8

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 333

Armor/Passive Defense: V-shaped hull to deflect blast, MEAP EFP protection

Other Features:



IMG/NAVISTAR DEFENSE

- MaxxPRO CAT I M1224
- MaxxPRO CAT I MEAP PROTECTED M1224A1
- MaxxPRO CAT I DASH DXM ISS M1235A1
- MaxxPRO CAT I PLUS AMBULANCE EFP PROTECTED M1234A1
- MaxxPRO CAT I PLUS EFP PROTECTED M1234
- MRAP CAT II RECOVERY VEHICLE M1249



MaxxPRO CAT I M1224

Mission Summary: Multiple missions including recon, convoy operations, troop transport, ambulance, and EOD/CE missions for maneuver units.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 2,399

Personnel Capacity: 7 (6 + gunner)

Gross Vehicle Weight (Pounds): 43,500

Combat Vehicle Weight (Pounds): 47,150

Payload Weight (Pounds): 3,650

Kit Weight (Pounds): N/A

Height (Inches):

151 (with Objective Gunner Protection Kit)

Width (Inches): 122

Length (Inches): 265

Minimum Ground Clearance (Inches): 9.8

Minimum Turning Diameter (Feet): L 59.2 / R 55.4

Maximum Slope: 60%

Engine (Type/Horsepower):

MaxxForce D/D8.7 International DT530 / 330

Transmission: Allison 3000 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 72

Time to 50 mph (Seconds): 8.7

Fuel Consumption Rate (Miles/Gallon): 7.4

Range (Miles): 321

Armor/Passive Defense: V-shaped hull to deflect blast

Other Features:

MaxxPRO CAT I MEAP PROTECTED M1224A1

Mission Summary: Multiple missions including recon, convoy operations, troop transport, ambulance, and EOD/CE missions for maneuver units.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 550

Personnel Capacity: 6 + Gunner

Gross Vehicle Weight (Pounds): 44,530

Combat Vehicle Weight (Pounds): 53,000

Payload Weight (Pounds): 8,470

Kit Weight (Pounds): 8,000

Height (Inches): 151

Width (Inches): 122

Length (Inches): 270

Minimum Ground Clearance (Inches): 10

Minimum Turning Diameter (Feet): L 67.2/ R 67.5

Maximum Slope: 50%

Engine (Type/Horsepower):

MaxxForce D/D9.3International DT570 /375

Transmission: Allison 3200 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 64

Time to 50 mph (Seconds): 8.8

Fuel Consumption Rate (Miles/Gallon): 6.2

Range (Miles): 321

Armor/Passive Defense: V-shaped hull deflects blast, EFP medium protection with MRAP Expedient Armor Program but no suspension upgrades, so armor weight takes up payload

Other Features: OGPK

**MaaxPRO CAT I DASH DXM ISS M1235A1**

Mission Summary: Multiple missions including recon, convoy operations, troop transport, ambulance, and EOD/CE missions for maneuver units.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF. MaasPRO DAHS is lighter version of MaaxPRO PLUS with common drive train and increased maneuverability.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 2,272 (1,050 vehicles with Independent Suspension System (ISS))

Personnel Capacity: 6 + Gunner

Gross Vehicle Weight (Pounds): 37,300

Combat Vehicle Weight (Pounds): 49,000

Payload Weight (Pounds): 11,700

Kit Weight (Pounds): 7,400

Height (Inches):

138 (with Objective Gunner Protection Kit)

Width (Inches): 120

Length (Inches): 254

Minimum Ground Clearance (Inches): 10.4

Minimum Turning Diameter (Feet): 55

Maximum Slope: 60%

Engine (Type/Horsepower):

MaxxForce D/D9.3 16 International DT570 / 375

Transmission: Allison 3200 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 67

Time to 50 mph (Seconds): 8.0

Fuel Consumption Rate (Miles/Gallon): 6.5

Range (Miles): 342

Armor/Passive Defense: V-shaped hull deflects blast, A-Kit for full/heavy EFP protection

Other Features: Improved suspension (23K front axle, 26K rear axle)





MaxxPRO CAT I PLUS AMBULANCE EFP PROTECTED M1234A1

Mission Summary: Multiple missions including recon, convoy operations, troop transport, ambulance, CASEVAC/MEDEVAC, and EOD/CE missions for maneuver units.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF. This vehicle incorporates additional EFP armor protection and the added capability of providing Health Service Support (HSS) in the form of patient evacuation from point of wounding/casualty collection point/ambulance exchange point to the next level of care for the maneuver commander.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 505

Personnel Capacity: 6 (1 driver, 2 crew, 3 patients)

Gross Vehicle Weight (Pounds): 49,920

Combat Vehicle Weight (Pounds): 53,000

Payload Weight (Pounds): 3,080

Kit Weight (Pounds): 8,000

Height (Inches):

151 (with Objective Gunner Protection Kit)

Width (Inches): 121

Length (Inches): 270

Minimum Ground Clearance (Inches): 10

Minimum Turning Diameter (Feet): L: 67.2 / R 67.5

Maximum Slope: 60%

Engine (Type/Horsepower):

MaxxForce D/D9.3 16 International DT570 / 375

Transmission: Allison 3200 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 67

Time to 50 mph (Seconds): 8.0

Fuel Consumption Rate (Miles/Gallon): 6.5

Range (Miles): 342

Armor/Passive Defense: V-shaped hull to deflect blast, with medium EFP protection added

Other Features: Improved suspension, dual litter, MEDEVAC systems



MaxxPRO CAT I PLUS EFP PROTECTED M1234

Mission Summary: Multiple missions including recon, convoy operations, troop transport, ambulance, and EOD/CE missions for maneuver units.

System Description: These COTS vehicles are designed from the ground up to reduce casualties and increase survivability of personnel from land mines, IEDs, and SAF. This vehicle incorporates additional EFP armor protection.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 1,736

Personnel Capacity: 7 (6 + gunner)

Gross Vehicle Weight (Pounds): 44,530

Combat Vehicle Weight (Pounds): 53,000

Payload Weight (Pounds): 8,470

Kit Weight (Pounds): 8,000

Height (Inches):

151 (with Objective Gunner Protection Kit)

Width (Inches): 121

Length (Inches): 270

Minimum Ground Clearance (Inches): 9.8

Minimum Turning Diameter (Feet): L 67.2 / R 67.5

Maximum Slope: 60%

Engine (Type/Horsepower): MaxxForce D/D9.3 16 International DT570 / 330

Transmission: Allison 3200 5-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 64

Time to 50 mph (Seconds): 8.8

Fuel Consumption Rate (Miles/Gallon): 6.2

Range (Miles): 327

Armor/Passive Defense: V-shaped hull to deflect blast, with medium EFP protection added

Other Features: Improved suspension, OGPk

MRAP CAT II RECOVERY VEHICLE M1249

Mission Summary: Retrieve stranded MRAP vehicles.

System Description: Recovery vehicle to transport operators safely to stranded MRAP vehicles for retrieval and towing.

Manufacturer(s): Navistar Defense, West Point, MS

Number of Vehicles Delivered: 240

Personnel Capacity: 2 +1 gunner

Gross Vehicle Weight (Pounds): 59,000

Combat Vehicle Weight (Pounds): 90,500

Payload Weight (Pounds): 31,500

Kit Weight (Pounds): N/A

Height (Inches):
119 (with Objective Gunner Protection Kit)

Width (Inches): 102

Length (Inches): 410

Minimum Ground Clearance (Inches): 9.75

Minimum Turning Diameter (Feet): 94

Maximum Slope: 60%

Engine (Type/Horsepower): MaxxForce D/D9.3 16 International DT570 / 375

Transmission: Allison 3200 5-speed

Configuration: 6x6

Maximum Speed (Miles/Hour): 65

Time to 50 mph (Seconds): 8.7

Fuel Consumption Rate (Miles/Gallon):
5.5 (estimated)

Range (Miles): 317

Armor/Passive Defense:
V-shaped hull deflects blast, full/heavy EFP protection

Other Features: Improved suspension (25.5K front axle, 67K rear axle)



OSHKOSH DEFENSE

- MRAP ALL-TERRAIN VEHICLE (M-ATV)
- MRAP ALL-TERRAIN VEHICLE (M-ATV) SOCOM
- MRAP ALL-TERRAIN VEHICLE (M-ATV) UIK2 SURVIVABILITY UPGRADE



MRAP ALL-TERRAIN VEHICLE (M-ATV)

Mission Summary: The primary mission of the M-ATV is to provide protected ground mobility in a threat environment comprising ambushes, land mines and improvised explosive devices (IEDs), rocket-propelled grenades (RPGs), explosively formed penetrators (EFPs), and small arms fire (SAF). The M-ATV mission is for small unit combat operations in highly restricted rural, mountainous, and urban environments that include mounted patrols, reconnaissance, security, convoy protection, communications, command and control, and combat service support.

System Description: Highly maneuverable ATV with a focus on stability operations against unconventional enemy forces engaged in irregular warfare on a non-linear battlefield, derived from the Medium Tactical Vehicle Replacement (MTVR) platform.

Manufacturer(s): Oshkosh Defense, Oshkosh, WI

Number of Vehicles Delivered: 7,789

Personnel Capacity: 4 + gunner

Gross Vehicle Weight (Pounds): 33,280

Combat Vehicle Weight (Pounds): 37,000

Payload Weight (Pounds): 3,720

Kit Weight (Pounds): N/A

Height (Inches): 123.9 (with Objective Gunner Protection Kit (OGPK)) / 137.9 (with OGPK and Overhead Protection (OHP))

Width (Inches): 123

Length (Inches): 246.8

Minimum Ground Clearance (Inches): 13.6

Minimum Turning Diameter (Feet): 61.7

Maximum Slope: 50%

Engine (Type/Horsepower):
Caterpillar C-7 7.2 liter I-6 diesel / 370

Transmission: Allison 3500SP 6-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 65

Time to 30 mph (Seconds): 11

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 373

Armor/Passive Defense: V-shaped hull to deflect blast, EFP Kit (with doors)

Other Features:



MRAP ALL-TERRAIN VEHICLE (M-ATV) UIK2 SURVIVABILITY UPGRADE

Mission Summary: The primary mission of the M-ATV is to provide protected ground mobility in a threat environment comprising ambushes, land mines and improvised explosive devices (IEDs), rocket-propelled grenades (RPGs), explosively formed penetrators (EFPs), and small arms fire (SAF). The M-ATV mission is for small unit combat operations in highly restricted rural, mountainous, and urban environments that include mounted patrols, reconnaissance, security, convoy protection, communications, command and control, and combat service support.

System Description: Highly maneuverable ATV with a focus on stability operations against unconventional enemy forces engaged in irregular warfare on a non-linear battlefield, derived from the Medium Tactical Vehicle Replacement (MTVR) platform. The addition of the Underbody Improvement Kit-2 (UIK2) further enhances the underbody threat protection of the platform. The kit combines armor and interior occupant upgrades as well as automotive enhancements to increase survivability while maintaining platform safety and off-road capability.

Manufacturer(s): Oshkosh Defense, Oshkosh, WI

Number of Vehicles Delivered: 577

Personnel Capacity: 4 + gunner

Gross Vehicle Weight (Pounds): 31,900

Combat Vehicle Weight (Pounds): 37,000

Payload Weight (Pounds): 5,100

Kit Weight (Pounds): 2,653

Height (Inches): 129.1 (with Objective Gunner Protection Kit (OGPK)) / 143.6 (with OGPK and Overhead Protection (OHP))

Width (Inches): 123

Length (Inches): 246.8

Minimum Ground Clearance (Inches): 16.8

Minimum Turning Diameter (Feet): 65.9

Maximum Slope: 60%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter I-6 diesel / 370

Transmission: Allison 3500SP 6-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 62.2

Time to 30 mph (Seconds): 11

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 373

Armor/Passive Defense: V-shaped hull to deflect blast, UTK2 underbody protection, blast mitigation seats and floor mats, RPG nets

Other Features:

MRAP ALL-TERRAIN VEHICLE (M-ATV) SOCOM

Mission Summary: The primary mission of the M-ATV is to provide protected ground mobility in a threat environment comprising ambushes, land mines and improvised explosive devices (IEDs), rocket-propelled grenades (RPGs), explosively formed penetrators (EFPs), and small arms fire (SAF). The M-ATV mission is for small unit combat operations in highly restricted rural, mountainous, and urban environments that include mounted patrols, reconnaissance, security, convoy protection, communications, command and control, and combat service support.

System Description: Highly maneuverable ATV with a focus on stability operations against unconventional enemy forces engaged in irregular warfare on a non-linear battlefield, derived from the Medium Tactical Vehicle Replacement (MTVR) platform.

SOCOM Model is configured for special operations; capable of being fitted with special equipment packages.

Manufacturer(s): Oshkosh Defense, Oshkosh, WI

Number of Vehicles Delivered: 465

Personnel Capacity: 4 + gunner

Gross Vehicle Weight (Pounds): 30,040

Combat Vehicle Weight (Pounds): 37,000

Payload Weight (Pounds): 6,960

Kit Weight (Pounds): N/A

Height (Inches): 123.9 / 137.9 (with OGPK)

Width (Inches): 124.3

Length (Inches): 266.4

Minimum Ground Clearance (Inches): 12.4

Minimum Turning Diameter (Feet): 62.5

Maximum Slope: 60%

Engine (Type/Horsepower):

Caterpillar C-7 7.2 liter I-6 diesel / 370

Transmission: Allison 3500SP 6-speed

Configuration: 4x4

Maximum Speed (Miles/Hour): 65.6

Time to 30 mph (Seconds): 11

Fuel Consumption Rate (Miles/Gallon): 6.6

Range (Miles): 373

Armor/Passive Defense: V-shaped hull to deflect blast, EFP Kit (with doors), RPG nets

Other Features:

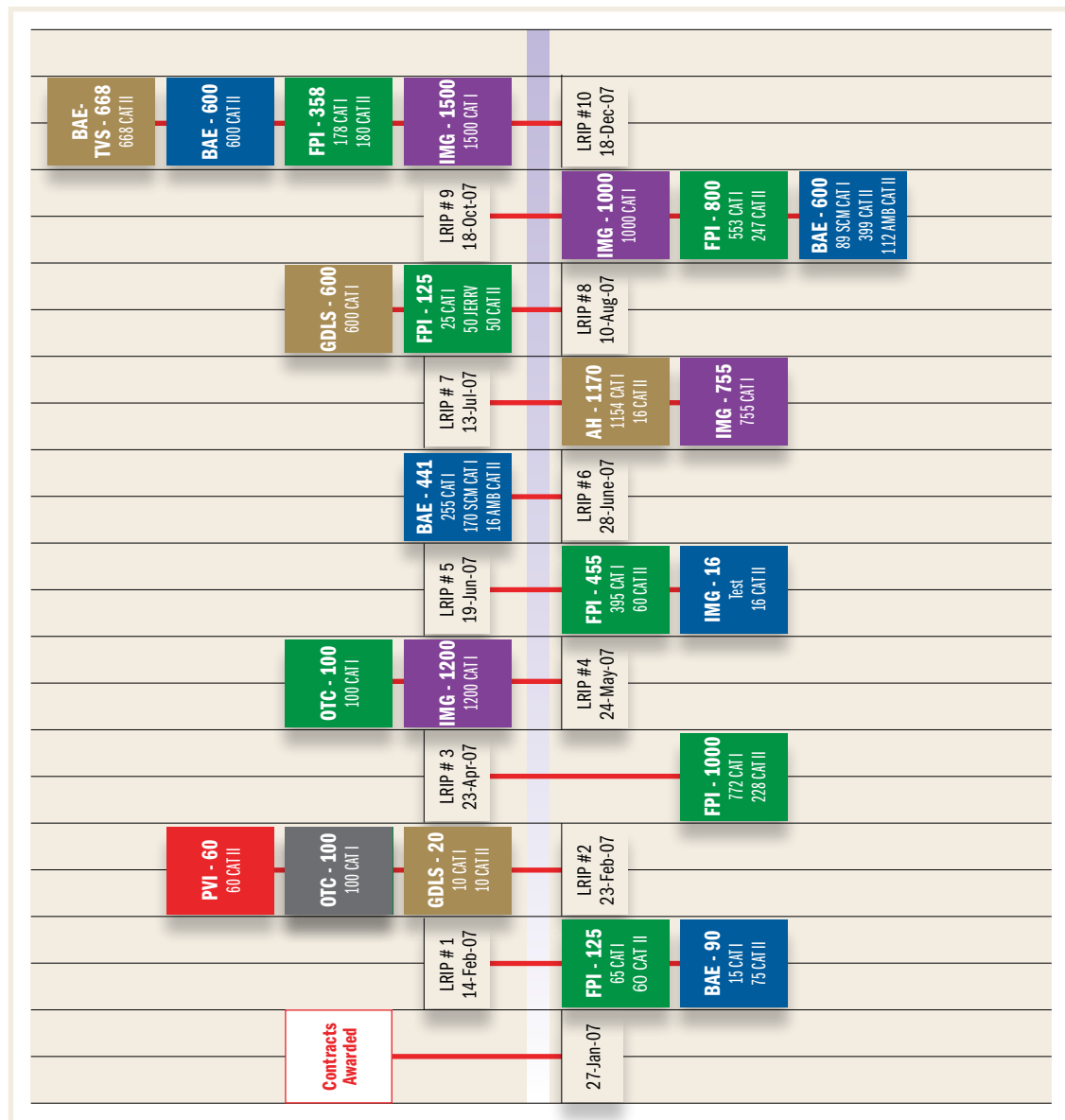


Contact Name	JPO MRAP Relationship	Interview Date(s)
Allen, Scott	Marine Corps Systems Command Chief of Staff	14-May and 29-Jul-13
Brockhoff, Nikki	DOT&E Physical Scientist	4-Jun-13
Brogan, Michael (Mike)	Commander, Marine Corps Systems Command and First JPEO MRAP BGen USMC (Ret)	4-Apr-13
Carmody, Thomas P.	First JPO MRAP Assistant PM RG-33	3-Apr-13
Carr, Jeff COL USA (Ret)	Former JPO MRAP Military Deputy	5-Jun-13
Carter, Ashton Dr.	DEPSECDEF and former USD AT&L	4-June-13
Chambers, Chris	Former Vice President, BAE	19-June-13
Coleman, Dr. Garry	JPO MRAP Strategic Management Support Contractor	2-Apr-13
Conway, John COL USA	Former JPO MRAP Logistics Product Manager	6-Jun-13
Corey, Grant	GDLS-C Director	21-Jun-13
Cresswell-Atkinson, Michelle	First JPO MRAP Budget and Financial Manager	4-Apr-13
Dean, Dennis	JPO MRAP Management Support Contractor	2 & 24-Apr-13
Dillon, Barry	Former Executive Director, Marine Corps Systems Command and First Deputy JPEO MRAP	23-Apr-13
Estevez, Alan	ASD L&MR	25-Apr-13
Etter, Delores Dr.	First ASN RD&A and Service Acquisition Executive for JPO MRAP	9-Jun-13
Fahey, Kevin	Army PEO CS&CSS	10-Jun-13
Gardner, LGen Emerson, USMC (Ret)	Former Principal Deputy Director, Cost Assessment and Program Evaluation, OSD	26-Jun-13
Gates, Robert	Former Secretary of Defense	14-Jun-13
Haddon, Coll LTC USA	Former JPO MRAP Logistics Product Manager	3-Sep-13
Hansen, David (Dave)	Former Joint Program Manager, JPO MRAP	2-Apr-13 and 31-Jul-13
Hove, Andy	Former Executive Vice President, Oshkosh	5-Jun-13
Ianitelli, Tim	JPO MRAP Test Director	12-Jun-13
Juergens, Ken	Former Program Manager for Oshkosh	5-Jun-13
Kaufer, Kate	Senate Appropriations Committee Staff	25-Apr-13
Kelley, Frank BGen USMC	Commander, Marine Corps Systems Command and former JPEO MRAP	13 & 20-Jun-13
King, William (Bill)	Former JPO MRAP Budget and Financial Manager	2-Apr-13
Krawchuk, Dave	JPO MRAP Chief Engineer	11-Jun-13
Livingston, Don	JPO MRAP Production and Quality Manager	11-Jun-13
Magnus, Robert GEN USMC (Ret)	Former Assistant Commandant of the Marine Corps (ACMC)	10-May-13

**APPENDIX B | INTERVIEWS CONDUCTED IN SUPPORT OF
THE MRAP VEHICLES LESSONS LEARNED AND HISTORY PROJECT**

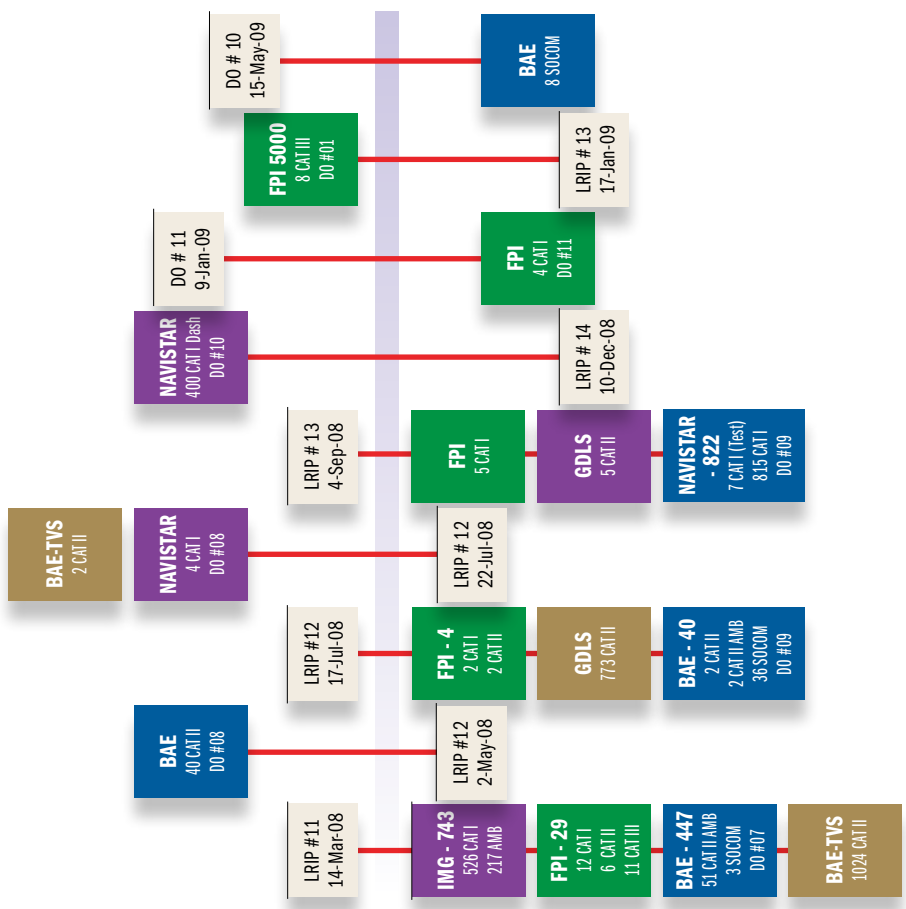
Contact Name	JPO MRAP Relationship	Interview Date(s)
Mann, Paul	First Joint Program Manager, JPO MRAP	4-Apr-13 and 31-Jul-13
Major, John	Former Program Manager, Navistar	6-Jun-13
Massicotte, Archie	President, Navistar Defense	26-Jun-13
McCarthy, Ryan	Former SECDEF Executive Assistant	22-Apr-13
McCusker, Elaine	Former ASN RDA Staff	3-Jul-13
McQuiston, Patricia LGEN	Former Commander, Defense Supply Center Columbus	16-Aug-13
Meyer, Thys	BAE OMC, International Programs Manager	2-Aug-13
Miller, Thomas (Tom) H.	First USMC PM MRAP	5-Apr-13
Oderkirk, Andy LCOL USA (Ret)	Former JPO MRAP Logistics Product Manager	11-Jun-13
Owen, Rick	JPO MRAP Management Support Contractor	22-Apr-13
Owens, Carl	Deputy Joint Program Manager, JPO MRAP	12-Jun-13
Peterson, Kevin COL USA	First JPO MRAP Military Deputy	25-Apr-13
Rangel, Robert	Former SECDEF Chief of Staff	23-Apr-13
Rienstra, Steve	Former MaxxPro APM	10-Jun-13
Rodgers, Joe	SPAWAR Charleston Integration Deputy	18-Jun-13
Rooney, John	JPO MRAP Technical Director and former Commander, Aberdeen Test Center	24-Apr-13 and 31-Jul-13
Russell, Bobby	Director, MRAP University, RRAD	25-Jul-13
Sayre, Rick	DOT&E Director of Life Fire T&E	4-Jun-13
Shaffer, Alan	ASD (R&E)	5-Apr-13
Sotomayor, Jerry	JPO MRAP Logistics Product Manager	11-Jun-13
Stackley, Sean Mr.	ASN RD&A and Service Acquisition Executive for JPO MRAP	25-Apr-13
Taylor, Gene	Former Congressman / House Armed Services Committee	6-May-13
Thigpen, James	Support Contractor Lead for SPAWAR Charleston	18-Jun-13
Thomas, Charlotte	Former Assistant PM International Program	3-Apr-13
Walsh, Bob	Vice President and General Manager, Navistar Defense	26-Jun-13
Walsh, Damon	Former Vice President, Force Protection Industries, Inc.	5-Jun-13
Ward, Pete	SPAWAR Charleston Integration Lead	18-Jun-13
Williamson, James (Jim)	JPO MRAP Acquisition Lead	4-Apr-13
Wolverton, Gordon	Program Manager, Navistar Defense	11-Jun-13
Yarboro, Kim	Former JPO MRAP Assistant PM Cougar	3-Apr-13
Young, John	Former ASN RD&A and USD (AT&L)	24-Apr-13

MRAP VEHICLE LRIP 1-10 TIMELINE



Dates Shown Represent Award of Delivery Order

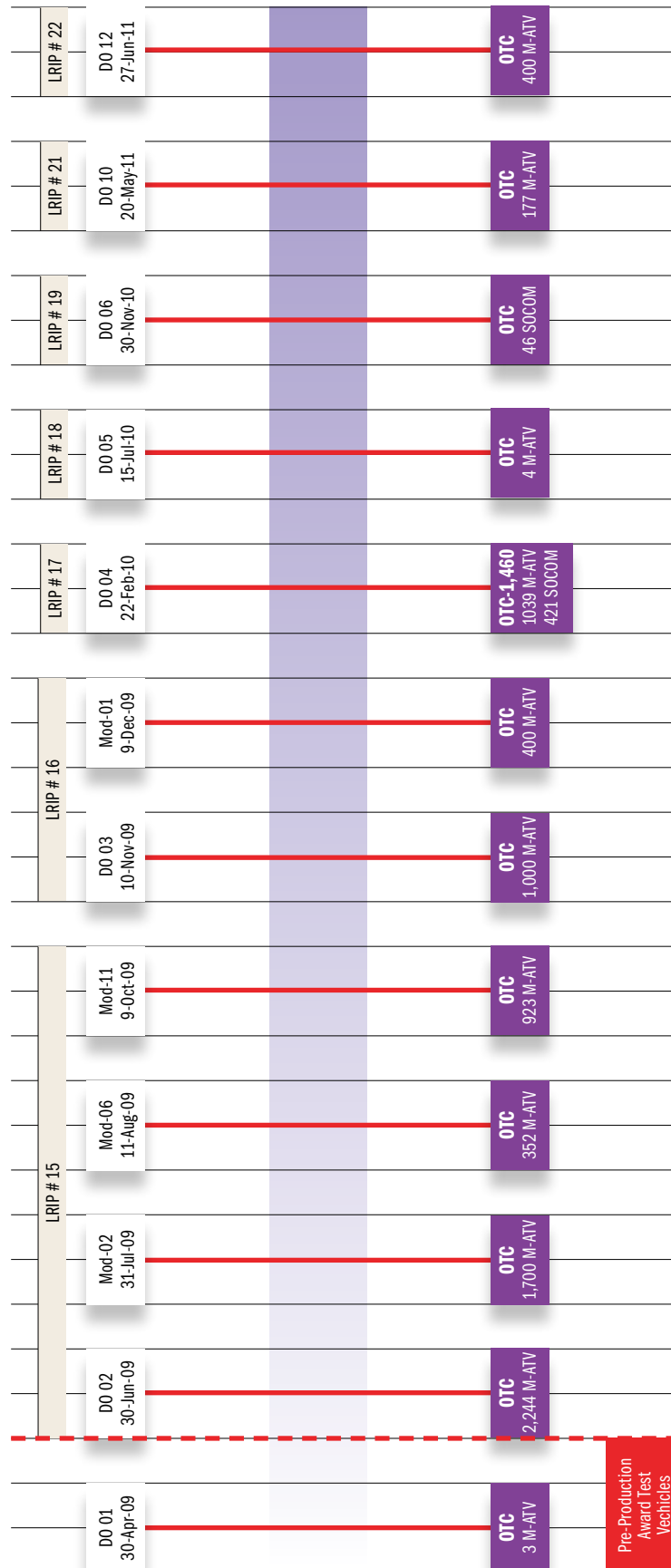
MRAP VEHICLE LRIP 11-14 TIMELINE



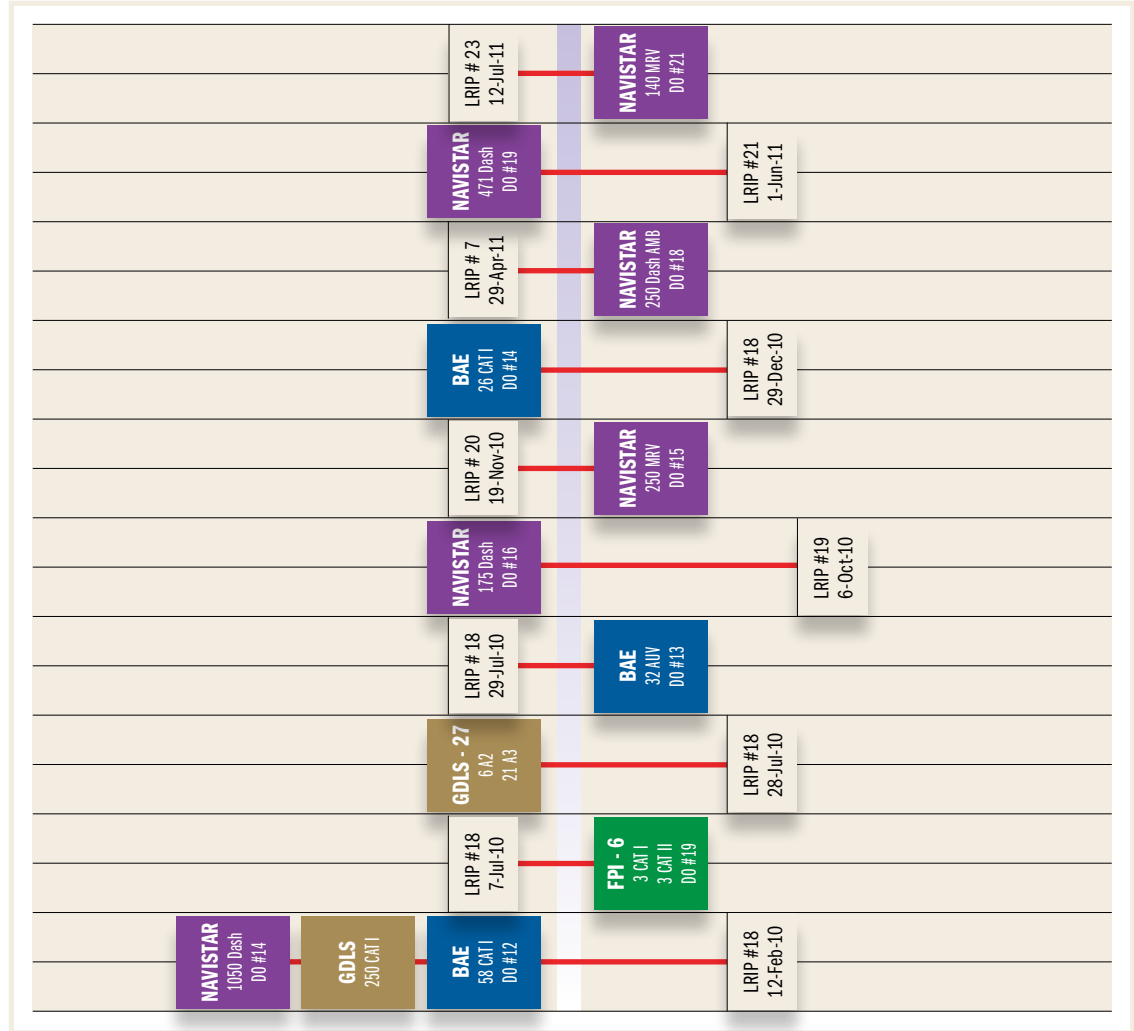
Dates Shown Represent Award of Delivery Order

MRAP VEHICLE LRIP 15-22 TIMELINE

(OSHKOSH M-ATV ONLY)



MRAP VEHICLE LRIP 17 - 23 TIMELINE (LESS OSHKOSH M-ATV)



Dates Shown Represent Award of Delivery Order



I. Correspondence

Acquisition Decision Memoranda (ADM) & Approvals

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Commander, Marine Corps Systems Command. Acquisition Decision Memorandum (ADM) (Milestone C) for Low Rate Initial Production of Mine-Resistant Ambush-Protected Vehicle Systems (MRAPS), February 9, 2007 (LRIP 1).

_____. Memorandum for the Commander, Marine Corps Systems Command. Approval #2 to Award Delivery Orders for Low Rate Initial Production of Mine-Resistant Ambush-Protected Vehicle Systems (MRAPS), February 21, 2007. (LRIP 2, Approval # 2).

_____. Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). Mine-Resistant Ambush-Protected (MRAP) Vehicle Acquisition, 20 April 2007 (ADM LRIP 3).

_____. Memorandum for the Commander, Marine Corps Systems Command. Approval #3 to Award Delivery Orders for Low Rate Initial Production of Mine-Resistant Ambush-Protected Vehicle Systems (MRAPS), 20 April 2007 (LRIP 3, Approval #3).

_____. Memorandum for the Commander, Marine Corps Systems Command. Acquisition Decision Memorandum for Increased Low Rate Initial Production of Mine-Resistant Ambush-Protected Vehicle Systems (MRAPS), 20 April 2007 (LRIP 3, Requirements).

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 4 (2,853 Vehicles), 25 May 2007.

_____. Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). Mine-Resistant Ambush-Protected (MRAP) Acquisition, 12 June 2007 (LRIP 5).

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 5, Approval #5, 12 June 2007.

_____. Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). ADM LRIP 6, 26 June 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. LRIP 6, Approval #6, 26 June 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. . ADM LRIP 6-7, Modification, 13 July 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 7, 11 July 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 7, Approval #7, 11 July 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 8, 6 August 2007.

_____. Memorandum for the Commander, Marine Corps Systems Command. ADM LRIP 8, Approval #8, 6 August 2007.

_____. Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). ADM LRIP 9, Award, October 2007.

Undersecretary of Defense. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). Funding Obligation Approval for the Mine-Resistant Ambush-Protected Vehicle Program. ADM LRIP 9, Funding Obligation, 17 October 2007.

_____. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 10, 18 December 2007.

_____. Funding Obligation Approval for the Mine-Resistant Ambush-Protected Vehicle II (MRAP II) Program. ADM LRIP 10, MRAP II, 18 December 2007.

_____. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 11, 13 March 2008.

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). Recommendation to Award LRIP 12 Production Contracts for of Mine-Resistant, Ambush-Protected (MRAP) Vehicles. ADM LRIP 12, 11 July 2008.

Undersecretary of Defense. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 12, Approval, 16 July 2008.

Undersecretary of Defense. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 13, Approval, 4 September 2008.

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). Recommendation to Amend LRIP 13 Approval-to-Award Delivery Order for 16 Category III Mine-Resistant Ambush-Protected (MRAP) Vehicles. ADM LRIP 13, Amendment, 31 March 2009.

Undersecretary of Defense. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 14, Approval (16,238 Vehicles), 24 November 2008.

_____. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 15 Approval (21,482 Vehicles), 23 June 2009.

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics). Recommendation to Award Production Delivery Order(s) for Mine-Resistant Ambush-Protected (MRAP) All-Terrain Vehicles (M-ATV). ADM LRIP 15, M-ATV, 19 June 2009.

Undersecretary of Defense. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 16 (22,882 Vehicles), 30 October 2009.

_____. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition). ADM LRIP 17 Approval, 29 January 2010.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 18 Approval, 28 June 2010.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 19 (26,346 Vehicles), 22 October 2010.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 20 (26,726 Vehicles), 22 October 2010.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 20, Modification (Immediate Acquisition of 250 V-hull Vehicles), 16 November 2010.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 18-19 Modification (Ambulance and LRIP 18 Quantity Change), 20 March 2011.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 21 (27,200 Vehicles), 25 March 2011.

Undersecretary of Defense for Acquisition, Technology and Logistics. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition): Transition of the Mine-Resistant Ambush-Protected (MRAP) Vehicle Program to the Services, 7 June 2010.

Undersecretary of Defense for Acquisition, Technology and Logistics. Memorandum for Secretaries of Military Departments; Chairman, Joint Chiefs of Staff; Commander, U.S. Special Operations Command; Undersecretary of Defense Comptroller; Director Cost Assessment and Program Evaluation; Director, Operational Test and Evaluation: Acquisition Decision Memorandum (ADM) – Transition of the Mine-Resistant Ambush-Protected (MRAP) Vehicles Program, 12 May 2011.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 22 (8, 731 M-ATV, 22, 27562 Vehicles), 10 June 2011.

_____. Memorandum for the Secretary of the Navy. ADM LRIP 23 (27,740 Vehicles, 140 MRAP Recovery Vehicles), 1 July 2011.

Joint Allocation Decision Board (JADB) Memoranda

The Joint Staff. Memorandum for the Assistant Secretary of the Navy (Research, Development, and Acquisition), Acceptance of High Risk for the Mine-Resistant Ambush-Protected (MRAP) Family of Vehicles, 16 February 2010.

The Joint Staff. Memorandum for Chairman, Joint Requirements Oversight Council; Commander, Naval Facilities Engineering Command, Chief of Civil Engineers; Deputy Director of Operations, U.S. Central Command; Director, Center for Force Structure, Requirements, Resources, and Strategic Assessments, U.S. Special Operations Command; Director of Security Forces, Headquarters U.S. Air Force; Director Operations Division, Headquarters U.S. Marine Corps; Director Capabilities, Integration, Prioritization, and Analysis, Headquarters U.S. Army: Joint Allocation Decision Board (8,104 M-ATV allocation), 8 March 2010.

_____. Joint Allocation Decision Board (Requirements to 23,316), 1 November 2010.

_____. Joint Allocation Decision Board. (1,028 allocation, requirements to 27,344), 24 January 2011.

_____. Joint Allocation Decision Board (MRAP fleet reallocation), 6 June 2011.

Joint Requirements Oversight Council Memoranda (JROCM)

The Joint Staff, Joint Requirements Oversight Council. Memorandum for Commander, U.S. Central Command; Vice Chief of Staff, U.S. Army; Vice Chief of Naval Operations; Vice Chief, U.S. Air Force; Assistant Commandant of the Marine Corps; Director for Force Structure, Resources, and Assessment, Joint Staff: JROCM 077-07, 3 April 2007 (Set 7,700 vehicle requirement) .

_____. JROCM 109-07, 10 May 2007 (Approved 7,774-vehicle requirement, key performance parameters for the MRAP Capability Production Document).

_____. JROCM 144-07, 14 June 2007 (Approved removal of requirement for gun ports and rifle racks on MRAP vehicles).

_____. JROCM 210-07, 5 September 2007 (Approved Army interim requirement for 10,000 vehicles, total requirement of 15, 374 vehicles, Explosive Form Projectile spiral protection and Joint Counter-Radio Controlled Improvised Explosive Device Electronic Warfare Version 2.1).

_____. JROCM 076-08, 31 March 2008 (Updated Marine Corps, Air Force, USSOCOM, and Army vehicle requirements).

_____. JROCM 151-08, 28 July 2008 (Approved requirement for 12,000 Army vehicles, additional vehicles for ballistic testing).

_____. JROCM 226-08, 20 November 2008 (Approved requirement for 16,238 vehicles, need for new vehicle suitable for Afghanistan operations).

_____. JROCM 115-09, 7 July 2009 (Approved/validated MRAP Family of Vehicles (FoV) Capability Production Document. Version 1.1, initial requirement for 5,244 M-ATVs, incorporation of MRAP FoV into future force structure).

_____. JROCM 147-09, 11 September 2009 (Approved M-ATV requirement for 6,644 vehicles).

_____. JROCM 026-10, 19 February 2010 (Approved increasing curb weight key performance parameter for M-ATV).

_____. JROCM 194-10, 15 December 2010 (Approved total requirement of 27,344 vehicles, requirement for 380 MRAP wreckers).

_____. JROCM 041-11, 25 March 2011 (Approved increased curb weight key performance parameter for M-ATV).

_____. JROCM 092-11, 27 June 2011 (Approved total vehicle requirement to 27,744).

_____. JROCM: MRAP Performance Baseline, 3 January 2012.

_____. JROCM 080-12, 26 March 2012 (Approved waiving current MRAP fleet's requirement to meet Capabilities Production Document Versions 1.0 and 1.1).

Memoranda of Agreement/Memoranda of Understanding

Memorandum of Agreement Between Defense Contract Management Agency, Tactical Wheeled Vehicles Chicago and Marine Corps Systems Command for the Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 8 August 2007.

Memorandum of Agreement Between Defense Contract Management Agency, DCMA Atlanta, and Marine Corps Systems Command for the Mine-Resistant Ambush-Protected (MRAP) Vehicle Program at Force Protection Industries Inc., May 2011.

Memorandum of Agreement Between Defense Contract Management Agency, DCMA Chicago, and Marine Corps Systems Command for the Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 15 May 2012.

Memorandum of Agreement Between Assistant Secretary of the Air Force (Acquisition); Assistant Secretary of the Navy (Research, Development, and Acquisition); Assistant Secretary of the Army (Acquisition, Technology, and Logistics); Special Operations Command, Acquisition Executive: Joint Mine-Resistant Ambush-Protected Vehicle Program (JMVP) Transition Plan, 15 April 2008.

Memorandum of Agreement Between JPO MRAP Vehicle Program and Product Group 11, MAGTF C2 Systems, to Receive Four MRAP All-Terrain Vehicles (M-ATVs), 8 November 2010.

Memorandum of Agreement Between JPO MRAP Vehicle Program and Tank Automotive, Development and Engineering Center (TARDEC), 17 August 2009.

Memorandum of Agreement Between Joint Program Office Mine-Resistant Ambush-Protected Vehicles and Defense Contracting Agency, DCMA Atlanta, Southwest Georgia Team, 15 June 2010.

Memorandum of Agreement Between Joint Program Office Mine-Resistant Ambush-Protected Vehicles and Specialized Reconnaissance Assault Transport Systems: Suspension of Work on MRAP Programs, 5 February 2009.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 1 November 2007.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 3 December 2007.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 10 January 2008.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 13 March 2008.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 16 June 2008.

Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and the Department of the Navy, the Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, United States Special Operations Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 25 July 2008.

Memorandum of Agreement Between Project Management Office Stryker Brigade Combat Team, Warren, Michigan, and Joint Program Office Mine-Resistant Ambush-Protected Vehicles, Quantico, Virginia, and Tank Automotive Research, Development and Engineering Center, Ground Systems Survivability, Warren, Michigan, for Development, Maturation and Transition of an Active Protection System for RPG Defeat, 2 August 2011.

Memorandum of Understanding Between Program Executive Office Soldier and Program Executive Office Intelligence, Electronic Warfare and Sensors and Joint Program Office Chemical and Biological Defense and Program Executive Office Combat Support and Combat Service Support and Joint Program Office Mine-Resistant Ambush-Protected Vehicles: Roles and Responsibilities for the Army's Counter Sniper Quick Reaction Capability (QRC), 28 May 2009.

Memorandum of Understanding Between Joint Program Manager Mine-Resistant Ambush-Protected Vehicles and Naval Facilities Engineering Command (NAVFAC) Expeditionary Programs Office (NEPO); Army Mine-Resistant Ambush-Protected Office; Air Force Support Equipment and Vehicles Division; and United States Special Operations Command Family of Special Operations Vehicles Office: Processes By Which the Joint Program Office Mine-Resistant Ambush-Protected Vehicle Program Will Support the Mine-Resistant Ambush-Protected Vehicles as Being Safe, Suitable and Supportable and Acceptable for Use by the Services in Support of Their Respective Enduring Requirements, 2 July 2012.

Other Memoranda

Ahern, David. Action Memo for Under Secretary of Defense (AT&L): MRAP Vehicle Program Monthly Congressional Report, 6 September 2007.

Ahern, David. Action Memo for Under Secretary of Defense (AT&L): MRAP Vehicle Program Monthly Congressional Report, 18 November 2008.

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Assistant Secretary of the Army (Acquisition, Technology, and Logistics); Assistant Secretary of the Air Force (Acquisition); Component Acquisition Executive (Special Operations Command); Commander, Naval Sea Systems Command; Commander, Naval Air Systems Command; Commander, Naval Facilities Engineering Command; Commander, Naval Supply Systems Command; Commander, Space and Naval Warfare Systems Command; Commander, Marine Corps Systems Command, Personnel Support for Mine-Resistant Ambush-Protected (MRAP) Vehicle Joint Program Office (JPO), 16 October 2007.

Assistant Secretary of the Navy (Research, Development, and Acquisition). Rapid Development and Deployment Response to Urgent Global War on Terrorism Needs, 8 March 2007.

Chief of Staff, Marine Corps Systems Command. Memorandum to Chief of Staff, Marine Corps Combat Development Command: Request for Mine-Resistant Ambush-Protected (MRAP) Vehicle Program Requirements Definition, 25 April 2007.

Commander, First Naval Construction Division. Memorandum to Commander, Navy Expeditionary Combat Command: Urgent Request for Force Protection Vehicles, 1 November 2006.

Commander, Navy Expeditionary Combat Command. Memorandum to Commander, Naval Engineering Facilities Command via Commander Fleet Forces Command: First Endorsement on COMFIRSTNCD Ltr 11260 Ser N43/353 of 1 November 2006, Urgent Requirement for Force Protection Vehicles, 7 November 2006.

Commanding General, Marine Corps Combat Development Command. Memo for the Assistant Secretary of the Navy (Research, Development, and Acquisition): Request for Initiation of Rapid Deployment Capability for Mine-Resistant Ambush-Protected (MRAP) Vehicle, 26 January 2007.

Commandant of the Marine Corps. Memorandum for the Chairman of the Joint Chiefs of Staff: Mine-Resistant Ambush-Protected (MRAP) Vehicle, 1 March 2007.

Commander, U.S. Marine Corps Forces Central Command (COMMARCENT). Approval Authority for Mine-Resistant Ambush-Protected (MRAP) Vehicle Urgent Universal Needs Statement (UUNS), 28 September 2006.

Marine Corps Systems Command, Director of Information Assurance and Joint Requirements. Memorandum for Product Group Director 15, Ground Transportation and Engineer Systems, PM Mine-Resistant Ambush Protection: Interim Authority to Operate the Mine-Resistant Ambush-Protected (MRAP) Vehicle Joint Program I.O.X.X, 20 September 2007.

McCusker, Elaine. Action Memo for Assistant Secretary of the Navy (Research, Development, and Acquisition): Recommendation to Approve Obligation Authority for Procurement of U.S. SOCOM Mine-Resistant Ambush-Protected (MRAP) Vehicles, 22 April 2008.

Office of the Secretary of Defense. Memorandum of Agreement Between the Office of the Secretary of the Department of Defense and Department of the Navy, Department of the Army, Department of the Air Force, the Joint Chiefs of Staff, United States Central Command, and the United States Special Operation Command for the Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program, 1 November 2007. (Sets joint program management duties).

Secretary of Defense (Robert M. Gates), MRAP Acquisition, 2 May 2007.

_____. Memorandum for the Commander, U.S. Central Command: Request to Change the Name of OPERATION IRAQ FREEDOM to OPERATION NEW DAWN, 17 February 2010.

_____. Memorandum for Under Secretary of Defense for Acquisition, Technology, and Logistics; Commander, U.S. Special Operations Command; Assistant Secretary of the Army (Acquisition, Logistics and Technology); Assistant Secretary of the Navy (Research, Development and Acquisition); Assistant Secretary of the Air Force (Acquisition); Director, IED Defeat Organization; Director, Joint Staff: Approval of DX Industrial Priority Rating for the MRAP Vehicle Program, 1 June 2007.

_____. Memorandum for the Commander, U.S. Central Command: Request to Change the Name of OPERATION IRAQ FREEDOM to OPERATION NEW DAWN, 17 February 2010.

_____. Memorandum for Under Secretary of Defense for Acquisition, Technology, and Logistics; Commander, U.S. Special Operations Command; Assistant Secretary of the Army (Acquisition, Logistics and Technology); Assistant Secretary of the Navy (Research, Development and Acquisition); Assistant Secretary of the Air Force (Acquisition); Director, IED Defeat Organization; Director, Joint Staff: Approval of DX Industrial Priority Rating for the MRAP Vehicle Program, 1 June 2007.

U.S. Army Test and Evaluation Command. Support of the Mine-Resistant Ambush-Protected (MRAP) Vehicle Joint Developmental Test (JDT) at U.S. Army Aberdeen Test Center (ATC), 6 February 2007.

Under Secretary of Defense. Memorandum for Assistant Secretary of the Navy (Research, Development, and Acquisition): Mine-Resistant Ambush-Protected (MRAP) Program Direction on Revising Requirements and Acquisition Documentation, 21 April 2009.

II. Documents

ACAT II and ID Designation

Assistant Secretary of the Navy (Research, Development, and Acquisition). Memorandum for the Undersecretary of Defense (Acquisition, Technology, & Logistics): Designation of MRAP as an ACAT II Program, 31 January 2007.

Under Secretary of Defense. Memorandum for Secretary of the Army; Secretary of the Navy; Secretary of the Air Force; Vice Chairman of the Joint Chiefs of Staff; Commander, U.S. Special Operations Command; Deputy Under Secretary of Defense (Acquisition & Technology); Director, Acquisition Resources and Technology: Mine-Resistant Ambush-Protected Vehicle Acquisition, 8 February 2007.

Under Secretary of Defense, Acquisition, Technology and Logistics. Memorandum for Secretaries of the Military Departments; Chairman of the Joint Chiefs of Staff; Commander, U.S. Special Operations Command: Designation of the , Mine-Resistant Ambush-Protected (MRAP) Vehicle as a Joint Acquisition Category ID Major Defense Acquisition Program (MDAP), 6 September 2007.

Acquisition Strategy/Acquisition Plans (AS/AP)

Joint Program Office, Joint Mine-Resistant, Ambush-Protected Vehicles. Acquisition Strategy/Acquisition Plan (AS/AP), 14 April 2008.

Joint Program Office, Joint Mine-Resistant, Ambush-Protected Vehicles. Acquisition Strategy/Acquisition Plan (AS/AP), Final Revision 1, 19 March 2010.

Capability Production Document (CPD) Memoranda

The Joint Staff, Joint Requirements Oversight Council. Memorandum for Commander, U.S. Central Command; Vice Chief of Staff, U.S. Army; Vice Chief of Naval Operations; Vice Chief, U.S. Air Force; Assistant Commandant of the Marine Corps; Director for Force Structure, Resources, and Assessment, Joint Staff: JROCM 109-07, 10 May 2007.

_____. Capability Production Document for Mine-Resistant Ambush-Protected (MRAP) Family of Vehicles (FoV) (Includes MRAP All Terrain Vehicle (M-ATV)), Version 1.1, 7 July 2009.

_____. Capability Production Document for Mine-Resistant Ambush-Protected (MRAP) Family of Vehicles (FoV) (Includes MRAP All Terrain Vehicle (M-ATV)), Version 1.1, Appendix A (Unclassified), Integrated Architectures and Net Ready KPP, 7 July 2009.

Test and Evaluation Master Plans (TEMPs)

Product Group Director Ground Transportation and Engineer Systems, Product Group 15, Marine Corps Systems Command and Program Manager for Mine-Resistant Ambush-Protected Vehicles Program Executive Office, Ground Combat Systems. *Test and Evaluation Master Plan (TEMP) for the Mine-Resistant Ambush-Protected System (MRAPs)*, 26 September 2007.

Joint Program Office, Joint Mine-Resistant, Ambush-Protected Vehicles. *Test and Evaluation Master Plan (TEMP) for the Mine-Resistant Ambush-Protected Vehicle Program*, 21 January 2009.

_____. *Test and Evaluation Master Plan (TEMP) for the Mine-Resistant Ambush-Protected Vehicle Program*, 4 December 2009.

_____. *Test and Evaluation Master Plan (TEMP) for the Mine-Resistant Ambush-Protected Vehicle Program*, 15 February 2011.

III. Other Program Documents

Army Capabilities Integration Center. Final Report, Army Capabilities Integration Center: Mine-Resistant Ambush-Protected Study II (Revalidation of Decision Point 147), 22 June 2011.

BAE Land Systems OMC RG31 Mine Protected Vehicles Overview Brief, Undated

Defense Logistics Agency Land and Maritime, Mine-Resistant Ambush-Protected (MRAP) Playbook, undated (est. late 2012)

General Dynamics Land Systems – Canada RG31 Production Information, Undated

Joint Program Office, Joint Mine-Resistant, Ambush-Protected Vehicles. JPO MRAP OCONUS Operational Campaign Plan, 30 May 2012.

_____. JPO MRAP OEF Campaign Plan, 3 June 2011.

_____. JPO MRAP OEF Campaign Plan Revision A: MRAP-All Terrain Vehicle Underbody Improvement Kit (UIK) Installation Plan, Final, 30 March 2011.

_____. JPO MRAP OEF Campaign Plan Revision B: MaxxPro Wrecker, 25 March 2011 (Updated 25 May 2011).

_____. JPO MRAP OEF Campaign Plan Revision C: MARCENT FMC+ Planning Directive, 2 April 2011.

_____. JPO MRAP OEF Campaign Plan Revision D: Procurement Funding Request ISO Regional Command-Southwest (RC-SW) Expansion On Operation Enduring Freedom, 2 December 2010.

_____. JPO MRAP OEF Campaign Plan Revision J: JPO MRAP Planning Directive – Cougar CAT II A2 Ambulance Upgrade, 18 November 2010.

_____. JPO MRAP OEF Campaign Plan Revision K: JPO MRAP Planning Directive – Transfer of CAT 1 Cougars From Army to USMC, 24 January 2011.

_____. JPO MRAP Vehicles Program Capabilities Insertion Brief, March 2009.

- _____. JPO MRAP Vehicles Program Government Furnished Equipment Brief, August, 2007.
- _____. JPO MRAP Vehicles Program International Programs Brief, 30 August 2007.
- _____. JPO MRAP Vehicles Program JMVP Review: Joint Allocation and Distribution Board (JADB) Allocation and Transportation Processes, 20 March 2007.
- _____. JPO MRAP Vehicles Program MRAP Pedigree Charts, March 2011.
- _____. JPO MRAP Vehicles Program Program Management Review, 25 October 2012.
- _____. JPO MRAP Vehicles Program Program Overview: Transition Thoughts, 14 March 2008.
- _____. JPO MRAP Vehicles Program Program Overview: Transition Thoughts, December 2010.
- _____. JPO MRAP Vehicles Program Program Review, 30 August 2007.
- _____. JPO MRAP Vehicles Program Program Review, December 2008.
- _____. JPO MRAP Vehicles Program Smartbook, August 2009.
- _____. JPO MRAP Vehicles Program Smartbook, 15 September 2010.
- _____. JPO MRAP Vehicles Program Smartbook, 28 March 2011.
- _____. JPO MRAP Vehicles Program Smartbook, 29 March 2012.
- _____. JPO MRAP Vehicles Program Transition Support Plan, October 2011.
- _____. JPO MRAP Strategic Campaign Plan (JMSCP 12-01): "No Matter What," 10 April 2012.
- _____. JPO MRAP Strategic Campaign Plan Update, 30 April 2012.
- _____. JPO MRAP Strategic Execution Conference Briefing, 25 April 2013.
- _____. MRAP Document Data Sheet: JPO Summary of GAO Light Tactical Vehicle Study, 12 August 2010.
- _____. MRAP Performance Baseline (MPB): Frequently Asked Questions (FAQs), 27 June 2012.
- _____. MRAP Program Acceleration Lessons Learned: Request for Information (RFI) from Marine Corps Systems Command Program Executive Office Land Systems (LS), 2009.
- _____. MRAP Program Acceleration Lessons Learned: MRAP Lessons Learned that Parallel New 5000 direction, undated.
- _____. MRAP Requirements Flow Chart, 8 March 2007.
- _____. MRAP Vehicle Program History and Lessons Learned, 2 June 2008.
- _____. Configuration Management Plan (CMP), Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Program (JMVP), 9 September 2010.
- _____. Joint Mine-Resistant Ambush-Protected (MRAP) Vehicle Performance Specification, 13 December 2006.
- _____. Joint Mine-Resistant, Ambush-Protected Vehicles Program: Transition Implementation Plan, October 2011.
- _____. Performance Specification for Mine-Resistant Ambush-Protected All Terrain Vehicle (M-ATV), Version 4.0, 8 December 2008.
- _____. Senator Biden Letter of 23 May 2007 Questions and Answers, 23 May 2007.
- _____. Strategic Plan 2008-2010, 31 December 2008.

_____. Strategic Plan 2011-2013.

_____. Transition Execution, Operations Base Plan, 21 July 2012.

Marine Corps Capabilities Development Directorate, Department of Combat Integration and Development. Urgent Universal Need Statement (Urgent UNS): MROC Decision Brief, 24 June 2011.

Marine Corps Combat Development Command, Logistics Integration Division. MROC Approval of Mine-Resistant Ambush-Protected (MRAP) Vehicle Enduring Requirement (briefing), 1 July 2009.

Marine Corps Systems Command. 2011 Command Chronology: Joint MRAP Vehicle Program, 22 March 2012.

Marine Corps Systems Command. Submission for Security Classification Guide (SCG) for Joint Mine-Resistant Ambush-Protected (MRAP) Program Family of Vehicles (JMVP FOV), 1 November 2010.

Office of the Secretary of Defense (Edie Williams), Information Paper – History of the Mine-Resistant Ambush-Protected Vehicle Program, 18 March 2008

Office of the Secretary of Defense, MRAP Task Force Brief – MRAP Vehicle Program Overview, 26 June 2007

U.S. Army Tank Automotive Research, Development and Engineering Center. Ground Vehicle Integration Center Update: MRAP Capabilities Insertion, 2-13 November 2009.

U.S. Marine Corps, Information Paper, 30 November 2007

IV. Stakeholder Reports

Feickert, Andrew. *Mine-Resistant, Ambush-Protected (MRAP) Vehicles: Background and Issues for Congress*. Congressional Research Service, August 2007.

_____. *Mine-Resistant, Ambush-Protected (MRAP) Vehicles: Background and Issues for Congress*. Congressional Research Service, 24 January 2008.

_____. *Mine-Resistant, Ambush-Protected (MRAP) Vehicles: Background and Issues for Congress*. Congressional Research Service, 29 March 2011.

General Accountability Office. *Global War on Terrorism: Reported Obligations for the Department of Defense* (GAO-08-853R), 13 June 2008.

_____. *Rapid Acquisition of Mine-Resistant Ambush-Protected Vehicles* (GAO-08-884R), 15 July 2008.

_____. *Rapid Acquisition of Mine-Resistant Ambush-Protected Vehicles* (GAO-08-884R), 15 July 2008.

_____. *Defense Acquisitions: Assessment of Selected Weapon Programs* (GAO-09-326SP), 30 March 2009.

_____. *Defense Acquisitions: Department of Defense Needs a Unified Strategy for Balancing Investments in Tactical Wheeled Vehicles* (GAO-09-968R), 28 September 2009.

_____. *Defense Acquisitions: Rapid Acquisition of MRAP Vehicles*. Statement of Michael J. Sullivan, Director Acquisition and Sourcing Management (GAO-10-155T), 8 October 2009.

Inspector General, U.S. Department of Defense. *Procurement Policy for Armored Vehicles* (Report no. D-2007-107), 27 June 2007.

_____. *Marine Corps Implementation of the Urgent Universal Needs Process for Mine-Resistant Ambush-Protected Vehicles* (Report no. D-2009-030), 8 December 2008.

_____. *Government Oversight of Field Service Representative and Instructor Services in Support of the Mine-Resistant Ambush-Protected Vehicle Program* (Report no. D-2010-068), 17 June 2010.

_____. *Competition Should Be Used for Instructor Services for the Mine-Resistant Ambush-Protected Vehicles* (Report no. D-2011-036), 3 February 2011.

_____. *Contract Management of Joint Logistics Integrator Services in Support of Mine-Resistant Ambush-Protected Vehicles Needs Improvement* (Report no. D-2011-081), 11 July 2011.

Office of the Undersecretary of Defense. *Report of the Defense Science Board Task Force on the Fulfillment of Urgent Operational Needs*, July 2009.

Testimony

BAE Systems. Statement of Linda P. Hudson, President Land & Armaments, Before the House Armed Services Committee, Seapower and Expeditionary Forces Subcommittee, Air and Land Forces Subcommittee, 8 November 2007.

Commander, Marine Corps Systems Command. Statement of Brigadier General Michael M. Brogan Before the Subcommittees on Seapower and Expeditionary Forces and Air and Land Forces of the House Armed Services Committee on Marine Corps Force Protection Efforts, 17 March 2010.

Commander, U.S. Central Command. Statement of General David H. Petraeus, U.S. Army, Before the Senate Armed Services Committee on the Afghanistan-Pakistan Strategic Review and the Posture of U.S. Central Command, 1 April 2009.

Director, Defense Research and Engineering. Statement of the Honorable John J. Young, Jr., Before the Subcommittees on Seapower and Expeditionary Forces and Air and Land Forces of the House Armed Service Committee, 19 July 2007.

U.S. House of Representatives. Joint Hearing Before the Seapower and Expeditionary Forces Subcommittee Meeting Jointly with Air and Land Forces Subcommittee of the Committee on Armed Services, House of Representatives, 110th Congress, 1st Session, 8 November 2007. Government Printing Office, 2008.

U.S. House of Representatives. Joint Hearing of the Seapower and Expeditionary Forces Subcommittee Meeting Jointly with Air and Land Forces Subcommittee of the Committee on Armed Services: Army and Marine Corps Force Protection Programs, 4 February 2009.

V. Secondary Sources

Axe, David, "Oshkosh M-ATV Military Vehicle in Afghanistan – Battle Ready," *Automobile*, July 2010.

Blakeman, Seth T., Anthony R. Gibbs, and Jeyanthan Jeyasingam. *Study of the Mine-Resistant Ambush-Protected (MRAP) Vehicle Program as a Model for Rapid Defense Acquisitions*. Thesis, Naval Postgraduate School, December 2008.

Chia, Tommy. *A Model to Estimate the Operating & Maintenance (O&M) Costs of the Mine-Resistant Ambush-Protected (MRAP) Vehicles*. Thesis, Naval Postgraduate School, December 2010.

Connors, Shaun C. and Foss, Christopher F. *Jane's Military Vehicles and Logistics 2008-2009*, Jane's Information Group, 2006

Eshel, Tanir, "After Winning Britain, Navistar's MXT Competes for M-ATV," *Defense Update*, 11 March 2009.

Foss, Christopher F. *Jane's Armour and Artillery 2005-2006*, Jane's Information Group, 2005

Foss, Christopher F. *Jane's Armour and Artillery 2010-2011*, Jane's Information Group, 2010

Gayle, Franz J. *Mine-Resistant Ambush-Protected Vehicle: Ground Combat Element (GCE) Advocate Science and Technology (S&T) Advisor Case Study*, 22 January 2008.

Gordon, Rebekah. "Brogan: M-ATV Program to Benefit from MRAP Pricing Lessons," *InsideDefense.com*, 5 February 2009.

Hedelt, Carden. "MRAP Joint Program Office Takes Home Inaugural Vehicle Award," *Defense AT&L*, May-June 2012, pp.1-2.

Holley, I.B., *Buying Aircraft: Materiel Procurement for the Army Air Forces*, Office of the Chief of Military History, Department of the Army, 1964

- Howitz, Michael C. *The Mine-Resistant Ambush-Protected Vehicle: A Case Study*. Research paper, U.S. Army War College, 15 December 2008.
- Lamb, Christopher J., Matthew J. Schmidt, and Berit G. Fitzsimmons. "MRAPs, Irregular Warfare, and Pentagon Reform," *Joint Force Quarterly*, Issue 55, Fourth Quarter 2009, pp. 76-85.
- Lamb, Christopher J. and Sally Scudder. "Why the MRAP Is Worth the Money: Dispelling the Flawed Logic of One Battlefield Study," *Foreign Affairs*, 23 August 2012,
- McGriff, Roy, Major, USMC, Mine-Resistant Armor Protected Vehicles, Research Paper, School of Advanced Warfighting, Quantico, VA 2003
- Miller, Thomas H. "Does MRAP Provide a Model for Acquisition Reform?" *Defense AT&L*, July-August 2010, pp. 16-20.
- Peterson Kevin B. *Acquisition Reform: Does MRAP Provide a Model?* Research paper, U.S. Army War College, 21 March 2011.
- Rohlf, Chris, "The Government's Valuation of Military Life-Saving in War: A Cost Minimization Approach" Working Paper, Naval Postgraduate School, 2006.
- Rohlf, Chris and Sullivan, Ryan, "The Cost Effectiveness of Armored Tactical Vehicles for Overseas U.S. Military Operations," Working Paper, Naval Postgraduate School, 2011.
- Rohlf, Chris and Sullivan, Ryan, "The MRAP Boondoggle," *Foreign Affairs*, 26 July 2012.
- Schachtman, Noah, "The Secret History of Iraq's Invisible War," *Wired*, 14 June 2011.
- Sheehan, Neil, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon*, Random House, 2009.
- Sinclair, Wayne, Lieutenant Colonel, USMC, "Answering the Landmine," *Marine Corps Gazette*, July, 1996.
- Tadjeh, Yasmin "Middle East MRAP Sales Give Hope to Truck Manufacturers." *National Defense*, October 2012.
- Uncredited, "Defense Spending: Squeezing the Pentagon," *The Economist*, 6 Jul 2.
- Whitlock, Craig, "U.S. Forced to Take Costly Route to Move Gear out of Afghanistan," *The Washington Post*, 13 September 2013, p. A7.

ABS	Anti-lock Braking System (ABS)	CCC	Canadian Commercial Corporation
ACAT	Acquisition Category	CE	Combat Engineer(ing)
ACMC	Assistant Commandant of the Marine Corps	CEC	Cooperative Engagement Capability (Navy)
ADM	Acquisition Decision Memorandum	CECOM	Communications Electronics Command (US Army)
AFB	Air Force Base	CENTCOM	U.S. Central Command
AFES	Automatic Fire Extinguishing System	CI	Capability Insertion
AFSS	Automatic Fire Suppression System	CIU	Communications Interface Unit
ALF	American LaFrance	CLS	Contractor Logistics Support
AMC	Air Mobility Command (USAF)	CMC	Commandant of the Marine Corps
AMC	Army Material Command	CMP	Configuration Management Plan
AMCB	Army Marine Corps Board	COA	Course of Action
AMCS	Area Mine Clearing System	COCOM	Combatant Commander
AMS	Assured Mobility Systems	COIN	Counter-Insurgency
AOA	Analysis of Alternatives	CONOPS	Concept of Operations
AP	Armor Piercing	CONUS	Continental United States
APB	Acquisition Program Baseline	COTS	Commercial-Off-The-Shelf
APG	Aberdeen Proving Ground, MD]	CPD	Capabilities Production Document
APM	Assistant Program Manager	CREW	Counter-Radio Controlled IED Electronic Warfare
APU	Auxiliary Power Unit	CROWS	Crew Remote Optical Weapon System
ARCENT	Army Central Command	CRSP	Coalition Readiness Support Program
ARL	Army Research Laboratory	CSI	Critical Solutions Inc.
ARV	Armored Recovery Vehicle	CSIR	Council for Scientific and Industrial Research (South Africa)
AS/AP	Acquisition Strategy/Acquisition Plan	CSTC-A	Combined Security Transition Command - Afghanistan
ASA (ALT)	Assistant Secretary of the Army Acquisition, Logistics, and Technology	CTIS	Central Tire Inflation System
ASD (L&MR)	Assistant Secretary of Defense Logistics and Material Readiness	CTV	Combat Tactical Vehicle
ASL	Authorized Stocking List	CVRJ	CREW Vehicle Receiver Jammer
ASN (RDA)	Assistant Secretary of the Navy (Research, Development, and Acquisition)	CWIED	Command Wire IED
ASV	Armored Security Vehicle	DC P&R	Deputy Commandant for Programs and Resources (USMC)
ATC	Aberdeen Test Center	DC PPO	Deputy Commandant for Plans, Policy, and Operations
ATR	Above Threshold Reprogramming	DCMA	Defense Contract Management Agency
AUV	Armored Utility Vehicle	DCS	Direct commercial sales
BAE SC	BAE Santa Clara	DCSC	Defense Supply Center Columbus
BAE TVS	BAE Tactical Vehicle Systems	DDR&E	Deputy Director Research and Engineering
BDAR	Battle Damage and Repair	DEPSECDEF	Deputy Secretary of Defense
BFM	Budget and Finance Manager	DHS	Department of Homeland Security
BFT	Blue Force Tracker	DJPM	Deputy Joint Program Manager
C2	Command and Control	DLA	Defense Logistics Agency
C4I	Command, Control, Communications, Computers and Intelligence	DLIS	Defense Logistics Information Service
CASCOM	Combined Arms Support Command (Army)	DOD	Department of Defense
CASEVAC	Casualty Evacuation	DODIG	Department of Defense Inspector General
CAT	Category	DON	Department of Navy

DOT&E	Director, Operational Test and Evaluation	GFE	Government-Furnished Equipment
DPAS	Defense Priorities and Allocation System	GLOC	Ground Line of Communication
DSCA	Defense Security Cooperation Agency	GPS	Global Positioning System
DSMC	Defense Systems Management College	GSD	Ground Systems Division (BAE)
DT	Developmental Test	GSTAMIDS	Ground Standoff Minefield Detection System
DVA	Dual Vehicle Adapter/Amplifier	GTES	Ground Transportation and Engineer Systems (USMC)
DVE	Driver Vision Enhancement	GVW	Gross Vehicle Weight
EA	Executive Agent	GWOT	Global War on Terror
ECP	Engineering Change Proposal	HAGA	Heavy Armored Ground Ambulance
ECV	Enhanced Capacity Vehicle	HArd	Humvee Armored Demountable kits
EDA	Excess Defense Article	HEV	Hardened Engineer Vehicles
EFP	Explosive-Formed Penetrator	HMMWV	High-Mobility Multi-Purpose Wheeled Vehicle, "Humvee"
EFV	Expeditionary Fighting Vehicle	HST	Home Station Training
EM	Enhanced Mobility	HTSV	Heavy Tactical Support Vehicle (UK)
EMC	Electro-Magnetic Compatibility	HTVR	Heavy Tactical Vehicle Replacement
EMD	Engineering and Manufacturing Development	HVAC	Heating, Ventilating, and Air Conditioning
EMI	Electro-Magnetic Interference	IA	Interrogation Arm
EOD	Explosive Ordnance Disposal	IBPM	Internal Ballistics Protection Module
EPLRS	Enhanced Position Location Reporting System	ID/IQ	Indefinite Delivery/Indefinite Quantity contract
ESC	Electronic Stability Control	IED	Improvised Explosive Device
EUCOM	European Command	IEDN	IED Network
FBCB2	Force XXI Battle Command, Brigade and Below (USA)	IG	Inspector General
FCS	Future Combat System	ILAV	Iraqi Light Armored Vehicle
FDL	Force Dynamics Limited	IMG	International Military and Government (Navistar)
FLIR	Forward-Looking Infrared	IP	International Programs
FLMNET	Field Level Maintenance New Equipment Training	IPO	International Programs Office
FMC	Full Mission Capability	IPT	Integrated Product Team
FMS	Foreign Military Sales	IR	Infrared
FMTV	Family of Medium Tactical Vehicles	ISR	Intelligence, Surveillance and Reconnaissance
FOB	Forward Operating Base	ISS	Independent Suspension System
FOC	Full Operational Capability	ITAS	Improved Target Acquisition System (TOW)
FOV	Family of Vehicles	IVMMD	Integral Vehicle Mine Mounted Detector/Detection (South Africa)
FPI	Force Protection Industries Inc.	IWN	Immediate Warfighter Need
FRP	Full Rate Production	JADB	Joint Allocation and Distribution Board
FRPDR	Full Rate Production Decision Review	JCS	Joint Chiefs of Staff
FSR	Field Service Representative	JDT	Joint Developmental Test
FTTS	Future Tactical Truck System	JERRV	Joint EOD Rapid Response Vehicle
FY	Fiscal Year	JIEDDO	Joint Improvised Explosive Device Defeat Organization
FYDP	Five Year Defense Plan	JLI	Joint Logistics Integrator
GAO	Government Accountability Office	JLTV	Joint Light Tactical Vehicle
GCE	Ground Combat Element	JMSCP	JPO MRAP Strategic Campaign Plan
GDLS	General Dynamics Land Systems		
GDLS-C	General Dynamics Land Systems-Canada		

JMVP	Joint MRAP Vehicle Program	MEB	Marine Expeditionary Brigade
JOPEs	Joint Operational Planning and Execution System	MEDEVAC	Medical Evacuation
JPEO	Joint Program Executive Office/Officer	MEF (FWD)	Marine Expeditionary Force (Forward)
JPM	Joint Program Manager	MEF	Marine Expeditionary Force
JPO	Joint Program Office	MEU	Marine Expeditionary Unit
JRAC	Joint Rapid Acquisition Cell	MMPV	Medium Mine-Protected Vehicle
JROC	Joint Requirements Oversight Council	MOA	Memorandum of Agreement
JROCM	Joint Requirements Oversight Council Memorandum	MPB	MRAP Performance Baseline
JSC	Joint Solutions Center	MRAP U	MRAP University
JTAPIC	Joint Trauma Analysis and Prevention of Injuries in Combat	MRAP	Mine Resistant Ambush Protected
JTF	Joint Task Force	MRAT	MRAP Rate Absorption Team
JTRS	Joint Tactical Radio System	MROC	Marine Requirements Oversight Council
JUONS	Joint Urgent Operational Need Statement	MRV	MRAP Recovery Vehicle
KPP	Key Performance Parameter	MSC	Military Sealift Command (Navy)
LAR	Logistics Assistance Representative	MSF	MRAP Sustainment Facility
LATV	Light Armored Tactical Vehicle	MST-A	MRAP Support Team – Afghanistan
LAV	Light Armored Vehicle	MSU	MaxxPro Survivability Upgrade
LCS	Littoral Combat Ship	MTVR	Medium Tactical Vehicle Replacement
LED	Light-Emitting Diode	NATO	North Atlantic Treaty Organization
LFT&E	Live Fire Test and Evaluation	NAVFAC	Naval Facilities Engineering Command
LOA	Letter of Authorization	NCO	Non-commissioned officer
LOR	Letter of Request	NDAA	National Defense Authorization Act
LRAS3	Long-Range Scout Surveillance System	NEPO	Navy Expeditionary Programs Office
LRIP	Low Rate Initial Production Decision	NET	New Equipment Training
LTAS	Long Term Army Study	NGIC	National Ground Intelligence Center
LUE	Limited User Evaluation	NSN	National Stock Number
LVSR	Logistics Vehicle Support Replacement truck	NSW	Naval Special Warfare
MAK	Marine Armor Kit	NVG	Night Vision Goggles
MARCENT	Marine Forces Central Command	O&M	Operating and Maintenance
MARFORPAC	Marine Corps Forces Pacific	OCO	Overseas Contingency Operations
MASS	MTVR Armor Supplement System	OCONUS	Outside Continental United States
M-ATV	MRAP All-Terrain Vehicle	OEF	Operation Enduring Freedom (Afghanistan)
MCCDC	Marine Corps Combat Development Command	OEM	Original Equipment Manufacturer
MCLB	Marine Corps Logistics Base	OGPK	Objective Gunner Protective Kit
MCLC	Marine Corps Logistics Center	OIF	Operation Iraqi Freedom
MCOTEA	Marine Corps Operational Test and Evaluation Activity	OLI	Overload Interrupt
MCSC	Marine Corps Systems Command	OMC	Olifant Motor Company
MCTAGS	Marine Corps Transparent Armored Gun Shield	ONS	Operational Need Statement
MDA	Milestone Decision Authority	OPNET	Operator New Equipment Training
MDAP	Major Defense Acquisition Program	OSD	Office of the Secretary of Defense
MDV	Mine Detection Vehicle	OT	Operational Test
MEAP	MRAP Expedient Armor Protection	OT&E	Operational Test & Evaluation
		OTC	Oshkosh Truck Company

OUSD (ATL)	Office of the Undersecretary of Defense for Acquisition, Technology and Logistics	SECDEF	Secretary of Defense
OWM	Overhead Wire Mitigation	SECNAV	Secretary of the Navy
PAIR	Priority Allocation of Resources	SES	Senior Executive Service
PdM	Product Manager	SINCGARS	Single Channel Ground and Airborne Radio System
PEO CS&CSS	Program Executive Office Combat Support and Combat Service Support	SM-3	Standard Missile 3
PEO	Program Executive Office (Officer)	SOCOM	U.S. Special Operations Command
PLL	Prescribed Load List	SON	Statement of Need
PM	Program Manager	SPARK	Self-Protection Adaptive Roller Kit
PMO	Project Management Office	SPAWAR	Space and Naval Warfare Systems Command (Navy)
PMR	Program Management Review	SSAC	Source Selection Acquisition Committee
POM	Program Objective Memorandum	SSEB	Source Selection Evaluation Board
POR	Program of Record	SVBIED	Suicide Vehicle Borne IED
PPBES	Planning, Programming, Execution and Budgeting System	TACOM	Tank Automotive and Armaments Command (Army)
PPBS	Planning, Programming and Budgeting System	TARDEC	Tank-Automotive Research, Development and Engineering Center (Army)
PPE	Personal Protective Equipment	TD	Technology Development
PPIIED	Pressure plate initiated IED	TEMP	Test and Evaluation Master Plan
PPV	Protected Patrol Vehicle	THHR	Tactical Handheld Radio
PRV	Production Ready Vehicle	TIWG	Test Integration Working Group
PVI	Protected Vehicles Inc.	TOCNET	Tactical Operations Center Intercommunications System
QRC	Quick Reaction Capability	TOW	Tube-launched Optically guided Weapon
R&D	Research and Development	TPE	Theater Provided Equipment
RADHAZ	Radiation Hazard	TRANSCOM	U.S. Transportation Command
RCIED	Radio controlled	TSG	Technical Solutions Group Inc.
RC-SW	Regional Command Southwest	TVS	Tactical Vehicle Systems
RDC	Rapid Deployment Capability	TWV	Tactical Wheeled Vehicle
RFI	Request for Information	UAH	Up-Armored High-Mobility Multi-Purpose Wheeled Vehicle, "Humvee"
RFP	Request for Proposal	UAV	Unmanned Aerial Vehicle
RHA	Rolled Homogenous Armor	UCA	Undefinitized Contraction Action
RPG	Rocket-Propelled Grenade	UIK	Underbody Improvement Kit
RRAD	Red River Army Depot	UONS	Urgent Operational Need Statement
RSA	Regional Support Activity	USA	United States Army; United States of America
RST-V	Reconnaissance, Surveillance and Targeting Vehicle	USAF	United States Air Force
RTR	Reduced Turning Radius	USD (AT&L)	Undersecretary of Defense (Acquisition, Technology, & Logistics)
RWS	Remote Weapon System	USMC	United States Marine Corps
S&T	Science and Technology	USN	United States Navy
SAF	Small-Arms Fire	UUNS	Urgent Universal Need Statement
SAIC	Science Applications International Corporation	VBIED	Vehicle Borne IED
SATCOM	Satellite Communications	VDDS	Video and Data Distribution System
SAW	School of Advanced Warfighting	WIAM	Warrior Injury Assessment Mannequin
SCG	Security Classification Guide	YPG	Yuma Proving Ground, AZ
SEBD	Supplemental Emergency Breathing Device		

Dr. Norman Friedman, PhD, Principal Investigator/Historian. Educated as a theoretical physicist, Dr. Friedman is concerned primarily with the interaction between technology and strategic, policy, program and tactical dynamics. Since 1973, he has conducted or participated in numerous studies for government and industry, including analyses of the future shape of the U.S. Marine Corps. In 2012, he completed extensive research to produce for the Aegis Ballistic Missile Defense Directorate, Missile Defense Agency, a history of U.S. Navy anti-air warfare/anti-ballistic missile technologies, systems, platforms and operations. In addition, he has published 39 books (plus five co-authored works), as well as numerous articles and chapters in books. His recent works include *Network-Centric Warfare: How Navies Learned to Fight Smarter in Three World Wars*; *Seapower as Strategy*; *Terrorism, Afghanistan, and America's New Way of War*; *Naval Firepower*; and two-volume histories of Royal Navy cruisers and destroyers. He also wrote five editions of the encyclopedic *Naval Institute Guide to World Naval Weapon Systems*. He holds a PhD in Theoretical Solid-State Physics, Columbia University (1974) and an MA and BA in Physics (1968 and 1967 respectively), Columbia.

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	May:	First MEAP kits fielded to provide increased protection from EFP attacks
	July:	JROC validates need for 15,838 vehicles JPO MRAP accepts 10,000th vehicle
	October:	JMVP receives David Packard Award for Excellence in Acquisition
	November:	JROC validates need for 16,238 vehicles
	December:	M-ATV RFP released
2009	January:	JPO MRAP accepts 15,000th vehicle
	February:	JPO MRAP fields 10,000 th vehicle in Iraq First ISS contract awarded, major modification improves mobility significantly
	July:	JROC validates need for 21,482 vehicles
	August:	JPO MRAP fields first Cougar with ISS in Afghanistan
	October:	MRAP Vehicle Program becomes largest U.S. defense program based on funding M-ATV SSEB receives David Packard Award for Excellence in Acquisition
	November:	JROC increases M-ATV requirement to 6,644 vehicles; total to date 22,882 vehicles
2010	January:	JROC validates need for 26,882 vehicles
	March:	JPO MRAP accepts 20,000 th vehicle
	September:	JPO MRAP fields 20,000 th vehicle
	December:	JROC validates need for 27,344 vehicles
2011	June:	JROC validates need for 27,744 vehicles--final MRAP vehicle requirement
	July:	Final production contract (LRIP 23) awarded to Navistar for 140 MRAP Recovery Vehicles M-ATV UIK upgrade commences in theater
	September:	JPO MRAP receives Joint Meritorious Unit Award
2012	January:	Original ID/IQ production contracts expired
	February:	JPO MRAP received the inaugural NDIA Red Ball Express Award
	October:	Last MRAP vehicle production line closed--27,740 MRAP vehicles produced and 23,560 fielded to U.S. warfighters Total of \$47.3 billion cumulative appropriations FY 2006-FY 2012 Services and SOCOM assume MRAP vehicle funding responsibility Total personnel reporting to the JMVP grows to more than 4,000 including JPO Forward JPEO MRAP transitioned from USMC to USA
	December:	SPAWAR Charleston completes final MRAP vehicle integration M-ATV fielding complete
2013	January:	MaxxPro MSU in-theater upgrade commences
	June:	All Services and SOCOM report ready to receive MRAP vehicle responsibilities from JPO MaxxPro MSU in-theater upgrade complete on 1,100 vehicles M-ATV UIK upgrade in theater complete on last vehicle variant
	July:	MSF in Kuwait completes final vehicle upgrade
	September:	MSF Kuwait closes MRAP vehicle responsibility transitions to the Services and SOCOM JPO MRAP stands down

IEDs are the tactic of choice for our enemies. They are cheap, and deadly, and difficult to detect on the dusty streets of Baghdad, Samarra, Mosul, and elsewhere. They have been the biggest killer of our troops in Iraq...

There is no failsafe measure that can prevent all loss of life and limb on this or any other battlefield. That is the brutal reality of war. But vehicles like MRAP, combined with the right tactics, techniques, and procedures, provide the best protection available against these attacks...

IEDs will be with us for some time to come—in Iraq, Afghanistan, the battlefields of the future. The need for these vehicles will not soon go away...

To put it in the words of one Sergeant Major... “Troops love them, commanders sleep better knowing the troops have them.”

Robert M. Gates, Secretary of Defense, 8 January 2008



JOINT PROGRAM OFFICE MINE-RESISTANT AMBUSH-PROTECTED VEHICLES

Department of Defense, Washington, DC

December 2013

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