This workshop laid the foundation to form a network of system of systems engineering education for the US Military and its future workforce via an exchange of ideas and brainstorming among scientists, engineers, professors, military personnel from all branches of the US Armed Forces as well as industry and other institutions. Several keynote speakers set the stage for the workshop. Presenters walked participants through their individual academic programs, both at military institutions and civilian institutions of higher learning. A proposal was made to formally establish this activity. Break-out sessions were split into government and civilian sessions and out-briefings held. These sessions contained the bulk of the intellectual output of the conference and will form the basis for future directions. A high-level overview of the content and results of the workshop are contained in these minutes.
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Overview

Over 40 professionals, representing the DoD, Academia, and Industry, attended a 1½ day workshop to lay the foundation to form a network of systems engineering education for the US Military and its future workforce. The workshop is a result of a tele-conference which took place on February 26, 2010 in which scientists, officers and leaders from US Air Force Research Laboratory (AFRL), Air Force Institute of Technology (AFIT), Air Force Academy (AFA), Naval Postgraduate School (NPS), US Military Academy (West Point), US Air Force Center for Systems Engineering, Colorado Tech (Colorado Springs), and the University of Texas, San Antonio (UTSA) determined a need and opportunity existed for the coordinated efforts among interested parties to increase the level of excellence in engineering education with a focus on system of systems.

Sessions included coverage of:
- Current SE Programs of military graduate schools, such as AFIT, NPS, DAU, etc.
- Current SE Programs at USAFA and USMA.
- Current SE Programs at GMU, MIT, ODU, Purdue, Stevens, UTSA and other institutions

Panel sessions included:
- Industry’s view point of the future of Systems Engineering Education
- DoD’s view point of the future of Systems Engineering Education

The workshop ended with a Proposed Armed Forces SE Education Network (US-AF_Net) discussion and plans for the future, including a specialized track at an upcoming Systems of Systems Engineering Conference.

Copies of individual presentations, where possible, are posted on the workshop webpage as well as the DAU Acquisition Community Connection.

Dr. Dave Wisler¹, NAE: “Rethinking Engineering Education”

Dr. Wisler began the workshop with an engaging discussion and presentation about Engineering Education and applying a new approach in this area. He believes educational institutions should rethink engineering education away from a passive and single discipline focus due to the nature of complex systems and technologies of the modern era.

He pointed out that technologies today are built by teams and industry has provided substantial feedback that graduates not only don’t know much about system of systems, but they are unprepared to “engineer” as an employee of a large company. They have to be re-taught. From his own personal

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¹ Dr. Dave Wisler recently retired from a career at GE Aviation (GEA), formerly GE Aircraft Engines, spanning 38-years. During this tenure, he held positions of increasing responsibility for conducting and managing advanced technology programs. He built and managed GEA’s Aerodynamics Research Laboratory. Dr. Wisler is a Sr. Vice President and Fellow of the American Society of Mechanical Engineers (ASME) and the Editor of the ASME Journal of Turbomachinery. He is Past Chair of the Board of Directors of the International Gas Turbine Institute of the ASME and an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA). Dr. Wisler was elected to the US National Academy of Engineering (NAE) in 2004.
experience, he related how, during the course of his professional career, he taught newly hired graduates how to do engineering.

One aspect of his presentation was about using concepts in teaching. He suggested it proves to be a more effective means or method because this is the same way the brain stores information. A significant difference between experts and novices in any field is the ability to see meaningful patterns of information.

To underscore this insight, he introduced the formal CDIO (Conceive Design Implement Operate) Methodology as a method to facilitate active learning. There is an existing CDIO community that seeks to extend this into various university settings. Currently, the organization has over 50 universities that have joined. The concepts have also been published in a book entitled “Rethinking Engineering Education.” He noted that both the USAFA and the USMA are members of CDIO.

Dr. Wisler’s talk set the stage for the workshop by tapping into the shared concern about the future of engineering, particularly systems engineering. One participant wrote “Dr. Wisler's presentation on teaching today's students using experiential/action learning approaches” as one of the most beneficial aspects of the workshop.

Donald Gelosh², Ph.D., OSD: “Preparing Our Engineering Leaders: Workforce Development Initiatives”

Dr. Gelosh was the second keynote speaker and provided the DoD view on the current state of engineering within the DoD. His presentation explored how to focus on people in his theme of “Policy, People, and Practice.” In order to prime the workforce, Dr. Gelosh outlined three goals: grow the current systems engineering workforce; improve systems engineering capabilities in the defense industrial base; and make efforts to grow the future systems engineering workforce. To grow a future workforce, multidisciplinary integrated capstone courses should be developed in undergraduate programs to improve systems engineering undergraduate curriculum.

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² Dr. Don Gelosh is the Deputy Director for Workforce Development in the OSD Directorate of Systems Engineering. He provides expertise in workforce development, competency models and assessments, and knowledge management with over 34 years of systems engineering experience from the US Air Force, government, industry, and academia. While serving in the Air Force, Dr. Gelosh worked as a systems engineer on the Space Shuttle as a member of NASA’s Vehicle Integration and Test Team where he was responsible for communications and payload integration and ensuring the Shuttle was ready for launch. Dr. Gelosh also taught electrical and computer engineering at the Air Force Academy in the early 90’s and later served as Deputy Department Head for Electrical and Computer Engineering at the Air Force Institute of Technology. Don received his PhD in Electrical Engineering from the University of Pittsburgh in 1994, a MS in Computer System Design from the University of Houston at Clear Lake in 1989, and a BS in Electrical Engineering from the Ohio State University in 1981. He also holds an INCOSE CSEP-Acquisition certification and is DAWIA Level III certified in SPRDE – Systems Engineering.
At a recent undergraduate systems engineering workshop, Dr. Gelosh noted four challenges facing the development and enhancement of undergraduate systems engineering degrees. First, programs must meet future customer needs while staying within curriculum constraints. Second, undergraduate programs must sustain technical and societal relevance. Third, programs must integrate real world problem solving skills. Finally, systems engineers' identity must be developed while establishing a systems engineering community.

Dr. Gelosh called for the systems engineering community to evaluate four future steps. First, identify key multidisciplinary competencies needed by key leaders. Second, propose a career development model from intern to executive demonstrating proper mix of competencies and proficiency. Third, evaluate current standards versus the model. Finally, develop learning and career management assets needed to support recommended changes.

Some of the questions he fielded from the workshop participants touched on some of the unique challenges and concerns that often exist around systems engineering. For instance, he was asked about the AFRL Commander’s Challenge – a step outside of the normal work environment where junior personnel are allowed to tackle pressing challenges away from the typical bureaucracy and constraints that exist. Another discussion was about the art versus science of systems engineering. While the question if SE should only be a postgraduate program was not answered, may opinions were given. Another interesting exchange occurred during the discussion about SE accreditation and some of the pressures, intentional or not, that exist and how that tied into this workshop’s objectives.

**Dr. Steve Rogers**, AFRL: “QUEST - Qualia Exploitation of Sensor Technology”

Dr. Rogers was the third keynote speaker representing a view from the research laboratory community. He chose to frame his discussion for the workshop by presenting a partial solution to modeling input and output as a human system.

Large amounts of data cannot be processed into information due to limitations of human and computer systems. Humans process data into information using both the raw data and the context of the situation. Dr. Rogers suggested computer modeling would allow the processing of surplus data if

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3 Dr. Steven K. Rogers is the Senior Scientist for Automatic Target Recognition and Sensor Fusion, Air Force Research Laboratory, Air Force Materiel Command, Wright-Patterson AFB, OH. He currently serves as the principal scientific authority and independent researcher in the field of multi-sensor automatic target recognition (ATR) and sensor fusion. Dr. Rogers received his PhD in Electrical Engineering from the University of Colorado in Colorado Springs. He has had an extensive career in both government service and civilian industry. He retired from active duty in the Air Force after 20 years service ranging from work in the logistics community, teaching at AFIT and then the Air Force Research Lab. Additionally, he is the President and Founder of Qualia Computing, Inc., CADx Systems and iCAD, Inc. Among the companies work is research into prostate cancer prognosis using imaging and proteomic/genetic signatures, cardiovascular monitoring during exercise for early detection of coronary artery disease, and feedback control medicine that allows customization of current medical practice to account for an individual patients response to standard therapy.
Computers could attack problems with changing requirements. He outlined four large systems of systems issues or challenges that we face. These are: layered sensing for ISR; integrated systems health monitoring; cyber operations; and medical decision aids.

Challenges surrounding the development of models include abstract concept integration, generalized solutions, the integration of sensors and monitors without intrusion and damage, improvement of cyber situation awareness, and integration of context. He presented some notional solutions that included structured presentation of data, a stronger framework for the computer to work as a mind, etc.

He challenged the audience that there is a real need for an educated workforce – a workforce prepared to address the challenges in solving the really difficult “wicked” problems out there.

In the discussion that followed his presentation, participants asked specifically about the research he is conducting. For instance, he fielded questions about areas that computers are not necessarily good at, e.g., the “conscious” activities that require defined relationships and context. He also fielded questions about human memory and some of the unique traits it displays, suggesting memory, imagination, and sensing are really the same thing. Our long-term memory is really “imagining what might have happened to you” and our short-term memory is often “imagining what is happening to you now.” Computers are not able (yet) to mimic this capability.

**Art Pyster**, Stevens Institute of Technology: “The Body of Knowledge and Curriculum to Advance Systems Engineering”

Dr. Pyster’s presentation outlined the framework for the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE), which seeks to inform a credible Systems Engineering Body of Knowledge (SEBoK) and Graduate Reference Curriculum in Systems Engineering (GRCSE-pronounced “Gracie”). This project was started in September of 2009 by the Stevens Institute of Technology and the Naval Postgraduate School with primary support from the Department of Defense. This project will run through 2012 and is intended for worldwide use. The SEBoK aims to describe the boundary, terminology, content, and structure of SE that are needed to systematically and consistently support the following activities: inform practice, inform research, define curricula, certify professionals, and decide competencies.

One metric for demonstrating resiliency of the BoK will rely on review by the world community using wiki technology to allow people to provide feedback on it. GRCSE provides guidance for constructing and maintaining a reference curriculum, entrance expectations, outcomes, and architecture.

From his presentation: “If we are successful, SEBoK will strongly influence the INCOSE SE Handbook Version 4, the INCOSE SE Professional Certification Program, DoD SE competency efforts, will highlight

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4 Art Pyster, a Ph.D. Alumni of Ohio State, is a Distinguished Research Professor in the School of Systems and Enterprises at Stevens Institute of Technology and the Deputy Executive Director of The Department of Defense’s university affiliated research center for systems engineering. He has a very distinguished career before he joined Stevens, as Sr. VP of SAIC, Chief Scientist and Technologist at FAA. Art is a Fellow of INCOSE.
places where research is needed, become a standard reference for practitioners, and improve the quality and richness of communication among systems engineers worldwide [and] GRCSE will clearly distinguish between graduate and undergraduate education in SE and influence the content of both undergraduate and graduate SE programs worldwide.”

Corey King⁵, SwRI: “Twenty Years Later - Perspectives from an AFIT Graduate”

Mr. King used his presentation to underscore the value of his engineering education from AFIT, even twenty years later. His purpose was to reiterate the need for systems thinking and the requisite skills needed by today’s engineer in the workforce.

After briefly reviewing his career within and outside of the Air Force, Mr. King highlighted common threads he has encountered over time. Among these are the unexpected opportunities that emerge as well as the constant of changing technology. Graduates need to be prepared for these situations.

Key to his own success is the idea of “systems thinking.” Whether it is comprised of technologies, processes or people, it is an essential tool for today’s graduates. Further, graduates need a solid grounding in the technical fundamentals – “be able to talk the talk” – as well as experience in integrating diverse disciplines. Multidisciplinary studies are important and need to remain in engineering education.

Some of the great advantages a military engineering education brought him were working on relevant problems and access to the actual users of systems. Being able to engage in practical research for his thesis was extremely rewarding and motivating.

In concluding his remarks, he asked that graduates have practical information systems experience. They should be able to reverse engineer and conduct vulnerability assessments in order to build resilient systems. They need to understand how requirements are developed and have the skills to elicit and validate these requirements. Exposure to today’s test and evaluation environment is critical – before they arrive in the workforce. They need to understand and have experience in prototyping and rapid application development. Finally they need to know how to learn as well as be able to communicate, both orally and in written form.

Panel Session PS-1: Systems Engineering Education in US Armed Forces

Panel members were: Dr. David Jacques, AFIT; Dr. Thomas Otani, NPS; Col Robert Kewley, USMA; LtCol Daniel McCarthy, USMA; and Dr. Irvin Jones, USAFA

⁵ Corey King, a 1989 Alumni of AFIT, is manager of the System Security and High Reliability Software Section, Communications and Embedded Systems Department. Mr. King has over 25 years experience in technical design, development, operations, and project management in technical areas ranging from ground-based space surveillance and satellite systems engineering to network and computer security.
AFIT, NPS, USAFA, and USMA presented their current undergraduate and graduate programs and objectives in systems engineering. Dr. Jacques presented an overview of the differing systems engineering programs at AFIT ranging from an 18 month graduate program to a 36 month PhD program. He also reviewed the long history AFIT has with Systems Engineering. AFIT’s offerings now include a certificate program as well as a distance learning degree plus a specially tailored program offered to mid-career officers as part of their professional development education. The degree process includes various core systems engineering courses, specialization in another engineering program, and a thesis/design project producing engineers with systems perspectives.

Dr. Jacques concluded his presentation with an overview of some of the more recent SE research and his assessment of the strengths AFIT possesses in the area of Systems Engineering.

Dr. Otani from NPS spoke of the specific application of System of Systems Engineering within the Computer Science Department. NPS has a specific institute dedicated to systems engineering, The Wayne E. Meyer Institute of Systems Engineering – one of four such institutes at NPS.

Dr. Otani also presented some overview information about his department, its degree programs, course structure, and a sampling of ongoing and recently concluded research. As such the department “participate(s) in NPS-wide interdisciplinary SOSE research, in cooperation with the following departments and academic groups: Electrical & Computer Engineering; Systems Engineering; Information Sciences; and Space Systems. They welcome cooperation and collaboration with other universities, especially if through a dedicated SOSE Consortium, as being proposed by this workshop. They “view the consortium path as the best way to leverage our research and education expertise and resources to the advantage of the DoD.”

USAFA and USMA have similar undergraduate programs each with a large number of core classes with systems classes inserted beginning the second half of sophomore year (USAFA) and junior year (USMA) as the presentations from Col Kewley, LTC McCarthy and Dr. Jones indicated. USMA cadets take only systems engineering classes with a department goal to graduate cadets with problem solving skills, whereas USAFA students take systems engineering courses and courses in a focus area (i.e. aeronautical engineering) graduating more specialized problem solvers. Both approaches are tailored to the stated desires of the respective services.

Both presentations from these academies received a lot of attention from the workshop participants.

**Open Panel Discussion**

In the discussion after the panel presentations, a large debate arose concerning the value of undergraduate systems engineers as junior officers. Both academies presented the goal of graduating junior officers who have an understanding of how systems work with advanced problem solving skills. Dr. Jacques pointed out the huge disparity in systems thinking capacity between junior officers and the IDE (mid-career officers) students. It is not that junior officers are incapable of thinking systemically, but that their experience base is limited and it is difficult for many of the conceptual memes or causal mechanisms to be established. The question was not resolved and remains an open item for research and analysis.
Panel Session PS-2 Systems Engineering Education Experiences with/for US Armed Forces

Panel members were Dr. Alex Levis, George Mason University; Dr. Ricardo Valerdi, Massachusetts Institute of Technology; Dan De-Laurentis, Purdue University; Adrian Gheorghe, Old Dominion University; and Alan Chalker, Ohio Supercomputer Center.

Dr Alex Levis\(^6\) presentation discussed the undergraduate and graduate degrees in Systems Engineering as well as graduate certificates at George Mason University and focused on the specialization track on Architecture-based System Integration (ABSI). All degree programs emphasize capstone team projects to solidify SE concepts.

Dr. Valerdi\(^7\) discussed the SE opportunities at MIT and the modes of engagement for Armed Forces students at all levels of education. Finally, he reviewed the Lean Advancement Initiative (LAI) Air Force fellow program which sends 2-3 AF officers per year to MIT to fulfill intermediate and senior development education while addressing topics of interest to the Assistant Secretary of the Air Force for Acquisition (SAF/AQ).

Dr. De-Laurentis\(^8\) illuminated Purdue University’s System Engineering development and its focus on system of systems. Purdue is offering a graduate concentration in Systems Engineering versus a degree in Systems Engineering. The SE concentration is seen as the implementation of an interdisciplinary graduate area of study. One course being offered places emphasis on the methodology of understanding dynamic systems, their interactions, and definition of the problem space. Only after these items are addressed is mathematical modeling introduced.

He also spent a few minutes talking about how Purdue accommodates the unique needs of the Armed Forces personnel when they are assigned to Purdue for graduate school. It revolves around a tailored approach for the sponsoring service.

\(^6\) Alex Levis, a 1968 Sc. D. Alumni of MIT, is University Professor of Electrical, Computer, and Systems Engineering and heads the System Architectures Laboratory of the Electrical and Computer Engineering department, George Mason University, Fairfax, VA. From 2001 to 2004 he served as the Chief Scientist of the U.S. Air Force, on leave from GMU. He serves on the Dept of Homeland Security Science and Technology Advisory Committee; he chairs the Avionics, Software and Cybersecurity subcommittee of the NASA Advisory Council, and he is a member of the Panel on Nuclear Engagement and Global Strike of the USSTRATCOM Strategic Advisory Group. For the last fifteen years, his areas of research have been system architectures including organization architecture design and evaluation, adaptive architectures for command and control, methodologies for architecture design and evaluation. Current research focus is the application of discrete event system theory to a variety of architecture and command and control problems.

\(^7\) Ricardo Valerdi, a 2005 Ph.D. in SE from USC, is a Research Associate at MIT and a visiting Associate at the Center for Systems and Software at USC. He is the co-Editor-in-Chief of the INCOSE Journal of Enterprise Transformation.

\(^8\) Dan De-Laurentis, a Ph.D. degree Alumnus of GA Tech, is an Associate Professor in Purdue’s School of Aeronautics and Astronautics. He leads the System-of-Systems Laboratory (SoSL) which includes 12 graduate students and three Post-Doctoral researchers. His primary research interests are in the areas of problem formulation, modeling and system analysis methods for aerospace systems and systems-of-systems (SoS). He is Associate Fellow of the AIAA and an Associated Editor for the IEEE Systems Journal.
During the presentation, Dr. De-Laurentis discussed the new System of Systems Institute at Purdue. It is expected to be a major presence on campus for the next 20+ years. Its purpose is “...to lead the world in understanding intricate connections – in healthcare, energy, aerospace, transportation, defense, and more.” It seeks to generalize any solutions generated through its research and also maintain a focus on methodologies and approaches (primarily quantitative) needed to design, plan and operate systems of systems.

Dr. Gheorghe discussed the National Centers for System of Systems Engineering established as a research center at Old Dominion because traditional systems engineering is not adequate to deal with a new class of problems that are emerging.

Their integrated research revolves around some core principles: 1) Enhance practice and capabilities for dealing with complex system problems; 2) Explore phenomena associated with complex system problems to enhance understanding; and 3) Develop and test approaches and technologies to more effectively deal with complex system problem domains.

After discussing the current research thrusts, he outlined the center’s capabilities in supporting research, followed by an overview of current research activities. One such area was the System of Systems Engineering Training ODU has developed for Naval Engineers. It is both a training and a research program “designed to expose Navy engineers and technicians to thinking, techniques, and methods for System of Systems Engineering.” The program cites a recent MIT study that suggests in order to instill “systems thinking” in individuals, that context and environment is important. Furthermore, the need for experiential learning opportunities in regard to temporal context of systems is key. Therefore, the program is build upon segments of Foundational Training, Case Study learning, and has a requirement for Case Study deliverables by the students. They have also pursued joint credentialing for coursework through the DOD professional educational school, the Defense Acquisition University.

Dr. Gheorghe concluded his presentation with a review of the Master of Engineering in Systems Engineering program at ODU. He discussed the core curriculum and necessary pre-requisites and the structure of the program.

Dr. Chalker reviewed the educational outreach efforts of the Ohio Supercomputer Center and its partnerships with businesses, Ohio faculty, research staff, and graduate students. One program is designed to interface directly with DOD activities by transferring leading-edge high-performance

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9 Adrian Gheorghe, a 1975 Ph.D. Alumni of City University of London, UK is currently Professor of Engineering Management and Systems Engineering, and Batten Endowed Chair on System of Systems Engineering with the Department of Engineering Management and Systems Engineering, Batten College Engineering and Technology, Old Dominion University, Virginia. He is the Editor-in-Chief of Int. Journal of System of Systems Engineering. (UK)

10 Alan Chalker, a 2005 Ph.D. Alumni of UNC-Chapel Hill, is a program director at the Ohio Supercomputer Center (OSC), where he leads OSC’s Blue Collar Computing industry outreach program. Additional responsibilities include helping to plan, coordinate and staff OSC’s appearance at the annual supercomputing conference and being project group leader for OSC’s Summer Institute program for high school students, of which he is an alumnus.
computing technology into DoD from other government, industrial, and academic communities. Along with that mission is a dual role to educate and train these new users.

He finished his presentation by reviewing some of the educational partnerships that exist at local colleges to further this kind of education and gave an overview of the respective programs at the undergraduate level (associate’s degree and minor program) as well as similar certificate programs.

Dr. Jamshidi discussed his experience in advising 15 USAF personnel at Kirtland Air Force Base in New Mexico and how the students’ theses and dissertations topics were related to actual work on-going at AFRL in Albuquerque, NM. This practice led to a fast graduate program from statement of need to defense of the work. Duration of MS and PhD education at non-military institution is one of the points that need to be shortened for commissioned officer-students in the US Military.

Open Panel Discussion
During the discussion period following the panel members’ presentations, several issues were raised with regards to the SE discipline and military members. What should programs use as the measurement of success: develop SEs or engineers who understand systems? Also, is a degree program necessary or is a certification program or OJT adequate?

Other topics for further investigation are the concepts of architecture, system of systems, and enterprise and how does SE interact with each of these concepts. The consensus of the group was that emphasis in education should be placed on rapid and robust problem formulation and modeling.

Chair: Mo Jamshidi: University of Texas, San Antonio, “Launching the Network - A Proposal Presentation”
Dr. Jamshidi proposed the creation of the US Armed Forces Sub-NET. This subnet is so-called because it represents just one application domain of complex systems. Others include Homeland Security, the Planet Earth, Healthcare, Energy, etc. It would link interested institutions together in a way that would allow for an exchange of curriculum, case studies, and research results. The idea for a subnet comes from an earlier Journal Article, entitled “A Case for an International Consortium on System-of-Systems Engineering” (ISJ, vol 1, no 1, Sept 2007, pp 68-73). A subsequent concept paper, entitled “US Complex Systems Engineering Network (US-ComSeN), given at a GMU workshop, Jan 19, 2010, further expounded upon the idea. From this US-ComSeN concept came the idea for specific sub-networks that would be tailored to individual areas. The purpose of the US Armed Forces Sub-Net would be to focus on the needs of its system engineering goals and to addressing the need of educating the right engineers for the armed forces. Furthermore, it would also provide transient military members the opportunity to pursue an accredited SE degree while taking classes from one or more members of the subnet, e.g. networked institutions. (Current civilian institutions will accept at most 12 hours transfer credit which

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11 Mo Jamshidi, a 1971 Ph.D. in Systems and Control Illinois, is currently Lutcher Brown Endowed Chaired Professor at UT San National and Regents Professor Emeritus, UNM, Albuquerque. He has had 28 years of advising US Government and US Military (9 years USAF, 10 at NASA and 9 years DOE and its Laboratories). Among his 40 PhD and 65 MS graduates 6 PhD’s and 9 MS students were from USAF.
does not support military members receiving a strong and credible degree. Universities participating in the Sub-NET program would accept courses taken at other Universities to grant degrees.) The Sub-NET would create a depository of ideas/suggestions for enhancing existing programs or the development of new programs.

Among the benefits of the subnet arrangement would be: provide networked systems concepts to those with conventional SE competency; and introduce or enhance curricula of complex SE into existing SE curricula. “This would lead to new courses, degree options or complete degrees in affiliated or participating institutions benefitting all.” Ultimately, the armed forces can recruit their future workforce from their own internal programs or from subnet institutions, having some assurance that these potential future commissioned and civilian employees, have been adequately prepared in SE education, thus saving both time and resources. Civilian institutions will have a new generation of potential faculty members to recruit and can tap into real-world examples and resources for their educational use.

The discussion surrounding the creation of the subnet was positive and the participants merely wanted more information. The tentative outcome was to proceed in its creation and the likely venue for further discussion will be at the International System of Systems Engineering Conference that will be held in Albuquerque, NM in early 2011.

**Workshops**

The purpose of the workshops was to give both the DoD personnel and civilian personnel an opportunity to discuss the implications of the subnet proposal for their respective constituencies. Any particular
concerns and ideas relative to the subnet could be discussed and then the groups would re-combine and outbrief each other on the highlights of their individual workshop.

Military Workshop
One of the first questions posed was “Is there a need for this subnet?” After some preliminary discussions, the consensus was “yes, it would be good thing.” With this understanding, the discussion proceeded as follows.

The current structure for military officers applying for continuing education presents many issues to applicants. While the Armed Services continually send exceptional students and officers to school, many graduate programs make graduating within military constraints difficult. MS students are given an 18 to 24 month timeline and PhD students are given a 36 month timeline. Many programs must be adapted specifically for military students and if a given advisor resists adapting the program, military officers may fail in the pursuit of a degree. For this reason, the pursuit of higher level degrees has gained a slight career ending reputation, adverse to the goals of the Armed Forces. For instance, the Air Force funds the student, therefore teachers and advisors at these schools cannot expect military students to be research assistants or teaching assistants. Prior to enrollment, students and universities should demonstrate the eagerness and ability to grant/earn a degree in the restrictive timeline. Universities and advisors should recognize the final product from military students’ education should benefit the reputation and structure of the DoD as well as the university. The military needs PhDs with “strong, credible degree within three years of initial enrollment.”

The panel discussion then turned to outline what it thought the value proposition for civilian institutions would be in this kind of arrangement. We should help them build their underlying business model. Beyond these, participating civilian universities should develop curricula with clear course/degree/research expectations, measurable to high standards, but also be able to realize the opportunity for DoD funding, and expect access to a larger availability of DoD data to aid in the research. An underlying business model could be developed to ensure institutions realize the value of shaping degrees to military students’ constraints. The proposed Sub-NET provides a possible solution for willing universities. Although the military cannot create a list of “difficult” universities, a list of schools with a conducive curriculum would tend to orient potential military students to these institutions.

Other topics that were brought up include some of the mechanics behind the operation of the subnet and participating universities. For instance, Sub_NET schools could have trusted network amongst members to transfer more credits. They would also need to formalize agreements to deal with military PCS moves. These could be in terms of a “standardized curriculum” of a few courses, e.g. BKCSE or GRCSE, that are universally recognized/transferrable, or a stated requirement of a minimum number of courses that would need to be taken at the “final” school that would increase a students’ probability of success. How does distance learning get treated in this mix of classes? Finally, the issue of the name of the degree (and the name of the school) means a lot and rules governing this would need to be established early and up front to avoid confusion and any disappointment on the part of students.
Some of the challenges the military faces and would need to address through other policy avenues include: advanced graduate education versus Promotion opportunities and the existing culture; the limited time to serve under the current retirement system; the support infrastructure for tuition assistance that would facilitate this subnet is thin (should a scholarship “pot” be created that students can compete for?); managing the funding mechanisms and total funding required; allowing more military to accept civilian scholarships; allowing more civilians to attend military graduate schools; and acknowledging that the influence of the military within academia may not be enough to get everything they desire – it is limited.

A few of the benefits of the subnet to the DoD and the Armed Forces in general would be: the ability to address the depletion of engineering talent in a more systematic (predictable) way; the subnet would lend itself well to the creation of a dynamic social network for DoD personnel to allow them to communicate with each other in residence; and the DoD would be more confident of the skills and abilities of their newly minted personnel with their degrees.

Non-military Workshop
The civilian members of the seminar found that System Engineers need to be able to integrate tools and testing in order to build and use purposeful models. This is something the schools cannot compromise on.

Regarding to tenure of the student at a civilian institution, the average time for PhD from a MIT or Stevens is 4.25 and 5 years, respectively. This is a high challenge to reduce it further. The military may need to reexamine its policy while addressing concerns about retaining competitive personnel for promotions, etc. Concessions granted to the military may involve a minimum set of prerequisites or earlier part-time or distance learning classes accomplished prior to coming full-time to campus.

Certainly, universities are seeking to find and/or eliminate NP hard problems and will expect DoD personnel to be engaged in this kind of research. With regards to the DOD SE education enterprise, there needs to be better coordination between the military sponsor and the research topic, standards of operation, job codes, and funding. Also, the mismatch between the need for advance SE education and promotion culture needs to be addressed. A SE degree could possibly be completed 100% through distance learning but this wouldn’t replicate the practical collaborative experience; however, the courses can be taken flexibly. For instance, a PhD student could take courses prior to attending a school to reduce length of residence. The larger challenge facing the nation is the large depletion of engineering talent. A social network could be used for uniformed military officers in order to provide guidance and encouragement.

Outbrief Results
The results of the outbriefings have been captured in the respective sessions above. However, the general consensus in the room was that it was a useful exercise. The perceived dovetailing of interests and desire to make the subnet viable was clearly evident at the conclusion of the last outbrief.
Mr. G. Richard Freeman, Technical Director, USAF Center for Systems Engineering

Mr. Freeman\textsuperscript{12} gave the concluding address of the workshop. In his address, he challenged attendees to think about the ways the DoD approaches meeting combatant commander needs and more specifically the complexities of designs. Are systems more complex than they need to be? He also emphasized the need for a simplified model of the integrated acquisition/logistics business, and at the root of the solution is a common SE language to communicate through the layered framework of SE. This “common language” development will lead to common methods, models and tools for common measureable processes. It is the foundation of any SE framework. He also presented a new way of looking at Systems Engineering through separate “Product,” “Enterprise” and “Customer” lenses.

Mr. Freeman also addressed the three different Science and Technology career paths in the services. There is the Technical Expert, the Manager/Leader, and the Senior Leader. They all have different roles and responsibilities, but what they must have in common across this spectrum of responsibility is: technical depth and breadth; leadership; and education.

With this background, Mr. Freeman concluded the workshop asking the community to work together, developing people who are equipped to develop a common language for SE, increase the understanding of “complexity” impacts, design & use common methods, models & tools, and finally help improve the execution of common measureable processes.

Summary and Conclusion

The purposes of the workshop were to explore the need for and possible creation of a network (or sub network) between the military and academia (including military schools). Overall, many common themes and observations were made and ultimately the vast majority of participants were pleased with the results of the workshop. Feedback from participants was positive. Here is a sampling of some of the feedback from the workshop, “Working with others with common goals.” “Program content was diverse and worthwhile.” “Very informative. Glad to see there is such thought being put into the education of tomorrow’s system engineers!” “Group discussion.” “The breakouts and discussion, with some synthesis, on the second day.” “Being able to understand the diversity SE needs in education and the willingness to collaboratively solve the problems.” “Even though participation was small, this was a benefit in that discussions and breakout session were easily managed.” “Discussions! Sub-net idea.”

In retrospect, the workshop may have been more successful if Dr. Jamshidi’s presentation and perhaps setting the stage for the workshop with goals and objectives had been done up front. And, of course, greater participation from other military institutions and universities would have been welcome.

\textsuperscript{12} Mr. G. Richard Freeman is the Technical Director of the US Air Force Center for Systems Engineering. Prior to joining the government workforce, Mr. Freeman enjoyed a successful career in the private sector working for companies such as GE. He is a Certified Systems Engineering Professional (CESP) and also CESP-Acquisition certified. He is an active member of INCOSE.
Appendix 1 – Registered Workshop Attendees

Mr. Jim Anthony, OSD(AT&L)/DDR&E/SE/MA/WF
Prof Adedeji Badiru, Air Force Institute of Technology
Ms. Elizabeth Birdsall, DDRE/DSE
Mr. Randall Brown, AFRL/XPB
Dr. Alan Chalker, Ohio Supercomputer Center
Capt Wilfredo Cortez, AFRL/RHPA
Dr. Daniel DeLaurentis, Aero/Astro Eng.- Purdue University
Mr. Steve Driskell, www.TASC.com
Dr. Don Duckro, AFRL/XPS
Mrs. Kate Farris, 711 HPW/RHCV
Capt Jason Freels, AFIT
Dr. Don Gelosh, OSD(AT&L)/DDR&E/DSE
Dr. Adrian Gheorghe, Old Dominion University
Mr. William Gillard, AFRL/RBOM
Dr. David Jacques, AFIT/ENV
Dr. Mo Jamshidi, University of Texas, San Antonio
Dr. Irvin Jones, Air Force Academy
Dr. Rochelle Jones, Air Force Institute of Technology
Dr. Brian Kelley, Univ. of Texas at San Antonio
COL Robert Kewley, West Point Department of Systems Engineering
Mr. Gilbert Kuperman, 711 HPW/RHXB
Mr. Charles Leonard, AFRL/RYS
Dr. Alexander Levis, George Mason University
Mr. Kyle Ley, AFRL/RBSD
Mr. John Livingston, ASC/XRE
Prof Karen Marais, Purdue University
Mr. James Massaro, UTSA
LTC Dan McCarthy, United States Military Academy
2Lt Tony Mitchell, AFIT/ENV
DR-03 Philip Mumford, AFRL/RYRR
Lt Col Scott Nowlin, Air Force Academy
Lt Col William O'Connor, AFIT/SYE
Thomas Otani, Naval Postgraduate School
Dr. Arthur Pyster, Stevens Institute of Technology
Dr. Ram Ramanujam, HQ AFRL/XPS
Mr. Jeff Reuter, BAE Systems
Ms. Bridget Sherer, AFRL
Dr. John Snoderly, DAU
Kevin Sweere, AFRL/RYT
Dr. Ricardo Valerdi, MIT
Mr. Maris Vikmanis, AFRL
2Lt Kate Wallace, AFIT/ENV
LtCol Robb Wirthlin, AFIT/ENV
Dr. David Wisler, CDIO