SELECTING ALTERNATE GRADE PARTS

THE TRIALS AND TRIBULATIONS

by DAVE GREINKE and CHRISTINE METZ

Selecting a new or replacement alternate-grade part, such as an automotive grade connector for a military or aerospace system, can be tricky. The best approach would use an already qualified, approved, and preferred part with known reliability and longevity characteristics. However, with lengthening life cycles for military systems, rapid technology development, materiel shortages, and other factors, replacements may be needed for parts that are no longer in production or otherwise available. Given this situation, employing established parts management and diminishing manufacturing sources and material shortages (DMSMS) management procedures can assist in finding and selecting alternate-grade parts to fit a system’s need.

An Aircraft Maintenance Squadron crew chief, inspects aircraft landing gear. U.S. Air Force photo by Joshua J. Seybert

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Semiconductors play an essential role in the evolution of the commercial electronics market.

**THE MARKET EVOLUTION**

The commercial parts market—especially the commercial electronics market, has changed dramatically over the last several decades—creating the need and the opportunity for designers and manufacturers to consider alternate-grade parts in military systems. When the DoD led the electronics market, the automotive and aircraft industries and others with special requirements turned to military-grade parts requiring high reliability, high-temperature resistance, hermetic sealing, robust mechanical strength, vibration resistance, and other qualities needed for operating under severe environmental stress.

In the 1940s, government demand largely drove the growth of development and manufacturing for the electronics industry. Beginning in the 1970s, the demand for electronic components shifted with the advent of industry automation and computers for business use. The commercial electronic industry further evolved in the 1990s, from demand for personal computers, mobile phones, and other consumer electronics.

The electronics business evolved from business-to-government, to business-to-business, and now to business-to-individual relationships. Military and space customers no longer have major influence. According to the 2019 *Semiconductor Industry Association Factbook*, government accounts for 1 percent of the semiconductor market, automotive and industrial buyers were 24 percent, and the remaining 75 percent of the market went to consumer products, such as smartphones and personal computers. Cellphones and tablet computers drive the electronics industry, so that cost, time to market, and volume production are keys to competitiveness. Systems needing long-lasting components are in the minority. The shorter life cycles of electronic components designed for the individual consumer market contribute to obsolescence issues for military equipment and systems.

In the past, automotive and industrial customers looked to the defense market. Today, the automotive and industrial electronics market, with its greater demand, offers the defense market an alternative for effectively sourcing electronic parts. The requirements for parts designed and manufactured for the automotive industry and other industrial operations are closer to the requirements for defense systems and offer less risk than the parts manufactured by the consumer product market.
WHAT IS AN ALTERNATE-GRADE PART?

An alternate-grade part is designed and manufactured for non-DoD applications, is not documented by military-unique specifications or drawings, and is not manufactured specifically to meet military requirements, leading to wide variation among commercial applications and the associated performance requirements and operating environments.

Outside the consumer product segment, a wide variety of parts are designed and manufactured to meet more rigorous requirements and function reliably under stressful operating conditions. Aviation, automotive, industrial plant, and medical devices have applications that may require greater performance and quality, and face more demanding environmental conditions. In addition, the rapid increase of electronics content in automotive applications creates a significant opportunity to leverage the greater choice and availability of electronic functions that can meet many military applications. In some cases, the established standards for quality and performance for these applications can be used to evaluate part acceptability for a specific design requirement.

Table 1 shows a few common differences among varying applications of commercial electronic parts compared to parts designed specifically for space or military applications. Environmental stresses refer to operational temperatures, vibration, radiation exposure, and operation in harsh geographic conditions, such as salt spray, sand, and high altitudes. In addition to the physical difference, the markets for these applications differ greatly in demand, production volume, and pricing.

POTENTIAL BENEFITS OF ALTERNATE-GRADE PART

**Newer technology**
The competitiveness of the commercial market for parts and customer demand drives technological advances, such as enhanced performance, decreased size and weight, and increased quality and reliability, especially for electronic components, which have experienced a great increase in application and demand in recent decades. By tapping the commercial market, DoD accesses newer and improved technology in state-of-the-art parts.

However, selecting new technologies has trade-offs. DoD Standardization Document 22 (SD-22), Diminishing Manufacturing Sources and Material Shortages Guide, notes that new technologies can deliver an important defense capability more effectively but care must be taken to balance performance and reliability when employing new technologies.

**Better availability**
The commercial market offers access to a larger supplier base of commercial manufacturers. In most cases, the size of the commercial market for parts dwarfs the defense-unique market. Over time, due to low demand, manufacturers may stop producing defense-unique parts. This causes parts to become obsolete or unavailable to meet defense sustainment requirements, resulting in back orders and system downtime. The larger commercial market can increase parts availability and reduce lead times, especially for replacement parts.

SD-22 furnishes the example of selecting field-programmable gate arrays instead of application-specific integrated circuits (ASICs). This choice enables purchasing of much larger quantities of a part type and thereby results in volume discounts, improved factory support, and reduced development cycle time and cost. However, the lower power and higher performance for an ASIC part designed for a specific task may be desirable where the volume or performance justifies ASIC development. Furthermore, since the commercial market can be more volatile than the defense market, parts may become obsolete sooner.

**Reduced cost**
Defense-unique parts, manufactured to military specifications, are produced in relatively small quantities and must comply with costly defense requirements for manufacturing, qualification, and testing. Commercial parts, produced in large quantities and competitively priced, offer potential cost reduction for defense systems.
Table 1. Standard Operating Environment for Electronic Parts Designed for Commercial Versus Military Applications

<table>
<thead>
<tr>
<th>Part application</th>
<th>Operational temp. range</th>
<th>Performance and quality assurance standards</th>
<th>Relative level of environmental stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>−55° to 125°C</td>
<td>AIAA, NASA, and Endorsed Military Standards</td>
<td>High</td>
</tr>
<tr>
<td>Military</td>
<td>−55° to 125°C</td>
<td>Military Standards</td>
<td>High</td>
</tr>
<tr>
<td>Automotive</td>
<td>−40° to 125°C</td>
<td>AEC Q Series</td>
<td>Medium</td>
</tr>
<tr>
<td>Industrial</td>
<td>−40° to 85°C</td>
<td>Industry Specific</td>
<td>Medium</td>
</tr>
<tr>
<td>Consumer Products</td>
<td>0° to 70°C</td>
<td>Manufacturer Established</td>
<td>Low</td>
</tr>
</tbody>
</table>

AEC = Automotive Electronics Council; AIAA = American Institute of Aeronautics and Astronautics; NASA = National Aeronautics and Space Administration.

Source: The authors.

An unmanned aerial vehicle delivers a payload to the ballistic missile submarine USS Henry M. Jackson during a test around the Hawaiian Islands. Photo by Navy Petty Officer 1st Class Devin M. Langer.
SELECTING AN ALTERNATE-GRADE PART

According to SD-19, Parts Management Guidebook, there several factors to consider in deciding on an alternate-grade part (see Figure 1). Specifically, an in-house parts selection process should be established for the parts management representative, the Parts Management Board, or a parts-selection integrated program team to follow and document.

Other factors to address include the following:

- **Part reliability and availability.** Will the alternate part work when needed, and will it perform as well as and for as long as needed?
- **Mission and part criticality.** Using alternate-grade parts instead of military-grade parts might be appropriate in certain defense applications if the mission and application for these products can tolerate reduced short-term or long-term quality or reliability.
- **Operating and storage environment.** Parts that function properly in normal environments may not perform adequately in space under extreme radiation, pressure, vibration, and temperatures. Likewise, a part intended for a dry environment may not perform adequately in a wet and corrosive marine environment. Parts stored in extreme environments without temperature control or monitoring may be unusable when needed.
- **Specific application in the system.** A lower-grade part may be adequate for the job based on an evaluation of mission requirements.
- **Availability of testing and usage data.** If adequate testing and qualification data are available from the manufacturer, it may be easy to assess the potential use of an alternate part. For example, evaluation can be easier for military uses of a part supported by manufacturer test data of failure rates and performance data, along with methods for excluding parts with defects, weak parts, and counterfeit parts. An example is parts certified by the Automotive Electronics Council (AEC).
- **Accepted standards.** Does testing show an alternate part meets (or doesn’t meet) accepted standards, such as mechanical, electrical, and environmental tests detailing part materials, design, and performance, as well as the parts reliability to meet the system requirements?
- **Cost-benefit analysis.** Part qualification and testing have an associated cost but may prove worth the investment, depending the criticality of the part.

To maximize standardization and reduce life-cycle costs, alternate-grade parts should be selected based on the order of preference list in Military Standard 3018, “Parts Management”:

- Parts required to meet government regulatory requirements
- Parts that are readily available within the DoD system, have projected continued usage within DoD, and have a documented technical description available to DoD and industry
- Industry standard parts from DoD-adopted non-government standards
- Military and other government standard parts
- Industry standard parts from other non-government standards
- Commonly available manufacturers’ part numbers from catalogs and component manufacturer drawings
- Other (e.g., parts documented on source control drawings, selected item drawings, and altered item drawings)

Figure 1. Alternate-Grade Part Selection
**Part qualification** tests a sample of parts from a single production line to verify compliance with performance requirements and validate production process controls.

**Part screening** tests every part for conformance to performance requirements and removes parts that fail or show defects indicating potential failure.

**Part derating** reduces stress or makes qualitative allowances for a part’s functional degradation to ensure that it will not be exposed to more stress than it can withstand.

**Part uprating** assesses the ability of a part to meet performance requirements when the part is used outside of the manufacturer’s specified temperature range.

**ADDITIONAL MEASURES**

Additional measures can reduce the risk from using alternate-grade parts by ensuring reliability and performance in the intended application. These measures may be part-oriented, such as part qualification, screening, derating, and uprating to ensure that the part meets the specific, intended application.

Effective measures can come from process changes, such as planning for more frequent part refreshes, building in redundancy, and furnishing additional insulation against environmental extremes. Another method uses existing standards—e.g., AEC-Q specifications—to predict performance and reliability.

The additional overall part acquisition cost and time of implementing such measures must be weighed against the benefits of using an alternate-grade part, which can be considerable. Beyond the potential cost savings, an alternate-grade part may offer improved technology or a value-added reduction in size and weight and may be more readily available from a larger supplier base than a military-grade part, supplying future reductions in lead times and costs.

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