*"The voice of the international test, assembly and packaging community"*

# Test, Assembly & Packaging TIMES™

Volume 5, Number 4
April 2014

U.S. Navy photo

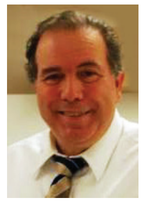




# New Technology Challenges in Military/Space Microcircuits

**Tom Green**
**Tom Terlizzi**
TJ Green Associates LLC
*tjgreenllc.com*
*tgreen@tjgreenllc.com*

Green



Terlizzi

**A major problem in fielding state-of-the-art military and space electronic systems is the lack of militarized electronic components and their swift obsolescence.[1]**

## A Brief History

This article describes a brief history of commercial product use by government mandates, industry solutions and the obstacles encountered in the development of high-reliability products.

Rapidly evolving RF microwave products, the back-and-forth with hermetic/non-hermetic packaging and new military/NASA "Class Y" initiatives are recent examples.

## Background

Almost 20 years ago, Dr. William Perry, Secretary of Defense at the time, introduced the famous (or infamous) "Perry Memo/ Mandate."[2]

The primary motivation behind this memo was the perception that ICs purchased to military specifications (MIL-Spec) add to the cost of doing business.

In addition, substantial economies of scale could be realized by taking advantage of lower cost commercial ICs.

The use of commercial ICs was seen as a way to obtain better access to the newest technologies, both in state-of-the-art availability and lead-time to acquire."[3]

## IC Market Forecast to Reach ~2.68B

As shown in Figure 1 (next page), the government/military IC market is forecast to reach ~$2.68 billion in 2017. This would then represent only ~ 0.8% of the total IC market (~$350 billion), the same percentage as in 2011.[4]

This trend is the reason many semiconductor vendors are exiting the military and space products markets. The economics cannot support the infrastructure to deal with these products in low-volume and low-revenue content.

## Military Products Are Low Demand

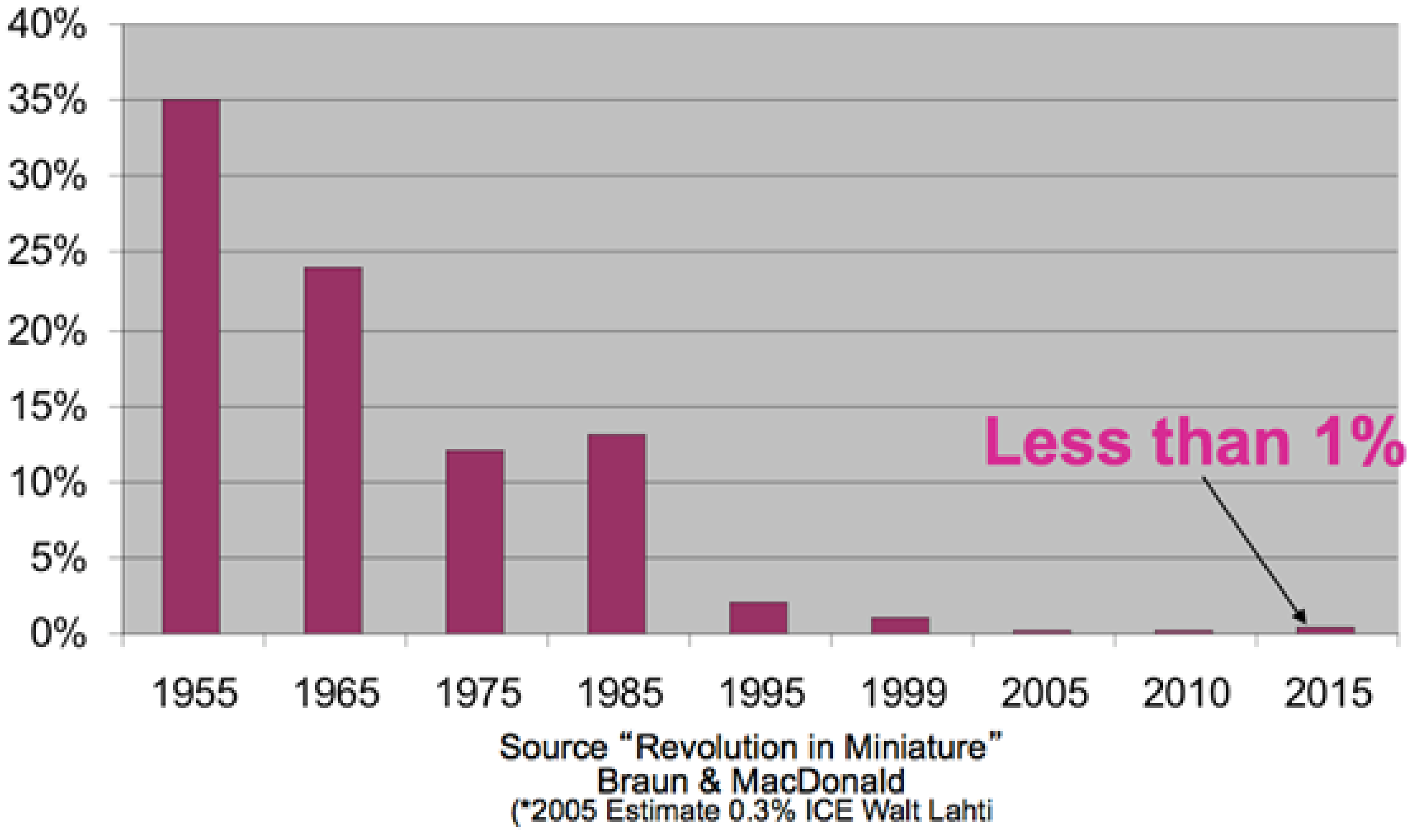
Added to this problem is the long life cycle of typical military products. This is not coincident with *Moore's Law* or the demand for new commercial products shown in Figure 2, next page.

## Industry Solutions and Obstacles

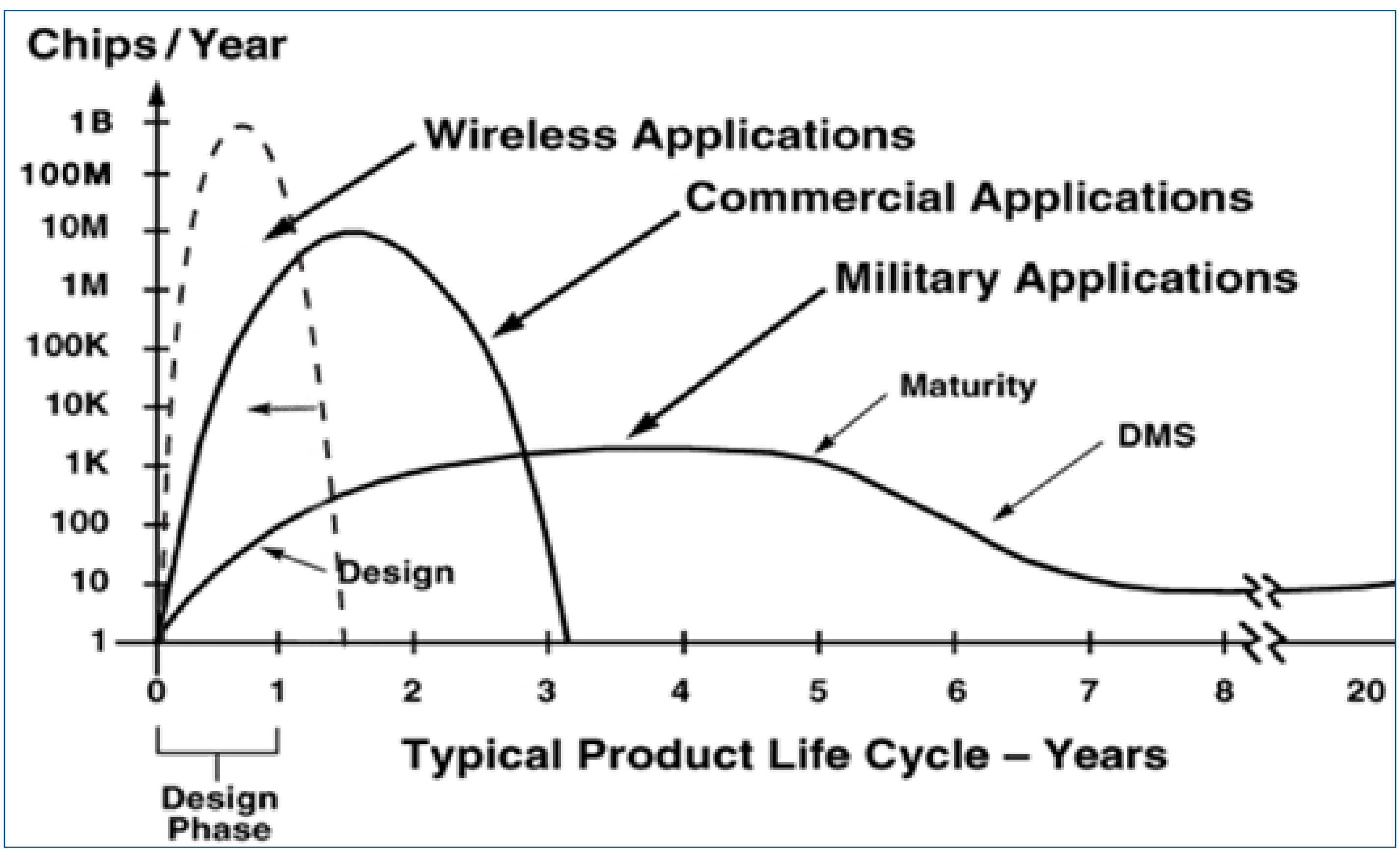
After the Perry document was issued, all military specifications were suspended and industry and the government jointly developed "performance-based" specifications using commercial guidelines and practices.

The new specifications replaced the "out dated" Qualified Parts List (QPL) system which "screens" quality-in through a rigid set of tests and strictly prescribed guidelines for achieving quality.

**See page 40**




*1. Percent of Semiconductor Production Designated Aerospace/Military by Dollar Value*




*2. Product Life Cycle vs. Number of Chips per Application*

**Military/Space Microcircuits (from 40)**

The QML process is flexible and allows the manufacturer to continuously improve the manufacturing process and quality of its products. It also allows for the elimination of non-value-added steps.[5]

**MIL-PRF-38534**
One of the first performance specifications (PRF) was MIL-PRF-38534 for hybrid microcircuits, MCMs, RF and microwave devices.

The goal was to develop a Qualified Manufacturers List (QML) defining process and technology capability and not to mandate military specifications. MIL-PRF-38535, a similar "performance-based" specification for ICs, was later generated, which allowed for approval of self-certified, newer "off-shore" wafer fabs.

**Standard Microcircuit Drawings (SMD)**
The government re-focused and evolved the "Standard Military Drawings" to "Standard Microcircuit Drawing" (SMD). Over ~3,800 SMD drawings and ~32,000 device types with 60 suppliers are now listed.

In 2003, the government and industry started the Vendor Item Drawing (VID) program which has resulted in the generation of over ~500 and ~1000 device types primarily for enhanced plastic devices.

Using plastic devices in military applications enabled the use of new technology, but also made it easier to counterfeit parts.

***See next page***

## Military/Space Microcircuits (from 40)

### Qualified Suppliers' List

Over the last few years, the government instituted a Qualified Suppliers List of Distributors (QSLD Program) and a Trusted Supplier Program to combat an influx of counterfeit parts.

The QSLD Program maintains a list of pre-qualified distributors and the Trusted Supplier Program is a list of approved manufacturers.

Recently, the Defense Logistics Agency (DLA) required the use of DNA marking on electronic components on all new purchase orders.

### Unique DNA Code

Each original design manufacturer (ODM) has a unique "DNA" code. While still controversial and not widely adopted by the semiconductor industry, it is one of the first steps advanced to deter counterfeiters.[6]

To support the extended life of our military systems, government and industry proactively address Diminishing Manufacturing Sources and Material Shortages (DMSMS) issues with a variety of mitigation techniques.

*DLA now requires DNA marking on electronic components.*

All semiconductor suppliers issue a Last-Time Buy (LTB) and End of Life (EOL) notice when parts are obsoleted through the Government Industry Data Exchange Program (GIDEP).

### Processing GIDEP Information

The military systems manufacturers and government agencies review the LTB list, which is facilitated by several commercially available software packages to process this GIDEP information.

The software compares LTB lists to their Bills of Material (BOM) and will flag any problems. If there is an obsolescence problem, an LTB can be initiated.

### The GEM Program

DLA (now known as Defense Land and Maritime) has at its disposal the Generalized Emulation of Microcircuits (GEM) program, which provides a form, fit, and function replacement for non-available microcircuits using current design and processing technologies.

The current GEM contractor is SRI (formerly the Sarnoff Corporation), which supplies a fully compliant product utilizing Bi-CMOS gate array technology.

Obsolete parts can also be obtained from "sunset" manufacturers such as Rochester Electronics and Lansdale Semiconductor which acquire the obsolete product lines, IP and tooling from the original vendors and manufacture these devices to MIL-PRF-38535.

**See next page**

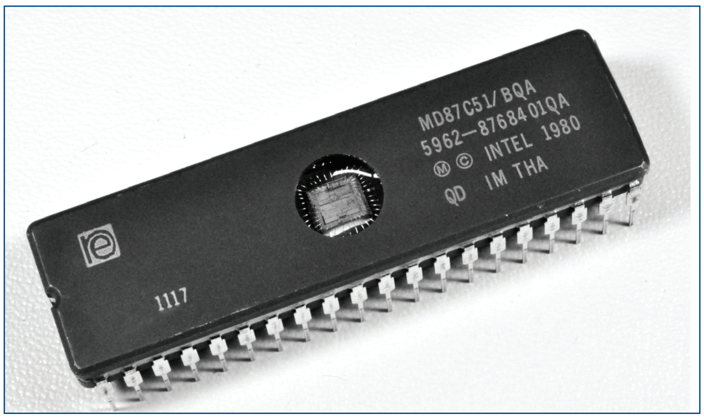
**Military/Space Microcircuits (from 43)**

### Aftermarket Suppliers

These aftermarket suppliers of obsolete semiconductor have large inventories of prior-generation parts.

### RF Microcircuits and Assemblies

As RF and Microwave applications proliferate within the military and aerospace command and control missions, the need to use commercial technology is essential.




*Rochester Electronics is a large supplier of legacy chips. Pictured is Intel's 87C51 single-chip, 8-bit microcontroller.*

### Unique Materials and Processes

Microwave hybrids, monolithic microwave integrated circuits (MMICs) and RF MMIC modules all require a unique set of materials and processes to achieve reliable operation in extreme military and aerospace environments.

Design issues, material trade-offs and process selection are extremely critical due to high-frequency electrical considerations.

### Each Hybrid Is a Unique Solution

Each hybrid is a unique solution, and the specs continue to evolve to handle these complex modules.

### The Electrical Circuit

The placement of the die, the die-attach methods to connect to ground planes, the thermal conductivity of the substrate and wire bond length all become part of the electrical circuit, as shown in Figure 3 on the next page.

Using state-of-the-art MMICs enables the assembly and manufacture of reliable microwave hybrids for military and space applications.[7]

### Hermetic versus Non-Hermetic

The hermeticity of microelectronics packages and hermeticity testing techniques continue to be of critical importance to the packaging community. These hermeticity factors are crucial, specifically, in the area of space qualified hybrids and microwave modules per MIL-PRF-38534.

Hermetic packages must consist of some combination of metals, ceramic and glass, with no polymeric materials allowed. However, many of the high-density IC packages such as Ball Grid Arrays are only manufactured in plastic.

### Class Y

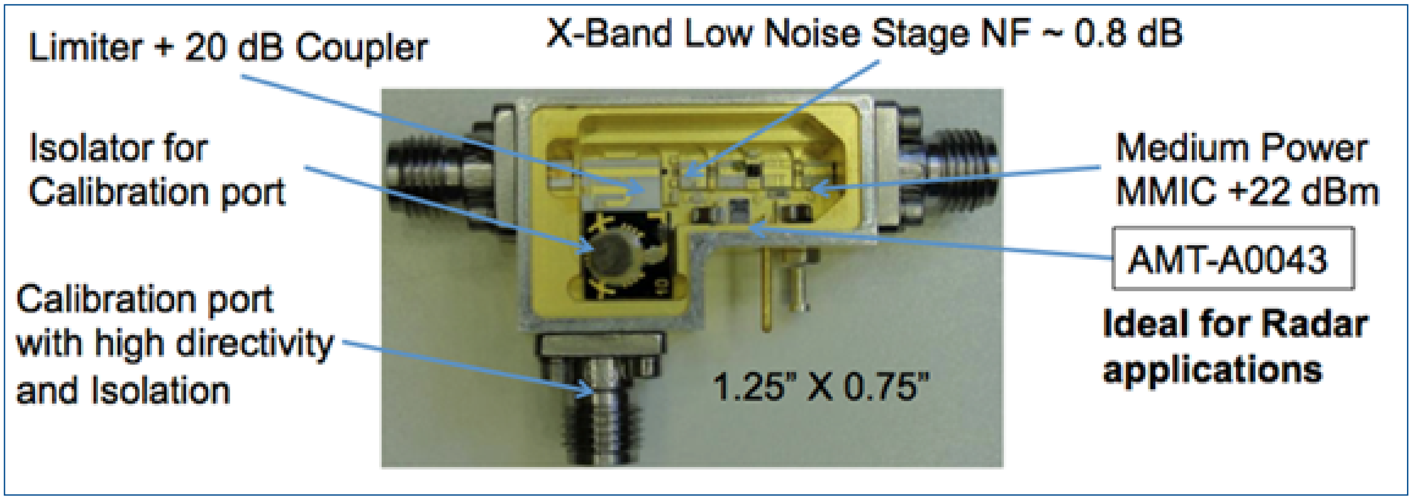
Several years ago, semiconductor maker Xilinx announced it would discontinue supplying FPGAs in a hermetic can.

This announcement forced NASA to develop a new quality designator called "Class Y" as part of the monolithic performance spec MIl-PRF-38535.

For some military and aerospace applications, plastic IC packages may be suitable, and some all-gold metallized microwave devices are inherently robust enough to

**See next page**

**Military/Space Microcircuits (from 42)**




*3. RF and microwave multifunction modules: This complex RF multifunction module required attention to detail to meet Mil-PRF-38534 requirements to enable the final electrical performance to operate over a wide temperature range and humidity extremes. (Photo: Agile Microwave Technology)*

escape moisture-related failure mechanisms.

**Hermeticity Test Method Changed**

Mil-STD-883J was released on June 7, 2013, and within that document there was a significant change to the hermeticity test method 1014.14 (Seal).

The hermeticity spec limit for space-qualified hybrids was tightened by two orders of magnitude. This has forced the industry to search out and qualify new hermeticity test equipment to meet this more stringent spec.

**A Dichotomy Exists**

However, there is a dichotomy that exists within the military community on the topic of hermetic versus non hermetic.

On the one hand, there is a push for tighter hermeticity specs;on the other, there is a move to accommodate and find ways to qualify non-hermetic products.

**Addressing the Issue**

For several years now the hybrid community has addressed the issue via MIL-PRF-38534 Appendix D, "Performance Verification of Non-Hermetic Device Technologies." More recently, Appendix B of MIL-PRF-38535 was released.

"Class Y" is intended to qualify non-hermetic monolithic devices for space applications.

**Conclusion**

The use of new commercial technology in military and aerospace systems will always bring many new challenges.

We must continue to recognize this fact and adapt our "military mindset" to a new way of doing business. After all we have no other choice.

**References**

1. Tom Terlizzi, "COTS Approach to Military Microprocessor MCMs" IMAPS Advanced Technology Workshop, March 12, 2003.

***See next page***

**Military/Space Microcircuits (from 44)**

2.William J. Perry, "A New Way of Doing Business" A memorandum, June 29,1994

3. Robert M. Rolfe, Herbert R. Brown et al, "Accelerating the Use of Commercial Integrated Circuits in Military Systems," Institute for Defense Analyses, Virginia, October 1995.

4. Brian Matas, "IC Market Drivers 2013—A Study of Emerging and Major End-Use Applications Fueling Demand for Integrated Circuits," IC Insights, Inc. Arizona: Scottsdale.

5. QML Information Texas Instruments

6. Lee Mathiesen, "Guest Viewpoint: The Microelectronics DNA Marking Moral Dilemma," March 6, 2013, *Military & Aerospace Electronics.*

7. Tom Green, "Die Attach Voiding Requirements in Eutectically Bonded GaAs and GaN MMIC Power Amplifiers," http://www.tjgreenllc.com/blog

**The Authors**

***Thomas J. Green*** *is principal of TJ Green Associates LLC, a veteran-owned, small business providing teaching and consulting services for high-reliability microelectronic components for use in military, space and Class III medical device applications. Mr. Green is a retired Air Force Lt. Col. with 28 years of service. He served as a research scientist at the USAF Rome Air Development Center and subsequently as a senior process engineer for Lockheed Martin, where he was responsible for the materials and processes employed to assemble hybrid microelectronics. Mr. Green holds a bachelor of science degree in materials science from Lehigh University and a master's degree from the University of Utah.*

**Tom Terlizzi** *is vice president of GM Systems LLC, a management and technology consulting firm, providing marketing and sales strategy, microelectronics and RF and microwave product design and development.*

*He has designed and developed power management systems, single-board computers, ICs, thick- and thin-film hybrids and systems for Aeroflex, Agile Microwave Tehnology and Norden Systems/UTC. He received a BEE from City College of New York and an MSEE from NYU Poly. He currently writes a blog for EDN Online.*