Take a Hybrid Approach to Component Obsolescence

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With 20% of digital ICs and 10% of analog ICs going obsolete every year, program managers and purchasing agents are scrambling for replacement products or solutions that will allow their programs to continue—and in some cases, to get off the ground. In fact, many of the weapons systems designed today are in jeopardy of failing because of the problem of unprocurable components before they even go into production. That's because while design, testing and qualification take several years, ICs are becoming obsolete at a faster rate than the development cycle (Table 1).

Component Type	Life Expectancy
Memory Devices	9 Months
Programmable Logic	1 Year
Gate Arrays	2 Years
Microprocessors	2 Years
Digital Signal Processors	3 Years
Logic Families	6 Years
Linear Devices	8 Years

Table 1

The commercial availability life expectancy of various component types is drastically shorter than that required by most military programs.

This problem is even more pronounced in systems using existing hardware. For example, the B-52 heavy bomber was developed in 1946, put into production in 1955 and is now expected to have a serviceable life to 2040, and possibly beyond. This life span couldn't have been previously predicted, but today most of the military's current systems are expected to remain fielded 15 to 30 years longer than the notional projected lifetime (Figure 1).

Yet this problem of obsolescence is well known in the military, and four main methods of sustaining fielded systems solutions exist, ranging from merely using the latest COTS components to entire system redesigns (Table 2). The trouble is, none of these individual solutions are ideal if implemented singularly. The real answer to obsolescence lies in combining several solutions together into a Form, Fit and Functional COTS-based multi-chip module (MCM).

COTS Components Create a Vicious Circle

The first solution to the obsolescence problem is moving from MIL-STD to COTS components—a transition that began with the Perry Initiative. This initiative, instigated by former Secretary of Defense Dr. William Perry, fostered a change in government procurement practices from military standards to what is known as Best Commercial Practices. Best Commercial Practices permit the use of any viable commercial component available.

Initially, COTS was seen as the panacea for all procurement issues because it made any device available.

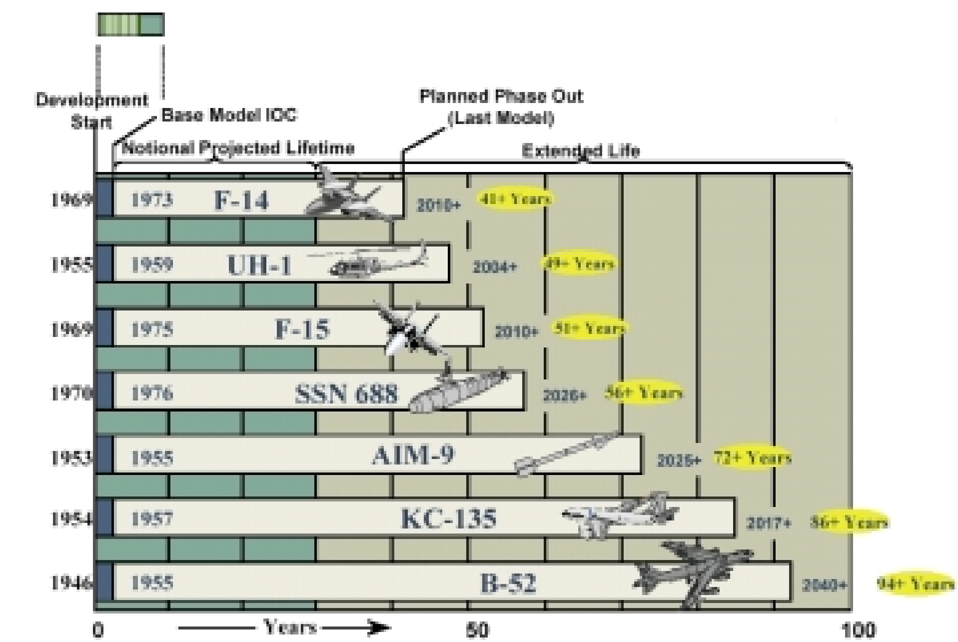

Figure 1

Many military systems are expected to last years beyond their original notional lifetime. The B-52, for example, entered service in 1955 but isn't slated for scrap until 2040—a lifetime of 94 years. (Image courtesy of DMEA.)

According to the Defense Microelectronics Activity (DMEA), COTS reduced the cost of many components from an average of $1000 each (for military-grade devices) to approximately $10 each. And while many COTS parts provide system performance that was previously unparalleled in military applications, they also create a new set of problems.

The first problem revolves around the commercial market's widespread use of plastic—a material whose durability is questionable in harsh environments. Indeed, plastic components absorb water and outgas, and they're not manufactured to accepted military standards. The second cause for concern is what is known as "upscreening." Upscreening involves subjecting commercial electronic components to electrical, mechanical and environmental stresses beyond those tested or guaranteed by the device manufacturer. As determined by an ARINC study, doing so adds an additional cost of $47,000 per 100 lot pieces.

Furthermore, many manufacturers don't want their devices placed in systems that will operate outside of the guaranteed range. Of course, they understandably fear the "black eye" that comes with a system or mission failure attributable to a component.

Finally, the use of an as-is COTS device fosters the paradoxical threat of even faster part obsolescence; that is, as commercial manufacturers continue to outpace one another with faster, newer, and better components, military purchasing agents are finding that their COTS solutions can disappear just as easily as the vanishing parts they originally sought to replace. As such, the average COTS part is available for only 3.5 years. By contrast, military-grade parts tend to have an average lifecycle of 12 years.

The B-52 once again provides a good illustration of this issue, as well as its cost impact. Using military components, the B-52 would have needed eight upgrades (96 years/12 years). However, with COTS devices, it will need about 27 (96 years/3.5 years). Using DMEA data, with the average cost of a major redesign hovering at around $410,000, COTS devices will cost the B-52 program $6.1 million more throughout its life than if it were only designed with military devices.

In the Aftermarket

In contrast to the COTS approach to obsolescence, the second obsolescence solution currently being used lies with aftermarket manufacturers. Compared with the multibillion-dollar semiconductor industry, these comparatively small companies purchase the inventory of major manufacturers as they discontinue a part type or product family. The aftermarket companies store the inventory and simply wait for the major manufacturers' supply chain to be depleted. After this occurs, the aftermarket companies sell the remaining product into the market.

In many cases, they will purchase the manufacturers' mask sets so they can continue to supply product as long as the fab doesn't change the process geometry. However, in cases where masks aren't available, this merely becomes a stopgap process until a redesign or other option becomes available. The price of this option is usually about 10x the piece part cost. But compared with a redesign, this is an acceptable option until too many devices on a board or system become obsolete, and it simply becomes more inexpensive to do a design overhaul.

Making What's Old New Again

The third obsolescence option is to simulate or reverse engineer the obsolete component. In this process, an organization like DMEA, formed by the DoD to support a broad spectrum of services, will make a Form, Fit and Function replacement part that meets the electrical characteristics of the original component. The advantage of this replacement method is that the DMEA has its own sil-

Obsolescence Solution	Comments
COTS Components	Refers to converting from Mil-Spec (and in some cases QML) to COTS components.
Aftermarket Supplier	Refers to procuring obsolete components—commercial or military—from an aftermarket supplier.
Reverse Engineer	Refers to simulating or reverse engineering an obsolete component in order to provide an equivalent device from a new source.
System Redesign	Refers to redesigning the entire system (board or chassis) and effectively eliminating the obsolete component(s).
Multi-Chip Module (MCM)	Uses a combination of all solutions, depending on program requirements.

Table 2

The five major solutions to the obsolescence problem. The best solution, a multi-chip module (MCM), offers a combination of the other four and is tailored to an individual program's needs.

icon foundry and can run a wafer at whatever geometry or technology the original design was fabbed in, guaranteeing a relatively inexorable availability of the device.

> The answer instead lies in applying a little bit of every approach into a single solution: the MCM.

But as with other approaches, this method works well only when a small number of components per board or system are antiquated. And yet, as many as 80% of the components on many aging systems are obsolete. With this high of a percentage, the cost of reengineering can be prohibitive. And with most designs, only one or very few of each component type are used on a board, and the commonality between boards is often not very high.

Starting All Over

The fourth method of dealing with obsolescence is redesign—a term that often strikes terror in the hearts of program managers. That's because redesign means new devices, new software, new engineers and, ultimately, new problems. Complicating the issue is the fact that redesign requires the new design to adapt to the old design. This requires the significant input of designers and engineers who understand the old system hardware, interfaces and software. And to make matters worse, much of the software used in aging military systems is no longer supported by its manufacturer or was custom-written for the system in which it's used. Most of the people who originally worked on legacy systems may long have since retired or moved to different companies.

As a result of these issues, the Electronics Industry Association (EIA) Manufacturing Operations and Technology Committee reported a cost range for the typical redesign of $26,000 to $2 million. For example, the Air Force is requesting $81 million for the F-22 program to purchase obsolete or soon to be out-of-production parts to redesign assemblies to accept commercial parts. Similarly, the F-16 program will require $500 million to redesign an obsolete radar system; and an avionics manufacturer spent $600,000 to replace one obsolete Intel chip. In short, redesign is a costly and time-consuming proposition.

MCM Solution: A Hybrid Approach

The trouble with any of these four obsolescence choices is that, applied individually, they each have drawbacks that may ultimately render their long-term problem-solving ability useless. The answer instead lies in applying a little bit of every approach into a single solution: the MCM.

What used to be called a hybrid microcircuit is now called a multi-chip module or MCM. An MCM consists of a hermetically sealed ceramic-packaged device that inside contains multiple

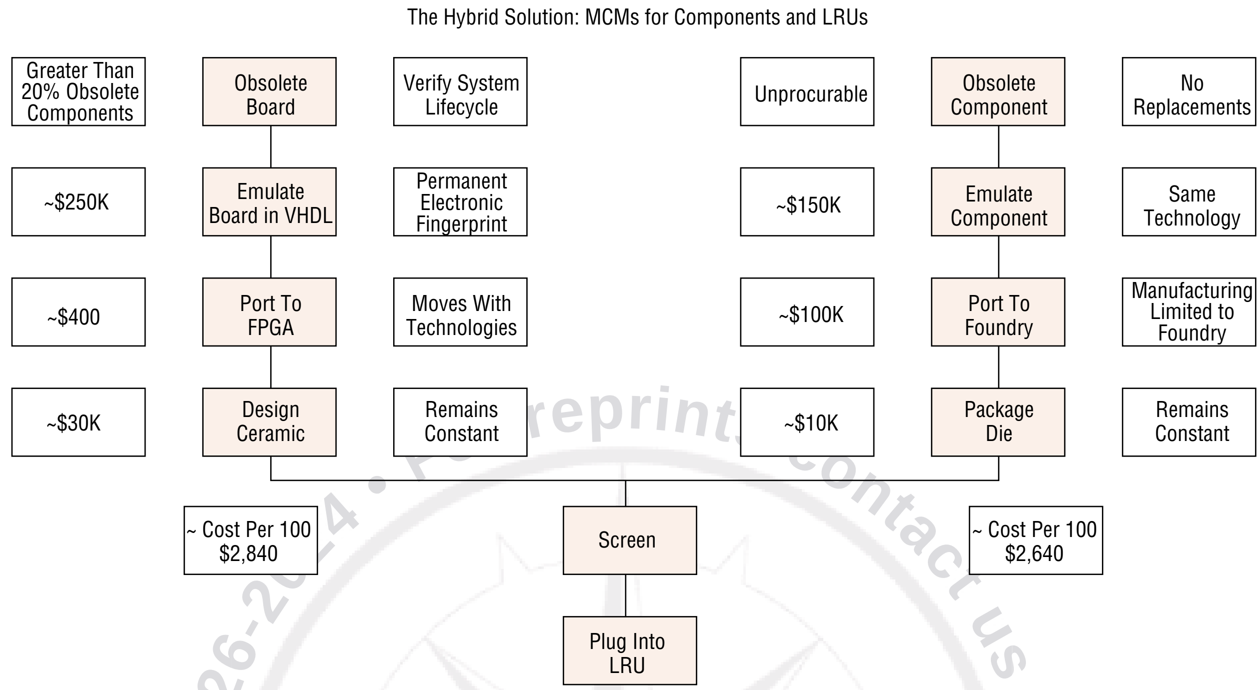

Figure 2

The Space Electronics multi-chip module (MCM) solution provides Form, Fit and Function replacement for components and entire line replaceable units (LRUs) and often at reduced costs vs. the obsolete product(s).

devices. The individual devices can each be in bare die form and bonded to a substrate or in complete packaged form and soldered to a miniature interior circuit board.

Using an MCM allows companies like Space Electronics (SEi) to replace individual components, groupings of components or an entire board's worth of components. In each case, Form, Fit and Function is maintained at the necessary level: component, component group or line-replaceable unit (LRU) (Figure 2).

At the Component Level

SEi's solution involves replacing unprocurable ICs with modern plastic-encapsulated microcircuits (PEMs) sealed in a hermetic ceramic MCM. In the simplest case, the custom-designed MCM can be small enough to match the footprint of the component being replaced. Encasing a COTS device in a hermetic module provides the durability to withstand the rigors of a military mission.

An added advantage of using the latest COTS component is that die shrinks and redesigns by the component manufacturer result in faster devices operating at lower I_{cc} and V_{cc}, resulting in reduced power consumption. This approach works especially well when used with memory devices. Indeed, by using this approach one modern memory IC can replace multiple, older ICs.

This strategy was recently used in a military contract to replace eight memory ICs (at approximately $600 each) with a ceramic module housing two COTS memory ICs (at a $2,500 total module cost). In this case the footprint of the eight devices was exactly matched by the MCM so no LRU change was required (Figure 3).

The elegance of this type of solution is an option either to expand the memory of the LRU of which the memory ICs are a part or to simply extend its life while changing the COTS device(s) as new memory becomes available. The savings recognized by sealing PEMs in a hermetic module is, therefore, tremendous.

Figure 2 shows the process works as follows: When a device or collection of devices is identified as obsolete, a new COTS replacement is found and verified for functional equivalency. Then a ceramic module is designed with the required footprint, and the COTS device is mounted and sealed into the module. This creates a hermetic, pin-for-pin, commensurate device.

In addition, a VHDL software model is built and delivered with the devices for a solution that can be updated as technology changes without having to redesign the system. This serves to "future proof" the MCM from eventual future obsolescence. That's because today's design tools enable designers to simulate and replace boards and systems with MCMs that can be updated as devices and technologies change. Instead of manufacturers storing mountains of schematics, they can store VHDL code, which takes up a lot less space. The code can later be transferred to subcontractors to maintain systems and spares to the end of a system's operating life, while reducing cost in the process.

In addition to up-front cost savings and avoidance, encasing a COTS component in a ceramic module housing extends the shelf life of the component itself. This is especially critical in, for example, a missile application where a system may sit for years before being called into service. In this application, there is only one chance for the missile to fire. As a result, part failure due to a commercial PEM's moisture absorbency over time has been one of the largest limiting factors of using COTS parts in military applications. And in systems with radiation requirements, the hermetic package can even incorporate Space Electronics' patented Rad-Pak radiation-mitigating technology to improve the radiation characteristics of the COTS device.

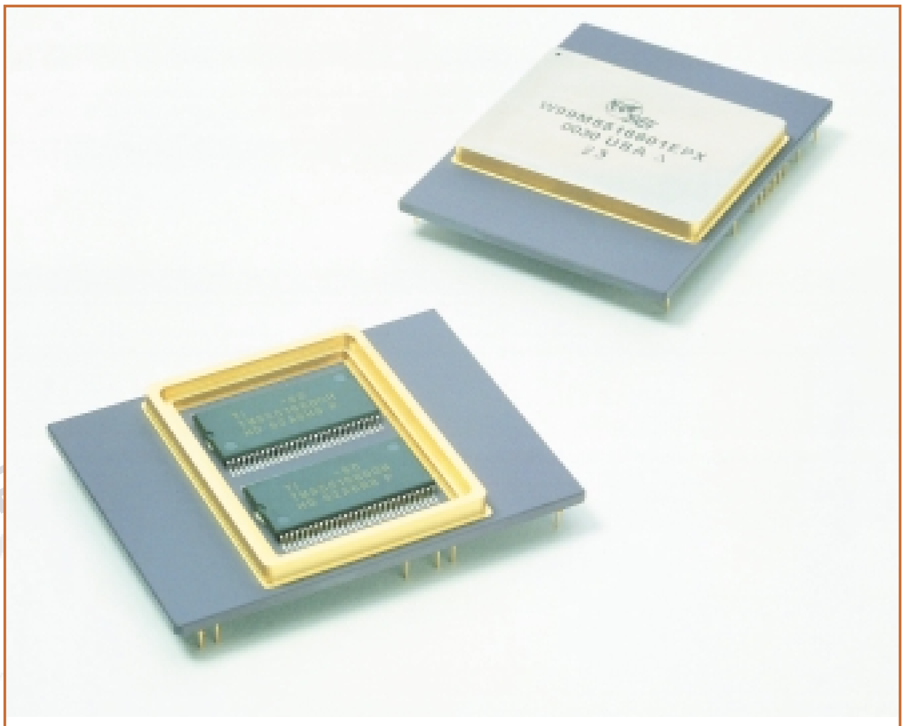

Figure 3

One custom MCM containing two COTS plastic-encapsulated microcircuit (PEMs) device was able to replace eight individual VRAM memories. The MCM maintained the same footprint on the board as the collection of eight VRAMs, so no board redesign was needed. (Image courtesy of Space Electronics.)

At the LRU Level

SEI's approach also works for entire boards. For example, when there are multiple obsolete devices on a board, an MCM can be designed with COTS devices replacing the unprocurable devices. The resulting "super MCM" can then be mounted on a replacement LRU that maintains the same functionality, mechanical and electrical interfaces as the original board.

This solution gives the program office time to decide if there is going to be a redesign of the board or system or to procure enough devices to complete the current lifecycle of the unit. With the knowledge that if the platform is extended 10–15 more years, the COTS approach can be used to procure parts without incurring large NRE charges.

In fact, some board houses are using this approach to reduce the cost of assembling modern boards. In one project, the military version of a necessary CPU was $2,800, while the COTS version of the same CPU was only $60. For a small NRE charge, the commercial device was placed in a ceramic module, hermetically sealed, screened to the required level and delivered for less than $600 each. The replacement CPU module might also have contained ancillary components such as L2 cache, UART and PCI bus bridge—effectively replacing the entire single board computer (SBC).

The MCM method can be applied to a large number of devices that are no longer supplied in military or ceramic versions with cost savings equally as impressive. And it also works well with devices that never will be supplied in a military version. The required device can be packaged in a ceramic hermetic package and screened—rather than upscreened—to the system's requirements because many applications don't need the advanced screening called for in military specifications. Instead, a reduced level of screening within the manufacturers' specification is often sufficient.

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