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A SKY Computers White Paper

When COTS Electronics Aren't Enough:
Repackaging, Reformatting and Technology Transfers

The SKY Extended COTS Program

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When COTS Electronics Aren't Enough

The first wave of COTS electronics operating in rugged environments began more than fifteen years ago when both Prime Contractors and the Government realized that data centers, whether on a Navy vessel or in a corporate office, had much in common. Initially the environment was a challenge, as those who have adapted COTS modules to pass MIL-S-901 shock testing well know. Today the technology to address these needs has developed to the extent that using COTS for naval applications is now common.

The success of adapting COTS to these extended environments has spurred program offices and prime contractors to explore how to extend COTS to where there is either an environmental challenge or a specialized form factor challenge that goes beyond off-the-shelf solutions.

How can COTS electronics be exploited for very harsh environments such as an armored vehicle, for avionics, or for deployment to space?

How can a COTS product be reformatted to fit an existing space on a legacy platform?

How can suppliers be leveraged to extend the affordability, flexibility and upgradability benefits of COTS to combat system projects and other mission critical programs?

The final answers are different for each program, but begin with an evaluation of the COTS landscape.

With more than 20 years of defense/military experience, SKY Computers believes that the next wave of COTS goes well beyond just supplying a point product. Today's COTS includes business flexibility and partnering to meet modified form factor, ruggedization and unique packaging requirements. When appropriate, the partnership extends to licensing intellectual property. Acomplete lifecycle approach only *begins* with the off-the-shelf development system -- it extends to packaging the fundamental COTS design specifically for the application. SKY Computers is one of the only companies in its class who has the experience and flexibility to explore the mission application needs beyond the point product approach.

But before a COTS, repackaging, or licensing decision is made, let's look at how COTS electronics are being exploited for harsh environments and let's look at the advantages and potential pitfalls involved in the evaluation process.

COTS Electronics Migrates to Rugged Environments

The COTS electronics industry grew up based upon the industry standards which allow interoperability between modules built by different vendors. Standards such as VMEbus and CompactPCI allow companies to supply components that will interconnect, allowing a supplier to build

SKY Computers – Key Customers

Acacia – System & Design Integration

UKAEA – High Energy Physics

AFRL Rome Labs – HPC

Analogic – CT – Bomb Detection

Alenia Marconi – Radar Systems

Arete Technology – Classified Adaptive Acoustics

Australian Navy – Collins Submarine

Australian Navy P3C

BAE Systems – Avionics

BAE Systems/Naval Air Warfare Center – Sea Sparrow Upgrade

Boeing – Simulation Technologies – Missile Simulation

CSIST – Infrared Tracker/Seeker

DERA (QinetiQ) – System Design & Integration

DSO – Airborne Radar, Electronic Warfare

DSTO – Sonar, Radar Simulation

EADS – Avionics

Eglin AFB

Lockheed Martin – FOPEN

Lockheed Martin – P3C Orion Radar

Lockheed Martin – SIMM

National Security Agency – Poppyseed Program (Classified)

Naval Surface Warfare Center – CDCS

Naval Underwater Warfare Center – MCAA

Naval Surface Warfare Center – SEOC

Nova Research

Perkin Elmer/Vivid – Bomb Detection

Philips – Medical Imaging

Princeton Plasma

PIT Polish Institute of Technology – TRD 1211 Radar

Sencom – System Design & Integration

Sencom – NPC

Smiths – 550c Project

SPAWAR – Sea Sparrow

Thomson Marconi Sonar

Tsing Hua University – Circuit SimulationE

a variety of different subsystems. This building block approach applies not only to electronic modules, but also to the software and development tools.

One of the biggest advantages of COTS electronics is the ability for a system integrator to procure hardware, a software development toolkit, and an operating system off the shelf. This allows the integrator to focus their time and effort on writing the mission applications software, rather than designing and debugging infrastructure software such as O/S's, device drivers, and debuggers. Continuous development, upgrade, and maintenance of the COTS products by the COTS vendor relieves the integrator of the these tasks over the life of the system.

The COTS industry is sufficiently developed that, if a system can be configured with COTS modules, it generally is. The advantages to the systems integrator are well known, and include QAI (quick application implementation), and reduced risk.

Standards for electronics have evolved to include standard levels of component and system ruggedization that are offered by many COTS vendors. Stiffening schemes to provide increased vibration tolerances, and parts that withstand extremes of temperature, and humidity are all commercially available to electronic module vendors to build rugged versions at the component, board, and subsystem levels. In addition to COTS, ready to run in a benign environment; rugged COTS is ready to run in some extended temperature, vibration, and humidity environments. Unfortunately, specialized requirements and unique constraints sometimes preclude the use of COTS modules.

Requirements that include any of the following criteria usually mean that COTS modules are not an option:

- Retrofit of an existing chassis that uses a proprietary card format
- Application unique interfaces not supported by COTS industry
- Specialized cooling techniques
- Confined spaces such as pylon/pod mounting on aircraft
- Unique assembly or quality assurance requirements
- Exceptional shock or vibration environment

Fighter jets typically require specialized form factors beyond those supplied commercially.

In these cases, a COTS solution is typically disqualified, and a custom design appears to be the only remaining option. There are other approaches, however. For some mission application requirements, the COTS electronics module may be reformatted by redesigning elements of the hardware, while preserving the available software infrastructure for the module. This approach has significant advantages in affordability, flexibility, upgradability, risk mitigation, and time to implementation, over launching a development initiative. Reformatted solutions can often be integrated much more rapidly and cost effectively than a custom design due to the following factors:

- The COTS module offers a proven Reference Design for the hardware that greatly reduces development time, cost and risk. In most cases, the COTS hardware design can be used essentially as is with new partitioning and printed circuit layouts.

- Parallel development efforts can be initiated by using the standard COTS modules to develop new application software while the Reference Design is being repackaged. Schedules can be reduced by having software and hardware design proceed in parallel.

- Wide deployment of COTS development tools means that less time will be spent developing a software infrastructure and debugging the environment, while more time will be focused on critical mission applications software development.

• As most COTS modules are periodically updated and maintained by the COTS vendor, maintenance of the reformatted design is simplified by leveraging design updates for software patches or component obsolescence initiated by the COTS vendor. Technology insertion and maintenance costs are reduced.

• Applications software designed for the COTS module can be ported, with minimal effort, to the repackaged hardware platform. Software for the COTS module is preserved including device drivers and board support packages.

What Are the Options? Make It or Buy It?

The realization that an existing COTS solution with guaranteed environmental performance or specialized form factor is not available off the shelf usually triggers an analysis of the options by the integrator. However, there are additional alternatives to the simple make or buy decision for COTS electronics.

• In some applications, integrators have chosen a hybrid approach where COTS or rugged COTS electronics are built into environments with interfaces or enclosures designed to give the COTS solution greater tolerance to the environment.

• In other applications, the COTS/rugged COTS supplier has reformatted or repackaged the electronics modules to fit the program requirements.

• Applications with extreme conditions and/or security have licensed the COTS technology to achieve both objectives.

Given that a suitable COTS product with the necessary functional characteristics is available, the simplest option is to redesign the hardware into a suitable form factor, while preserving the application programming interface. For COTS vendors that possess the necessary expertise in rugged hardware design, and have services to support the effort, this option is most efficient as the COTS vendor is in the ideal position to redesign one of their own existing products with a minimum of effort and risk.

When the COTS vendor is unwilling or unable to perform the redesign work, or where the application demands specialized processes or security measures, the integrator can perform the repackaging with their own resources. In this case, licensing the design from a COTS vendor minimizes schedule and risk factors. Technology licensing combines the advantages of COTS with the necessity of a custom design for some applications. Not all COTS designs can be successfully or economically be repackaged in a custom form factor. When electing to license an existing COTS design, the integrator should consider the risk factors in performing the repackaging. Things to consider include:

• Is the basic design robust enough to work in the rugged environment? Has the basic design ever been qualified to work over the necessary temperature ranges in the past?

• Will it be possible to select functionally compatible wide temperature range components that meet the environmental requirements?

• Will the COTS vendor support the effort with their expertise and software source code? Can the COTS vendor verify compatibility with existing software?

• Can the existing COTS vendor's test processes and software be integrated into the new module's manufacturing flow?

Evaluating COTS Vendors for Repackaging, Reformatting and Technology Transfers

There are many COTS electronics vendors, and some of these suppliers offer standard levels of ruggedization. However, few vendors are willing to extend mission application requirements outside of their standard form factors, or are willing to share their intellectual property. An important element in vendor selection is choosing the supplier(s) who do this as their standard of doing business, not just as an exception. Whether the COTS vendor does the design work, or the design is licensed by the integrator, form factor repackaging demands multi-disciplinary strengths in engineering. During the evaluation, the following check list of packaging capabilities identifies the critical competencies that must be present either with the COTS vendor or the integrator undertaking the work.

✓ Component Selection

When the semiconductor industry made military temperature range components, component selection was easy. Today, without those parts, selecting wide temperature range components will help, but ultimately, the hardware designer is faced with selecting components which are purely commercial, but are either known to work over a wide temperature range, or can be qualified to do so. Making the right choice requires the focus and expertise of people who do this 100% of the time.

✓ Thermal Management

Successful qualification testing depends on paying close attention to the management of temperature extremes. Where a PC uses a microfan to cool the microprocessor, operation at 50,000 feet usually means conduction cooling, pressurization, or even spray cooling. Design for optimum thermal management is a science that requires extensive knowledge of the ultimate platform requirements and of each component of the system.

✓ Component Placement

Extreme shock and vibration levels can sometimes be managed at the rack and chassis level, as is commonly done as a hybrid implementation in naval applications. In most cases however, the ultimate limiting factor in survival is the resonant frequency of the printed circuit assemblies, and the consequent movement of the boards under vibration loads. Experienced designers maintain maximum stiffness and minimum weight, while carefully deciding where to put fragile BGA packages.

✓ Component Retention

In commercial designs, there is usually little consideration given to the insidious effects of random vibration. Experienced designers know that the reliability of an electronic module is partly influenced by the reliability of the solder joints and the plated through holes in the printed circuit. These are in turn influenced by their mechanical topology, but ultimately, how much the solder joints are flexed by vibration, as well as thermal cycling. Experts focused on these considerations determine the survivability of the modules.

✓ Thermal Coefficients

Some commercial hardware designers are surprised to learn that a design can be over stressed with the power off simply by cycling temperatures between the extreme low and high that the module will experience in storage. When a COTS supplier is building a module for a mission application consideration must be given to the effect of differences in thermal coefficient of expansion for dissimilar materials which are bonded together.

✓ Connectors/Cabling

Commercial cabling solutions suffer from mechanical fragility as well as a lack of resistance to corrosive atmosphere and fluid contamination. Systems designed for exposure to high levels of random vibration or NBC decontamination procedures must consider the connector selection and cabling solution as critical points of failure in testing.

✓ Test Procedures

Some vendors use Highly Accelerated Life Testing (HALT) or Highly Accelerated Stress Screening (HASS) techniques as part of the design verification cycle. Few subject a design to test procedures intended to verify operation of the system well outside of its intended operating environment, or perform 100% testing over temperature and vibration as a military supplier would.

✓ Derating

Aclassic approach to maximizing the first pass success rates for a new hardware design is to derate the timing parameters and fanout values. Rather than using the commercial semiconductor vendor specifications for a part, the designer will ensure that a design can tolerate a component operating outside of its minimum/maximum timing parameter ranges.

Engineering and Re-engineering Focus

Beyond these critical skills, COTS and Rugged COTS suppliers can provide maximum focus to engineer the repackaged solution. By assembling a team of full-time, high-level experts in packaging technologies, physics, computer design, system analysis, production engineering and instrumentation the advantages of COTS can be realized for the most demanding mission application requirements.

Choose SKY Computers, Inc.

SKY Computers has been a leading innovator of high density computer boards and systems for more than 20 years. In that time, the Company has fielded numerous COTS electronics products which have found success in the demanding fields of medical imaging, industrial inspection, and in more than 30 defense and military programs. The last three product generations have included rugged versions for extended temperature, vibration, and humidity. Every new SKY product is 100% software compatible with its predecessors to minimize lifecycle software maintenance costs. SKY's computer experts have repackaged COTS solutions for harsh underwater applications, in specialized form factors for bomb detection systems, and have entered co-development efforts with customers.

SKYComputers' capabilities go well beyond the vendor expertise checklist above. SKYis a subsidiary of Analogic Corporation, a multinational $300M company built on engineering innovation and invention. With in-house, state-of-the-art manufacturing capabilities, prototypes can be built in days, not months; and full production runs of 1,500 boards per day can meet the most demanding schedules. Full compliance, regulatory, quality, and environmental testing push every product to failure to be sure it meets any/all operational demands. With 25% of our workforce devoted to engineering, the experts at SKY and Analogic mark their tenure in decades, not months or years – a testament to the Company's

SKY Repackages SKYstation for Submarine Detection and Classification

SKY was chosen by ORINCON Corporation in Washington, D.C., to supply the computer engine for the DARPASituationally Adaptive Sonar Technologies (SAST) sonar signal processing system for the detection and classification of submarines.

SKY was selected as the development and target platform for the program based on the strength and compatibility of its products. SAST uses multiple SKYcards in a small rugged VME chassis suitable for shipboard use with real-time sonar data input over an FDDI link.

SKY repackaged its SCSI-II product to provide a small, powerful, standalone signal processing computer for use in an autonomous system. The modification includes a repackaging to fit the mission application space, self-hosting capability, and battery power. Software compatibility is maintained thus it is easy to change and upgrade new algorithms from the laboratory hardware to field systems.

"The SASTprogram represents an excellent growth opportunity for SKY. The program already has committed to a substantial purchase of SKYproducts; in addition, solid performance in this environment is likely to lead to additional DARPAand Navy business," said Harry Cox, program director at ORINCON.

culture of innovation and invention. SKYbrings recognized experts in their field together for each development initiative.

SKY Extended COTS Program

Extended COTS is SKY Computers' Reformatting/Repackaging and Technology Transfer program. Put the SKY experts to the test with your next program challenge. Together, we can realize the affordability, flexibility, and upgradability benefits of COTS. SKYbegins with a thorough evaluation of the program requirements including operational objectives, upgrade and retrofit plans, and supportability goals across the life of the platform. Next, our experts go to work designing the optimal solution to the objectives. Once the designs are approved, manufacturing can begin, either in our state-of-the-art facilities, or the designs can be licensed for outside manufacturing. Simultaneously, application software development can begin using a standard COTS subsystem. The concurrent engineering process brings the program to fruition faster than an iterative process. Ongoing upgrades and support programs are built into the original design, ensuring complete application flexibility, upgradability and cost minimization.

Meet with SKY today to review the Extended COTS program.

SKY Repackages SKYbolt for Firefinder Radar

The Grumman Corporation selected SKY's compute engine for the electronics upgrade to the U.S. Army's Firefinder counterbattery radar system. The SKY board was used to improve Firefinder's detection probabilities, false location rate and projectile classification rate.

Through a technology transfer effort with SKY and Radstone, Grumman upgraded radar installations in the U.S. over a two-year period. The U.S. Army has also sold Firefinder counterbattery radar systems to a variety of friendly foreign governments. Grumman expects to generate additional contracts from foreign upgrades in countries such as Sweden and Korea.

Firefinder is a ground-based, front-line radar system that locates hostile artillery units and directs counterfire against them. Under the contract from the U.S. Army Communications and Electronics Command, Grumman, supported by the SKY board, will improve Firefinder's mobility, effective range and responsiveness to threats.

According to Walter Steck, Grumman's program manager for Firefinder, "This program clearly demonstrates the benefits of COTS technology. We have reduced the size of the radar processing unit by a factor of four while taking advantage of the fastest processing power available on the market.

"Furthermore, SKY's price/performance leadership, commitment to standards and sophisticated software tools ensure we can take the technology developed for Firefinder beyond its original market. The ability to transfer technology will not only allow us to maximize the return on our development investment, but more importantly will give Grumman a distinct competitive edge on future programs that demand this type of compute capability."