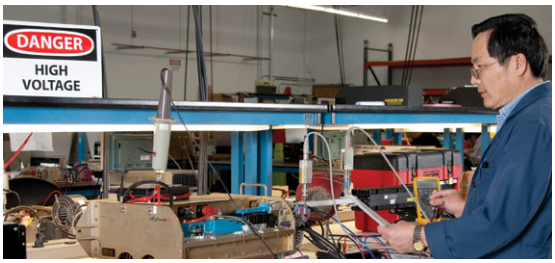
Manufacturing Reliable Defense Electronics

Defense electronics manufacturers must evolve to support complex and sophisticated platforms on the constantly changing modern battlefield.

by Steven Olson

Unmanned aerial vehicles (UAVs) like the MQ-9 Reaper (originally the Predator B) and the RQ-4 Global Hawk, have changed the military domain forever. When UAVs are involved, the modern battlefield resembles more of a video game than *Apocalypse Now.* However, even though a UAV can remove soldiers – or at least a good majority of them – from the battlefield and out of harm's way, today's war is often won in the design of the underlying technologies that go into these complex and sophisticated game changers.



A trained technician working with high-voltage, tests a TWTA.

Specifically, the MQ-9 can fly independently, operated by a pilot and a support airman in charge of sensors and weapons. These personnel operate the UAV from a ground control station thousands of miles away from actual combat. They rely on a high-resolution, all-weather synthetic aperture radar (SAR)/ ground moving target indicator (GMTI) airborne radar system to be their "eyes." The Lynx SAR/GMTI radar system onboard General Atomics Aeronautical Systems' MQ-9, as well as onboard various other unmanned and sometimes even manned platforms, provides the images. The accuracy of these images depends on the performance, reliability and operational capability of one of the most critical underlying technologies: the traveling wave tube amplifier (TWTA).

dB Control designed and manufactured high-power TWTAs used onboard the MQ-9, as well as high-voltage power supplies on the RQ-4 Global Hawk. One of the primary reasons these electronics can perform under the harshest of conditions is the manufacturer's strictly controlled processes and procedures. Because of required higher operating voltages for TWTAs and microwave power modules (MPMs), all factory personnel, including assemblers, must be extensively trained on how to work with high-voltage assemblies and products. Equipment and personal safety are vitally important.

In the defense electronics industry, reliability cannot be an afterthought. It must be incorporated in the initial design. Parts selections, manufacturing processes/controls and environmental stress screening/testing of the critical assemblies and the final product are essential for high reliability. Defense manufactures must adhere to stringent military specifications, focus on the training of assemblers and technicians, ensure repeatability of the quality of the products they produce, and do so while keeping the cost of the products affordable.

Selecting High-Quality Parts and Materials

As the demand for lighter, faster, more rugged military vehicles grows, many manufacturers are employing newer, more advanced materials. However, before integrating new components into an assembly, it is imperative that the evaluation process include a thorough design and analytical review. In fact, manufacturers must focus on verifying the design before the hardware ever gets out to the field where lives are at stake.

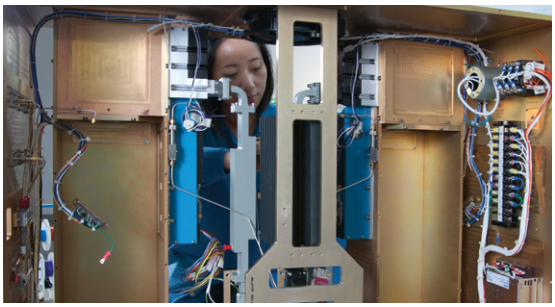
It is also essential to partner with suppliers that hold their parts to the most stringent requirements such as AS9100, the quality management standard specifically written for the aerospace industry. While AS9100 aligns with the globally recognized quality management system ISO 9001:2008 standards, there are additional requirements that must be considered, including acquisition traceability, configuration management, product documentation and control of work performed outside the supplier's facilities.

Manufacturing Process Controls Ensure Reliability

Another element of an effective defense manufacturer is internal process control, a method used to collect information during production so that productivity trends and quality issues can be identified and the process continuously improved. While the commercial market thrives on original applications and consumer demand, military applications require specialized innovation backed by mature technologies. Defense manufacturers must abide by proven, repeatable methods supported by stringent certifications and military standards.

For instance, dB Control assemblers are trained and certified to IPC-A-610 (Class 3) Acceptability of Electronics

Assemblies and IPC/EIA J-STD-001 (Class 3) Certified for Soldered Electrical and Electronic Assemblies. Both standards are recognized worldwide. The processes and standard operating procedures the assemblers use are consistent across product lines, no matter whether an amplifier is designed for use in a rugged environment with an extreme vibration requirement, such as in a military helicopter, or in a rack-mounted system similar to those commonly seen in commercial manufacturing facilities. In both cases, each assembly has the ruggedized design built into the product.



An assembler prepares a TWTA for test and integration.

Pushing Assemblies to the Limit

Once a design is established, proven on paper and preproduction runs are assembled, a full environmental testing regimen is required to mimic a long mission life. Reliable, internal screening processes must be incorporated into all aspects of the assembly manufacturing process and should be constant across the operation. In addition, using established, mature techniques facilitates repeatability.

Pushing subassemblies to extremes, regardless of the specific application, ensures that potential reliability issues are resolved before the units are shipped to customers. While this often requires defense contractors to invest more up front (training, documentation, etc.), doing so extends the lifecycle of the assembly, and thus reduces its total cost. In addition, using proven assembly designs reduces replacement costs and downtime in the field resulting from failed units. Reliability is also a critical issue for many defense contractors, as anticipated dwindling defense budgets will not support a surplus of spare components.

Protecting High-Voltage Defense Electronics

With much more output power than solid-state based products, TWT amplifiers (TWTAs) and microwave power modules (MPMs) can be used for numerous applications, such as radar, electronic counter measure (ECM) systems, electronic warfare (EW) simulation, test and measurement and data links. TWTAs and MPMs pack a lot of power in a small package. This can only be accomplished through a high-density packaging design. Proprietary potting and encapsulation manufacturing technology enables decreased size and weight so that the components within the final product are held closely together.

Regardless of size, military equipment must perform reliably for extended periods of time in rugged environments. Components are vulnerable to dust, moisture and extreme temperatures. Conformal coating solves this problem by protecting assemblies from the elements. Because of the nonconductive properties of conformal coatings, they cannot be used where electrical contact is required or on mechanical interface locations (i.e., connector pins or mounting holes). Finally, manufacturers must ensure that electro-static discharge (ESD) safety guidelines are followed throughout the manufacturing process to ensure that components are protected.

Manufacturers must make a substantial investment in capital equipment, engineering development and proprietary procedures held under disciplined documentation control to ensure mission-critical components are achieved. For example, dB Control's 40,000 square-foot facility in Fremont, California contains a modern encapsulation and potting laboratory and a dedicated environmental test area, which includes shock and vibration equipment, temperature cycling and altitude chambers. In addition to investing in equipment, manufacturers who deal with high voltages must provide extensive and costly training for personnel to ensure they thoroughly understand and practice proper safety precautions. While large-scale contract manufacturers may not choose to invest the time and money to train employees in these procedures, manufacturers who specialize in high-voltage environments must ensure that technicians are accurately building and testing products.

Manufacturing to Withstand the Heat

Emerging military applications often require that more power be housed in a smaller enclosure, which creates more heat that must be removed. Effective thermal dissipation starts with good design and modern materials. For example, manufacturers should employ high-temperature materials that improve performance while still lowering material and manufacturing costs.

Specifically, thermal management in TWT amplifiers can be accomplished by including large-area heat sinks and forced-air cooling fans. Traditionally, TWTA manufacturers have used solid copper heat sinks under the collector blocks to reduce thermal stress and increase the life of the amplifier. Unfortunately, this solution is not ideal for modern applications, as copper weighs more than aluminum. Some manufacturers have found that specialized aluminum injected with carbon composites provides improved thermal management for rugged defense applications.

Balancing It All

The modern battlefield is in a constant state of transformation. New threats to national security arise daily – sometimes even hourly. A successful defense electronics manufacturer must evolve to support this dynamic landscape. Technological

strengths, experience of personnel, manufacturing capabilities and facility capacity all come together to produce reliable, technically-superior products on time and within budget. This is especially true when manufacturers are providing the underlying technologies of the complex and sophisticated platforms, like the MQ-9 Reaper or RQ-4 Global Hawk.

Liquid nitrogen is used to simulate extreme cold temperatures.

In addition to the expected challenges faced to achieve these goals, manufacturers should have a plan in place to survive expected DoD budget cuts. One option is to add commercial products to the defense portfolio. For instance, in addition to being employed by the military, UAVs are also being used by the U.S. Customs and Border Protection Agency. The CBP flies a fleet of MQ-9s along the United States borders for homeland defense, customs and immigration enforcement and monitoring drug trafficking. And in late 2010, the RQ-4 Global Hawk was used for NASA's GRIP Mission to monitor the development of Atlantic basin hurricanes. Other applications that may make UAVs immune to potential budget cuts include commercial imaging, search and rescue, and natural disaster relief.

The one constant for any successful defense electronics supplier is reliability. Mission-critical hardware must be the byproduct of quality manufacturing practices and continuous improvement. After all, performance, reliability and operational capability are nonnegotiable. ■

Steven Olson is the marketing manager at dB Control. An industry veteran, he has marketing, business development, and program management experience with microwave, radio frequency and high-power product solutions for a range of industries, including defense, communications, industrial, medical, scientific, and others. Olson holds a BS in Marketing from San Jose State University, San Jose, Calif. and an MBA from Notre Dame de Namur University, Belmont, Calif.