# Beyond Ruggedization

## Ensuring Long-Term Reliability

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# Unmatched Long Term Reliability

Evaluating and comparing rugged commercial off-the-shelf (COTS) products and COTS-based solutions can be confusing. Although military ruggedization standards make the process easier, the techniques and methodologies used to ensure ruggedness and reliability can differ from one vendor to another.

Ruggedization involves testing and validating that COTS solutions can withstand extreme temperatures, shock, vibration, and other challenging environmental conditions present in aerospace and defense applications. Reliability requires much more in-depth, scientific testing and validation to ensure that ruggedized solutions dependably perform in the harshest field conditions for many years.

Curtiss-Wright Defense Solutions goes well beyond standard industry processes to deliver ruggedized solutions with trusted and proven reliability that cannot be matched in the industry. And we use the insight gained through our advanced reliability testing to continuously optimize designs and further improve reliability.

## Root Cause Analysis Drives Innovation

### RELIABILITY DEFINED

Curtiss-Wright follows the reliability definition in the IPC-9701A standard.

"The ability of a product to function under given conditions and for a specified period of time without exceeding acceptable failure levels."

To ensure our technology doesn't fail in the field, we push it to the point of failure in the lab. We start testing for failures in the earliest stages of development and continue throughout the manufacturing process.

We use in-depth statistical analysis to understand the physics of failure – reliability physics – and the math behind it. We also use a range of advanced equipment and destructive and non-destructive analysis techniques to identify, evaluate, and understand why failures occurred, including:

+ Microsectioning
+ Scanning Electron Microscopy (SEM)
+ Energy Dispersive X-Ray Spectroscopy (EDS)
+ Scanning Acoustic Microscopy (SAM)
+ Fourier Transform Infrared Spectroscopy (FTIR)
+ X-Ray Fluorescence (XRF)
+ Dye-and-pry dye penetrant inspection

The insights we gain allow us to develop innovative mitigation techniques. And every mitigation we apply is tested and retested to verify it corrects the issue that caused the failure.

# Bringing New Levels of Reliability to Every Aspect of Solution Design

With our scientific approach to advanced reliability testing and analysis, and failure mitigation, we push reliability to the highest possible levels in every aspect of solution design.

## Extremely Robust Mechanical Designs

To ensure product integrity, Curtiss-Wright uses finite element analysis (FEA) tools to model mechanical designs and regularly test hardware, components, and connectors on representative boards. For example, the shock and vibration tests we put all circuit card assemblies (CCAs) through is key to understanding, measuring, and mitigating fretting wear and corrosion on connectors.

We also use enhanced, high reliability FR4 material for all of our rugged solutions and execute interconnect stress testing (IST) to weed out faulty PWBs prior to assembly.

All of our tests are based on decades of research and innovation that have led to new industry standards. For example, the VPX connector testing approach that we spearheaded as part of the original VPX (VITA 46.0) connector testing effort is now the benchmark for all new VITA-compliant connector tests. Our test methodologies have been applied to several VPX connector types, including optical interconnects, and are considered to be the most comprehensive ways to evaluate connector reliability.

## Superior Thermal Dissipation and Resilience

To ensure our solutions perform reliably for long periods of time in extreme environments, we put extensive time and effort into rigorous thermal testing and analysis. For example, we model and thoroughly test thermal designs to ensure they increase power dissipation while remaining within device limits. Our innovations in this area include using:

- TherMax thermal frame designs to increase heat flow from components to the external thermal interface
- Heat shunts from hot components to an unused chassis interface above the wedgelock
- Heat shunts from high-power PMC modules directly to the thermal interfaces
- The first effective solution development using heat pipes to cool a very high-power processor device

In addition, we perform rigorous thermal cycling tests to identify the risks associated with new and challenging electronic packaging, such as fine-pitch ball grid arrays (BGAs), lead-free packaging, stacked microvias, and lead-free solder.

At the solution level, we test to the VITA 47 ECC4 level as part of our standard evaluation and continuous improvement processes. Our analyses of test results and mitigation approaches have led to innovations in lead-free solder, microvia techniques, and other technologies that increase long-term reliability in the field.

For more information about the thermal management techniques used by Curtiss-Wright, check out our Thermal Management in Rugged Computer Systems white paper. To keep ruggedized systems running smoothly and performing as designed, suppliers have a variety of techniques they can use, including conduction, convection, Air-Flow-Through (AFT), Liquid-Flow-Through (LFT), and Fluid-Flow-Through (FFT). The white paper looks at the different cooling techniques available and aims to provide clarity on how to choose the best solution.

**We perform rigorous thermal cycling tests to identify the risks associated with new and challenging electronic packaging.**

## Pioneering Techniques in Lead-Free Solder

To address increasingly strict industry regulations around the use of lead, we have developed one of the industry's most advanced capability sets for implementing lead-free solder. Our techniques incorporate the critical knowledge we gained through our involvement in industry consortia, such as Pb-Free Electronics Risk Management (PERM), as well as Independent Research and Development (IRAD) projects, and more than a decade of testing. This enables our customers to comply with Restriction of Hazardous Substances (RoHS) and Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulations with complete confidence their solutions are engineered and proven to perform over the long term in the most rugged field conditions.

## Reliable High Density Interconnect (HDI)

To squeeze more functionality into smaller physical spaces without compromising reliability, we leverage more than two decades of reliability testing on PWB designs and technologies to successfully implement increasingly dense interconnects.

Our innovations in PWB interconnects include highly reliable microvias. Ensuring reliability of microvias is difficult, but very important as it's generally accepted that inferior microvia implementations can lead to early failures in defense and aerospace applications.

## Reliability at Almost Invisible Levels

To ensure that no PWB weaknesses go undetected, we take our reliability testing, fault identification, and mitigation techniques to microscopic levels. And, we have been going to these lengths for years.

For example, we've primarily used a single tested and proven material for close to a decade to mitigate against pad cratering. Pad cratering occurs when a mechanical stress such as temperature, vibration, or PWB bending creates tiny cracks that detach the pad from the PWB, leaving a "crater" on the board. It is one of the most insidious failures that plagues high-reliability electronics, but it can be difficult to detect.

We also lead industry efforts in applying conformal coatings, cleaning techniques, and lead-free soldering techniques that are proven to mitigate against tin whiskers. Tin whiskers are another extremely small, yet dangerous phenomenon that can occur on CCAs. These needle-like, crystalline structures are 10 to 100 times thinner than a human hair but conduct electricity and can cause short circuits on CCAs.

## Environmental and Stress Testing

To verify design integrity, all of our solutions are subject to strict qualification testing. For example, environmental testing is performed to MIL-STD-810 guidelines.

Every rugged product undergoes an Environmental Stress Screen (ESS), running functional test software. Hot and cold starts and variations of supply voltage are applied to identify early component failures or manufacturing defects.

# Never-Ending Dedication to Reliability Improvement

Curtiss-Wright understands that long-term reliability is the ultimate goal. That's why we've invested so much time, effort, and money to go above and beyond standard industry approaches to ruggedness and reliability testing.

Because we've been dedicated to improving reliability for decades, we have a huge knowledge base and extensive experience to draw on. And, because our reliability testing procedures are applied to every solution we offer, they affect almost every company process.

## Continuously Improving Reliability

We've used the results of our extensive failure testing and analysis to implement a number of operational improvements, including:

+ Reliability risk assessment (RRA) and mitigation on all new solutions, leveraging data in a reliability knowledge database
+ Reliability prediction tools
+ PWB design and fabrication and in-house manufacturing to IPC Class 3 enhanced with additional rules
+ Extensive qualification testing with full functional testing
+ VITA 47 Reliability Demonstration Testing (RDT)
+ In-house manufacturing to IPC Class 3
+ ESS for all ruggedized solutions
+ A microsectioning lab for failure analysis
+ Solution reliability tracking

Together, these initiatives allow us to take a holistic view of reliability. They also serve as a strong foundation as we continue to advance our failure detection and analysis capabilities to further increase the long-term reliability of our solutions in the field. And that reliability is one of the key reasons Curtiss-Wright has been a trusted provider of rugged and reliable solutions that have been proven in the field for decades.

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