



How the aerospace industry is facing the lead-free challenge.

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White Paper: Prepared by the Lead-free in Aerospace Project- Working Group (LEAP-WG). This group is jointly sponsored by the Aerospace Industries Association (AIA), Avionics Maintenance Conference (AMC), and the Government Electronics and Information Technology Association (GEIA).

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Shared concerns regarding the impact of lead-free technology on aerospace electronics have prompted the formation of the Lead-free in Aerospace Project- Working Group (LEAP-WG). This group is jointly sponsored by the Aerospace Industries Association (AIA), Avionics Maintenance Conference (AMC), and the Government Electronics and Information Technology Association (GEIA). This is an international working group which includes active members from North America and Europe. Represented among the membership are most of the world's major aircraft manufacturers and defense contractors, many mid-tier suppliers, and relevant governmental/customer organizations. The group has been working since early in 2004 to develop a set of documents that provide guidelines and standard practices to meeting the challenges of lead-free that are acceptable for use across our industry. These documents are being issued initially in the United States by the GEIA, and will then be submitted to the International Electrotechnical Commission (IEC) for adoption globally.

The global electronics manufacturing industry is in the midst the lead-free/RoHS (Reduction of Hazardous Substances) revolution. Most commercial electronics manufacturers began delivering RoHS compliant systems before the July 2006 European deadline. The situation is very different within the aerospace and military electronics industries. Most of the products manufactured within these industries are excluded from the European RoHS legislation, or are covered by approved exemptions. Few, if any, aerospace and defense manufacturers have near-term plans to comply with RoHS. However, these manufacturers are already feeling the effects of RoHS, and so are working together face challenges.

Aerospace and high-performance electronics industries draw upon the same supply chain for electronic components and materials as does the broader population of electronics manufacturers. The volume of materials and components purchased by commercial manufacturers greatly exceeds that purchased by aerospace manufacturers. Not surprisingly, suppliers focus their attention on the needs of their customers, most of whom demand RoHS compliance. Existing legacy products are sometimes supplied in both tin-lead and lead-free forms, but usually only temporarily before converting to the single RoHS-compliant version. New products are being introduced exclusively in RoHS-compliant (lead-free) form.

Avionics, military electronics, and other high reliability electronic applications differ in significant ways from the vast majority of commercial and consumer electronic applications. Field environments often include extreme conditions: extreme climates, high-altitude, high levels of shock and vibration, underwater exposure, and the extremes of space. Product lifetimes are often measured in decades, rather than in years or months. Significantly, maintenance and repair activities are routinely performed down to the level of replacing individual components on circuit cards. These maintenance and repair activities often occur many years after initial manufacture, at varied and distant locations, and under the control of agencies not always under control by the OEM. Finally, failure of the equipment to perform may have dire consequences.

Most of the principal stakeholders in the exempted industries realize the challenge posed by these issues. It is also recognized that consensus on common approaches will provide significant savings for the entire industry, as compared to the pursuit of divergent approaches.

As of January 2008 there are four documents that have already been issued by GEIA, with three additional documents still in progress. A description of each of these documents is provided below. Note, it is the intent of all the LEAP WG documents to work in concert with other published lead-free documents; and to address issues unique to, and within the control of, aerospace and other high performance electronics

Released documents:

[GEIA-STD-0005-1](#), "Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder"

This document specifies that users develop and implement written Lead Free Control Plans (LFCP). The purpose of the plan is to document processes that assure the Plan owners, their customers, and all other stakeholders that aerospace and high performance high-reliability electronics systems will continue to be reliable, safe, producible, affordable, and supportable.

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[GEIA-STD-0005-2](#), “Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems”

Although many aerospace electronics manufacturers will continue to use tin-lead as an attachment alloy for printed wiring assemblies, they will be forced to use piece parts with lead-free alloy finishes, the most common of which is pure tin. Pure tin finishes promote growth of “tin whiskers,” which can cause serious reliability problems in aerospace systems. The technical details of tin whisker growth and control are not completely understood; but their effects must be controlled in aerospace products. This standard provides a framework to execute certain levels of control and specifies that users develop and implement written Tin Whisker Risk Mitigation Plans. Requirements for plans are structured according to standard levels of mitigation, which are selected by aerospace electronics manufacturers and users, based on the level of control required for the given application. Appendices to the standard provide guidance and insight into addressing risks associated with tin whiskers.

[GEIA-HB-0005-1](#) “Program Management / Systems Engineering Guidelines for Managing the Transition to Lead-Free Electronics”

This handbook provides assistance for programs in assuring the performance, reliability, airworthiness, safety, and certifiability of product(s), in accordance with GEIA-STD-0005-1. Since the program manager is responsible for the overall reliability and performance of the product and since lead-free transitions may impact both reliability and performance, the purpose of this handbook is to illustrate what concerns should be voiced to ensure the lead-free transition does not have a negative impact to the product. Working with the program manager is the engineer who is responsible for assuring that all system requirements are addressed and verified via design and integration (typically the Lead Systems Engineer, or Technical Director, or Engineering Project Manager). Hence, the document was generated for both disciplines to use in assuring proper program execution and customer satisfaction.

[GEIA-HB-0005-2](#) “Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder and Finishes”

This document provides technical guidance for the use of lead-free solder and mixed Tin-Lead/Lead-free alloy systems while maintaining the high reliability standards required for aerospace electronic and electrical systems. The document discusses such topics as:

1. approach for analysis of tests and data
2. lead-free solder behavior
3. system level service environments
4. high performance electronics testing
5. solder joint reliability conditions
6. components
7. printed wiring boards
8. printed wiring board assemblies
9. module assembly conditions
10. aerospace wiring conditions
11. repair/rework
12. modeling/analysis

[Lead-Free Control Plan Template](#)

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This document provides a framework for generating a lead-free control plan that would satisfy the requirements cited in GEIA-STD-0005-1 "Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder". While companies are not required to use the template, it is intended to foster uniformity across the aerospace/defense industry.

Document in ballot cycle:

GEIA-STD-0005-3 "Performance Testing for Aerospace and High Performance Electronic Interconnects Containing Pb-free Solder and Finishes"

With the implementation of lead-free technology, aerospace and defense companies are faced with questions as to whether these new materials will provide, as a minimum, the same degree of confidence during the life cycle of critical systems and products.

Two approaches are used for evaluating performance: analysis/modeling and test. This document addresses the latter providing guidance and direction in the development and execution of performance testing of lead-free electronic interconnections. Users to be aware that document does not give answers as to how to perform a specific test. Because products and systems applications vary immensely, designers need to understand use conditions and the entire life cycle. Once this is understood, then this document can be used to give designers an understanding of how to develop a suitable test, e.g. ascertain the type of platform in which a product will be used, comprehending all the environmental effects on the platform, learning about why material characterization is key to deciding upon test parameters, etc. The standard is intended to provide a suitable approach to test lead-free assemblies. Users may utilize the data for whatever purpose they desire, i.e. reliability analysis, process development, etc.

Documents under development:

GEIA-HB-0005-3 "Guidelines for Repair and Rework of Lead-Free Assemblies Used in Aerospace and High-Performance Electronic Applications" (provisional title)

This document provides guidelines for repair and/or rework of Aerospace and High Performance electronics systems. It provides technical background, procurement guidance, engineering procedures and guidelines to assist organizations repairing and/or reworking. Anticipated release is mid-2008.

GEIA-HB-0005-4 "Guidelines for Performing Reliability Predictions for Lead-Free Assemblies used in Aerospace and High-Performance Electronic Applications" (provisional number and title)

This document will describe methods of quantifying the effects of lead-free solder on system reliability and certification analysis. This effort is just getting underway, so the document title and number are not yet fixed, nor has the anticipated release date been defined.

Aerospace Lead Free Timeline Report

The Lead Free Working Group LEAP-WG conducted a survey to help answer questions about events and milestones expected in the near future and out to 10 years and beyond. We are currently analyzing responses from across aerospace and defense, our supply base, research institutions and our knowledge base. We expect this timeline to become a roadmap that looks forward through and beyond the lead-free transition. Possible insights, conclusions and reasoned deductions can help our businesses to set direction, anticipate new challenges and plan forward.