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 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 two 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 November 2006 there are three 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 lead systems engineer who is responsible for assuring that all system requirements are addressed and verified via design and integration. Hence, the document was generated for both disciplines to use in assuring proper program execution and customer satisfaction.

Documents under development:

GEIA-HB-0005-2 "Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder and Finishes" (Planned date for initial release by GEIA: December 2006)

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

GEIA-STD-0005-3 “Reliability Testing for Aerospace and High Performance Electronics Containing Lead Free Solder” (Planned date for initial release by GEIA: June 2007)

The purpose of this document is to provide guidance for reliability testing of aerospace and high performance products containing lead-free solder and a protocol for designing, conducting, and interpreting results from reliability tests. This document will provide a default method for performing reliability testing in the near term. Although several major reliability test programs are nearing completion, some time will be required before the data can be understood and characterized. In the meantime, manufacturers need a methodology to conduct their own reliability given their own unique set of service conditions. The protocol, presented in this document, is meant to be used when little or no other information is available to define, conduct, and interpret results from reliability tests for electronic equipment containing lead-free solder.

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

This will be a document providing guidelines for repair and maintenance of lead-free electronics. This effort is just getting underway, so the anticipated release date has not yet been defined.

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.