Aerospace Response to Lead-free Solder - A Program Manager's Guide

Patricia Amick, Anduin Touw, Lloyd Condra, William Procarione,
The Boeing Company, St. Louis, MO

Abstract
On July 1, 2006, lead and certain other hazardous materials were banned from most forms of new electronic equipment in the countries of the European Union. Although most aerospace products are not directly subject to these restrictions, we are being forced to consider the use of lead-free materials and assembly processes that electronic part and assembly manufacturers implement for their non-aerospace target markets. This transition is disruptive to the aerospace industry, which must accommodate decisions made by others, while continuing to assure that aerospace products are reliable, repairable, certifiable, airworthy, supportable, affordable, and safe.

To be cost and performance effective, common solutions must be developed and accepted by commercial, military, and space avionics original equipment manufacturers (OEMs), platform integrators, operators, and regulatory agencies. The Aerospace Industries Association (AIA), Government Engineering and Information Technology Association (GEIA), and Avionics Maintenance Conference (AMC) has formed the Lead-free Electronics in Aerospace Project Working Group (LEAP WG) to enable the aerospace industry to accommodate lead-free electronics, provide common standards, and facilitate communications within the aerospace industry and with other industries. Its deliverables include a standard for defining top level requirements, a standard for delineating the detrimental effects of tin whiskers, and a handbook for assisting program and system engineering management in the transition. Four additional documents are also in work, covering reliability test protocols, technical guidelines for various aspects of the transition, reliability analyses/modeling, and rework/repair and maintenance.
The LEAP WG cooperates with other aerospace organizations to assure participation in this work and implementation of its results across the entire aerospace industry. This paper reports on the status of the work, with an emphasis on the program manager's handbook and an invitation for participation by all interested parties.

Introduction
Due to a variety of potential health and environmental issues, many constituent materials used in the production of electronic products have come under scrutiny. The European Union (EU) has enacted two directives; [1]2002/95/EC Reduction of Hazardous Substances (RoHS) and [2]2002/96/EC Waste Electrical and Electronic Equipment (WEEE) that restrict or eliminate the use of various substances in a variety of products that are now being produced. One of the key materials restricted is lead, which is widely used in electronic solder, printed wiring board (PWB) finishes, and electronic piece part termination finishes. While these regulations may appear to only affect products for sale in the EU, due to the reduced market share of the aerospace and high performance industry in electronics, many of the lower tier suppliers of components used in aerospace applications will change their products in response to the requirements of their target markets (e.g., consumer, computer). Additionally, several states in the United States of America have enacted similar "green" laws and many Asian electronics manufacturers have recently announced completely green product lines.

An aerospace-wide approach to the transition was determined to be of high value, due to the high criticality of aerospace and high performance (AHP) electronic systems, the immaturity of lead-free materials and processes, and the reliance of the industry on repair of circuit card assemblies. The Aerospace Industries Association (AIA), Government Electronics and Information Technology Association (GEIA), and the Avionics Maintenance Conference (AMC) formed the LEAP WG for the purpose of generating a series of industry standards and handbooks for the use and handling of lead-free solder and components in military and aerospace applications.

Seven documents are in various stages of publication and preparation by the LEAP WG, as shown in Figure 1. Two of the standards and one handbook have been completed and published by the GEIA. They have also been submitted for publication to the International Electrotechnical Commission (IEC) for international publication and use. Four additional documents are in work and are in various stages of completion.

[3]GEIA-STD-0005-1	Performance Standard for Aerospace and Military Electronic Systems Containing Lead-free Solder	Lloyd Condra, Boeing, Team Leader	Published by GEIA 30 June 2006	Submitted for publication by IEC 31 December 2006
[4]GEIA-STD-0005-2	Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems	Anduin Touw, Boeing, Team Leader	Published by GEIA 30 June 2006	Submitted for publication by IEC 31 December 2006
[5]GEIA-HB-0005-1	Program Management / Systems Engineering Management Guidelines for Managing the Transition to Lead-free Electronics	Patricia Amick, Boeing, Team Leader	Published by GEIA 30 June 2006	Submitted for publication by IEC 31 December 2006
[6]GEIA-HB-0005-2 (unpublished work)	Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-free Solder and Finishes	Stephan Meschter, BAE Team Leader	To be submitted for publication by GEIA 31 December 2006	Proposed submittal for publication by IEC 30 June 2007
Proposed [7]GEIA-STD-0005-3 (in work)	Reliability Testing for Aerospace and High Performance (AHP) Electronic Systems Containing Lead-free Solder	Anthony Rafanelli, Raytheon, Team Leader	Proposed publication by GEIA 30 June 2007	Proposed submittal for publication by IEC 31 December 2007
Proposed [8]GEIA-HB-0005-3 (in work)	Rework, Repair, and Maintenance of AHP Electronic Systems Containing Lead-Free Solder	Timothy Kalt, WPAFB, Team Leader	Proposed publication by GEIA 30 June 2007	Proposed submittal for publication by IEC 31 December 2007
Proposed [9]GEIA-HB-0005-4 (in work)	Reliability Assessment for AHP Electronic Systems Containing Lead-Free Solder	John Biel, Smiths Industries, Team Leader	Proposed publication by GEIA 30 June 2007	Proposed submittal for publication by IEC 31 December 2007

Figure 1 - AIA-GEIA-AMC Documents in Various Stages of Development and Publication

[3]GEIA-STD-0005-1, Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder. This document defines the requirements for documenting lead-free processes that assure that AHP electronic systems will satisfy the applicable requirements for performance, reliability, airworthiness, safety, and certifiability throughout the life of the system.

[4]GEIA-STD-0005-2, Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems. This document describes the effects of items containing pure tin-finish in AHP electronic systems. It provides a framework to communicate and agree on the processes to be used to mitigate the detrimental effects of pure tin.

[5]GEIA-HB-0005-1, Program Management / Systems Engineering Management Guidelines for Managing the Transition to Lead-Free Electronics. This document describes technical guidance to educate Program Managers and System Engineers on the issues and concerns associated with the transition from tin-lead to lead-free solder processes.

[6]GEIA-HB-0005-2, Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-free Solder and Finishes. This document describes technical guidance to aerospace and high performance electronic system suppliers, in developing and implementing lead-free designs and processes.

[7]Proposed GEIA-STD-0005-3, Reliability Testing for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder. This document describes methods to design, conduct, and interpret results from reliability testing.

[8]Proposed GEIA-HB-0005-3, Rework, Repair and Maintenance of Aerospace and High Performance Electronic Systems Containing Lead-free Solder. This document will describe technical issues/impacts and methods of rework and repair. It will also provide technical guidance for No Fault Found failures, when or when not to repair, part marking, and configuration management.

[9]Proposed GEIA-HB-0005-4, Reliability Assessment for Aerospace and High Performance Electronic Systems Containing Lead-free Solder. This document will describe the methods of reliability assessment, modeling, reliability impacts on design, and failure rate predictions.

Program Management Guidelines Overview

It was recognized early in discussions among avionics customers, systems integrators, and suppliers that a vehicle was needed to inform program management on all of the various issues of possible lead-free (Pb-free) transition efforts. To that end, [5]GEIA-HB-0005-1, "Program Management / Systems Engineering Management Guidelines for Managing the Transition to Lead-Free Electronics", was created by a team effort of ten organizations (Figure 2) within the LEAP WG.

Boeing, Team Lead
ACI
AIA
Bombardier
EADS
FAA
Lockheed-Martin
Raytheon
Parker
US Navy

Figure 2 - [5]GEIA-HB-0005-1 Document-Writing Team

The handbook is designed to assist program management and/or systems engineering management personnel in managing the transition to Pb-free electronics to assure product reliability and performance. Note that Pb-free technology can impact any program regardless of whether or not the program itself is subject to environmental regulations. **Also, note that [5]GEIA-HB-0005-1 does not assume that an avionics system is purposely converting to Pb-free**, but that Pb-free may enter the system regardless in one or several of the following ways:

- Through a change of a piece part termination finish to Pb-free;
- Through a supplier changing a printed wiring board (PWB) finish to Pb-free;
- Through a supplier changing the assembly solder to Pb-free;
- Through use of commercial-off-the-shelf (COTS) items.

The handbook starts with a general discussion of program management / system engineering concerns, then discusses program impacts. It also contains appendices describing tools that can be used in conjunction with the handbook. Please note that for the purposes of the handbook, "Program Manager" refers to program management and/or systems engineering management and/or the appropriate enterprise authority. Only the terms "Program Manager" and "Program Management" are used for the purposes of streamlining the document. The implications are that all of the aforementioned organizations work together in ensuring that all impacts of Pb-free are understood and risks are mitigated, and that it is not necessarily the actual program manager that is responsible for each effort.

Program Management Concerns

A program manager's role is to be aware of how a change will affect the program, regardless of whether the program deliverable is an avionics system, electronics unit, assembly, or a piece part. The change from traditional tin-lead (SnPb) solder to Pb-free will affect all electronics programs, regardless of integration level or size. In accordance with [3]GEIA-STD-0005-1, program management concerns should include reliability, configuration control, risk management, effects of pure tin in a system, and rework/repair and maintenance. The program manager also has additional concerns from a programmatic point of view. These include cost, use of commercial off-the-shelf, quality, contractual concerns, and schedule impacts (shown in Figure 3).

PROGRAM MANAGER CONCERNS (in accordance with [3]GEIA-STD-0005-1)
Reliability **Configuration Control** **Risk Management** **Detrimental Effects of Tin** **Rework/Repair & Maintenance**
ADDITIONAL PROGRAM MANAGEMENT CONCERNS
Cost **Commercial Off-The-Shelf** **Quality** **Contractual Language** **Schedule Impacts**

Figure 3 - Program Management Concerns

Program Management Concerns in Accordance with [3]GEIA-STD-0005-1

Reliability must be a top priority of aerospace and high performance electronic systems. The program manager should understand how the transition to Pb-free may affect the overall reliability of the system. System reliability may be adversely affected from either mixing SnPb and Pb-free alloys (e.g., use of Pb-free finished piece parts on SnPb-finished PWBs) or by how the Pb-free introduction reacts to the use environment (e.g., extreme high/low temperatures or excessive vibration). Reliability may also be compromised from manufacturing processes that require higher reflow temperatures to adequately solder the Pb-free alloy. Higher processing temperatures can cause more frequent piece part failures, PWB failures, assembly failures, and earlier reflow equipment malfunctions.

The need for configuration control in a Pb-free transition is extremely important. The program manager should understand the appropriate configuration controls that are necessary and encourage prime suppliers to do the same with regards to their sub-tier suppliers. For some high performance systems, the material content of the Pb-free alloy (used on piece part terminations, PWB finishes, and/or assembly solder) must be known to assure adequate reliability and performance of the delivered system (excessive amount of bismuth in the termination finish, for example).

Risk identification and risk assessment need to be performed for the Pb-free transition on the appropriate level. Risks need to be identified early and coupled with appropriate mitigation techniques. The risks from Pb-free introduction on all levels need to be rolled up into the overall system risk management plan.

Pure tin piece part terminations can have detrimental effects to the functionality of a system, due to spontaneous growth of tin whiskers from the termination surfaces. Program managers need to have a plan for either eliminating the use of Pb-free tin in their product (i.e., through life-time buys or refinishing terminations) or a plan for addressing and mitigating the tin whisker risks. [4]GEIA-STD-0005-2 provides standard methods for controlling and mitigating the use of Pb-free tin finished piece parts.

Rework, repair and maintenance of systems are extremely important in general to AHP electronic systems, where the systems are repaired at the printed wiring assembly level and the cost of replacement is too high. Mixing SnPb and Pb-free assemblies, PWBs, or piece parts may introduce unacceptable risks to the reliability of the system, especially if the person performing the rework, repair, or maintenance is unaware that there are different solder alloys present.

Additional Program Management Concerns

The costs of any facet of a Pb-free transition need to be quantified and decisions made as to how the additional costs will be handled. The program manager should also be aware that the situation will be dynamic over the next several years. Added costs may come from additional risk management determination, additional configuration controls, rework/repair and maintenance changes, drawing / design changes, or re-qualifying or re-testing.

The very nature of COTS items may involve Pb-free substitution irrespective of program requirements and the program manager may not be able to exert sufficient controls. For COTS piece parts, the program manager should understand [4]GEIA-STD-0005-2 to mitigate the risks associated with Pb-free finished terminations. For COTS assemblies, the program manager should be aware of the possible risks due to COTS assemblies containing either Pb-free piece part termination finishes and/or Pb-free soldered assemblies. A parts, materials, and processes control plan is highly advantageous.

Quality is a critical consideration in the transition to Pb-free and the program manager needs to be assured that the final product meets the technical and operational requirements with the specified reliability at all levels. This needs to include flow of requirements, implementation and documentation through and to subcontractors.

Appropriate contractual language needs to be included in new contracts that describe the customer requirements regarding Pb-free. Existing contracts will in all likelihood not have addressed Pb-free requirements. However, the program manager needs to coordinate with the customer as to the best approach for meeting the intent of [3]GEIA-STD-0005-1 and [4]GEIA-STD-0005-2.

Also, the program manager needs to be proactive in understanding all of the impacts to the schedule changes due to re-qualification efforts, additional quality inspections, additional reliability testing, or lifetime buys of long-lead SnPb-finished piece parts due to obsolescence, for example.

Program Impacts

There can be numerous program impacts from the introduction of new variables, such as Pb-free. The program manager needs to consider (or reconsider for existing programs) acceptance decisions, requirements definition, supplier procurement and subcontractor control, re-qualification, rework/repair and maintenance documentation, and customer education and interaction.

Early in the program schedule, the program manager must decide whether or not Pb-free will be accepted on the program and at what level (i.e., piece part termination finish, PWB finish, and/or assembly solder). Once that decision is made, the program manager should consider requiring compliance to [3]GEIA-STD-0005-1 to assure the supplier has the Pb-free transition under control. A re-evaluation of the program requirements should be performed to determine the impact of the Pb-free transition, including customer requirements, international/national/state directives and laws, and additional prime contractor requirements. Also, it should be determined if any change from SnPb to Pb-free constitutes a change for which customer approval is needed.

Communication with the supplier is critical. The supplier should be cognizant of the possible reliability issues related to Pb-free solder entry into an AHP electronic system. The program manager and customer need definitive assurance from the supplier (in the form of test data or analyses) that the transition from SnPb to Pb-free will not impact reliability of the product in the use, storage, and transport environment(s). The program manager should consider requiring a lead-free control plan (LFCP) from the supplier making the Pb-free transition (described in [3]GEIA-STD-0005-1). Elements of the LFCP may include the supplier procurement and subcontractor control plan, producibility plan, manufacturing changes, manufacturing risk management, and the schedule of Pb-free implementation. The program manager needs to be assured that the supplier is also controlling and mitigating the risks of the Pb-free transition of its sub-tier suppliers.

The program manager with customer concurrence should determine if the product that is transitioning should be re-qualified, partially qualified, accepted by analysis/test, or acceptance by similarity. Rework/repair procedures should be requested from the supplier that specifies the differences due to the Pb-free use. Note, for commercial aerospace applications, program managers may also refer to [10]ARINC Report 671, that gives specific guidance for soldering, maintenance, and repair.

The customer should be engaged throughout the transition. The program manager should brief the customer on the program-level aspects of the Pb-free transition. Deliverables may include the supplier Pb-free implementation plan, updated risk management plan, configuration control plan, recommended rework/repair procedures, cost impact analyses, possible performance and/or reliability impacts, and schedule impacts.

Brief Descriptions of [5]GEIA-HB-0005-1 Appendices

The appendices in [5]GEIA-HB-0005-1 describe tools that can be used in conjunction with the handbook. Due to space constraints, the appendices are not included in this paper, but brief descriptions are shown below. For the complete appendices, please refer directly to the [5]GEIA-HB-0005-1 document. .

- Appendix A describes a matrix of product tier level versus associated risks with respect to a Pb-free transition.
- Appendix B contains links to the European Union Directives and Executive Order 13148.
- Appendix C contains a General Program Manager Checklist for dealing with Pb-free issues that summarizes the content of [5]GEIA-HB-0005-1 (shown in its entirety in Figure 4).
- Appendix D contains General Manufacturing Process Assessment Checklist to assess supplier compliance to [3]GEIA-STD-0005-1.
- Appendix E describes recommended program language to assure performance, reliability, airworthiness, safety, and certifiability of Pb-free product(s).

Summary

This paper discusses the work of the AIA-GEIA-AMC Lead-free Electronics in Aerospace Project Working Group (LEAP WG) and deliverables to enable the aerospace industry to accommodate lead-free electronics, provide common standards, and facilitate communications within the aerospace industry and with other industries. [5]GEIA-HB-0005-1 is discussed in detail to assist program managers on various levels to understand lead-free program impacts. LEAP WG welcomes participation from aerospace integrators, maintenance, customers, and suppliers to ensure aerospace products continue to be reliable, air-worthy, and safe.

References

[1]"Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003", Restriction of Hazardous Substances Directive (RoHS).

General Program Manager's Checklist For Dealing with Lead-Free Issues
Requirements Issues Determine the impact to performance requirements. Reallocate system requirements; determine if this changes the scope of any contracts. Assess impact on reliability of the component, the sub-system, and the system. Assess safety issues. Review maintainability requirements and determine the impact on frequency of maintenance. Assess impact on interfaces and other components. Assess impacts on test equipment and/or test facilities. Determine any required changes in support equipment**.**
Supplier Management Issues Determine the availability of alternative suppliers. Determine the feasibility of a lifetime buy of the old part. Evaluate supplier's internal delivery schedule for any new parts. Assess relationships of supplier to vendor: • Is supplier's vendor new or existing? • If new, can former vendor continue delivering the old part? Evaluate risks due to changes of suppliers and vendors: • Schedule • Cost • Technical

Assess any opportunities for schedule or cost savings.
Schedule Issues Evaluate impact on: • Critical path • Activities on the near-critical paths • Deliveries to test and evaluation activities Assess schedule impact due to any additional required tests or equipment. Determine and evaluate risks due to any change in schedule.
Cost Issues Determine if any cost savings will be shared by the supplier. Assess cost impact due to any schedule or technical requirements changes: • Supplier costs • Internal labor costs Costs of additional testing/qualification (facility, labor, equipment)
Configuration Management Ensure new part is included in configuration management documentation. Alert any unrelated users of the same part within the organization.

Figure 4 - [5]GEIA-HB-0005-1 Appendix C - General Program Manager Checklist for Dealing with Lead-Free Issues

[2]"Directive 2003/108/EC of the European Parliament and of the Council of 8 December 2003, amending Directive 2002/96/EC" Waste Electrical and Electronic Equipment (WEEE).

[3]"Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder", GEIA-STD-0005-1, published by GEIA, June 2006.

[4]"Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems", GEIA-STD-0005-2, published by GEIA, June 2006.

[5]"Program Management/Systems Engineering Management Guidelines for Managing the Transition to Lead-Free Electronics", GEIA-HB-0005-1, published by GEIA, June 2006.

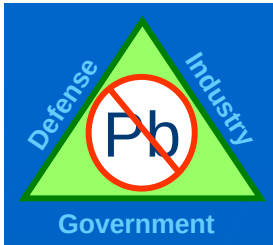
[6]"Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-free Solder and Finishes", GEIA-HB-0005-2, submitted for publication by GEIA, December 2006.

[7]"Reliability Testing for Aerospace and High Performance Electronic Systems Containing Lead-free Solder", proposed as GEIA-STD-0005-3, in-work by AIA-GEIA-AMC LEAP consortia.

[8]"Rework, Repair, and Maintenance of Aerospace and High Performance Electronic Systems Containing Lead-Free Solder", proposed as GEIA-HB-0005-3, in-work by AIA-GEIA-AMC LEAP consortia.

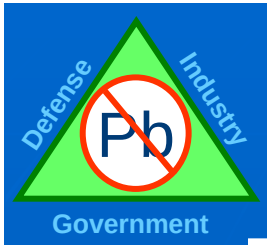
[9]"Reliability Assessment for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder" proposed as GEIA-HB-0005-4, in-work by AIA-GEIA-AMC LEAP consortia.

[10]"Guidance for the Transition to Lead-Free Soldering, Maintenance, and Repair", ARINC Report 671, published by ARINC, March 2006.



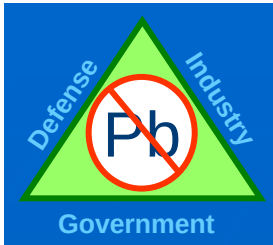
Aerospace Response to Lead-Free Solder – A Program Manager's Guide

Patricia Amick, Associate Technical Fellow
Lloyd Condra, Technical Fellow
Anduin Touw, Associate Technical Fellow
William Procarione, Senior Manager
The Boeing Company
February, 2007

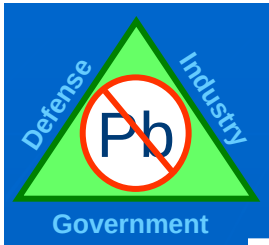


Outline

- Introduction
- AIA-GEIA-AMC Efforts
- Program Manager Guidelines
- Summary



Introduction

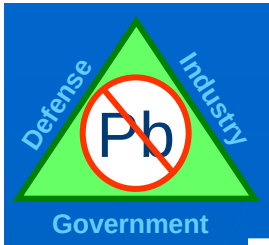


Affects of the European Directives on the Aerospace Industry

The move towards lead-free electronics driven by RoHS and WEEE European directives

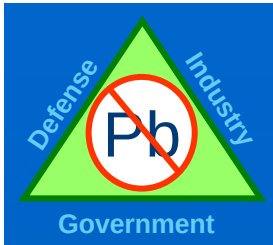
- **Disruptive** to the aerospace industry
- **Neither drive nor resist** it
- **Must work together** in response to it
- **Must ensure** that our products are ***Reliable, Repairable, Supportable, Safe, Affordable, Airworthy, Certifiable***

Lead-Free technology can impact any program regardless of whether the program itself is exempt or bound by environmental regulations.



Military & Commercial Aerospace Industries

- **Reality**
  - **Component manufacturers have already switched** and are currently delivering components with lead-free lead finishes.
  - **Aerospace suppliers sell** commercially in US and **worldwide**.
  - **Cost prohibitive for suppliers** to put in separate soldering lines.
- **Aerospace will be "swept along" by a supply chain** that is beyond our control



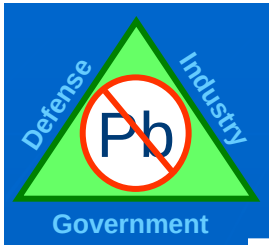
AIA-GEIA-AMC Efforts

AIA-GEIA-AMC Lead-free Electronics in Aerospace Project Working Group

- The **purpose** of LEAP is to **develop and implement actionable deliverable items** that enable the aerospace industry to accommodate the global transition to lead-free electronics. The deliverable items **address problems** that are **unique to,** and are **within the control of the aerospace industry.**

- **Goals & Objectives:**
  - **Enable the aerospace industry**, on an ongoing basis, to accommodate the global electronics transition to lead-free electronics
  - **Provide a common set of standards** to be used by suppliers and customers to address issues related to lead-free electronics ("level playing field")
  - **Provide avenues of communication between** the aerospace **industry and customers**
  - **Provide avenues of communication within** the aerospace **industry**

- Currently **over 80 corporations plus numerous US and European government agencies and educational institutions** actively participate**.**



Evolution

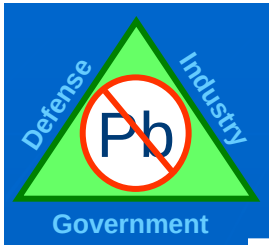
- ***2003*** - Boeing starts discussions with defense and commercial aerospace suppliers

- ***2004 - February*** - AIA Lead-free Aerospace Electronics Working Group (LAEWG) formed
- *March* - LAEWG Kick-off Telecon
- *May* - LAEWG first Face-to-Face Meeting with 13 companies + CALCE + AIA
  - Two standards and one handbook started
- *July* - LAEWG Telecon - Decision made to add program manager guidelines
- *October* - Evolved to the Lead-free Electronics in Aerospace Project (LEAP)
  Jointly sponsored by AIA-GEIA-AMC; Lead - Lloyd Condra of Boeing

- ***2005 - June*** - Several internationally-based companies join including EADS and Airbus
- *October* - IEC submittal process started; 23 companies + 6 government agencies
- *November* - 3 documents sent to GEIA for balloting, including PM guidelines

- ***2006 - January*** - Start of implementation effort; 5th document on Reliability Test Protocols
- *March* - Ballot comment resolution
- *June* - Three documents published by GEIA – 2 standards and PM guidelines
- *September* - Added two additional handbooks
  - Reliability Analyses and Models
  - Rework, Repair, and Maintainability

- ***2007 - January*** - 4th original document (GEIA-HB-0005-2) submitted to GEIA for balloting

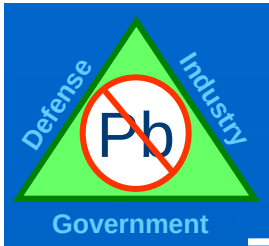


Actionable Deliverables

- **GEIA-STD-0005-1** Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder
- **GEIA-STD-0005-2** Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems
- **GEIA-HB-0005-1** Program Management / Systems Engineering Guidelines for Managing the Transition to Lead-free Electronics
- **GEIA-HB-0005-2** Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-free Solder
- **GEIA-STD-0005-3** Performance and Qualification Testing for Aerospace and High Performance Electronics Containing Lead-free Solder
- **GEIA-HB-0005-3** Rework, Repair and Maintainability for Aerospace and High Performance Electronics Containing Lead-free Solder
- **GEIA-HB-0005-4** Reliability Assessment for Aerospace and High Performance Electronics Containing Lead-free Solder

Actionable Deliverables

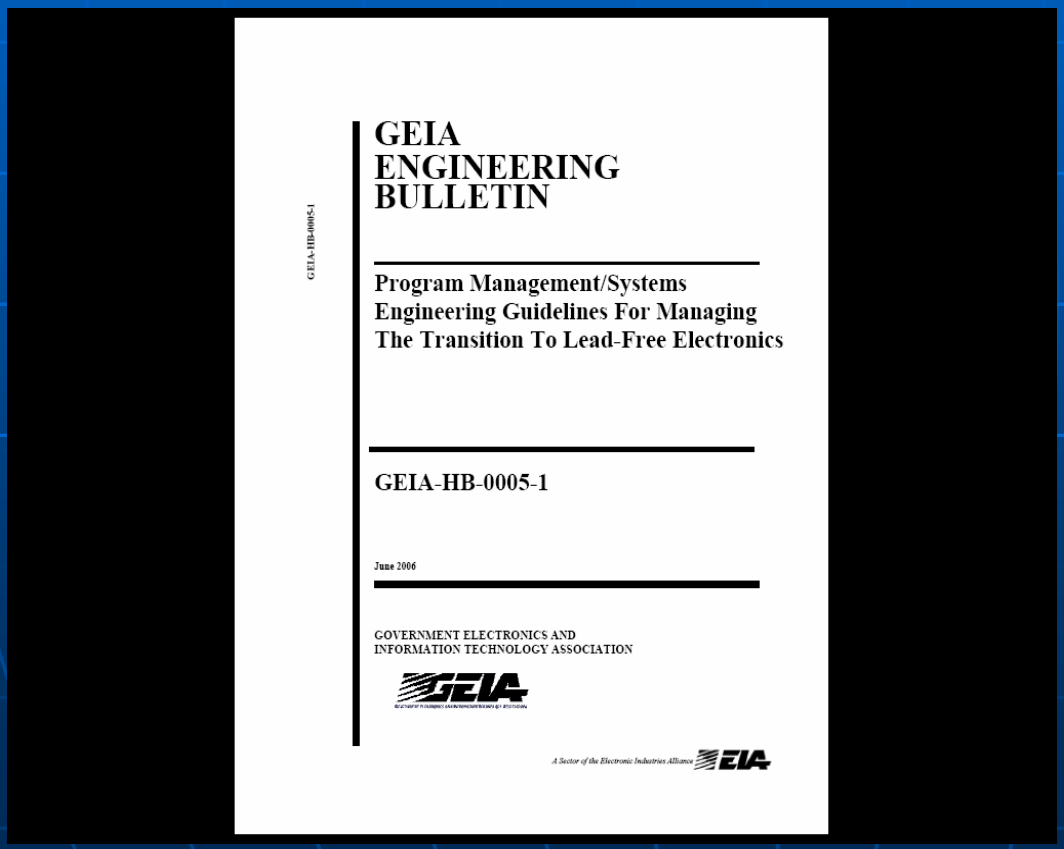
GEIA-STD-0005-1	Performance Standard	Lloyd Condra, Boeing	Published GEIA 30 June 2006	Submit to IEC 31 March 2007
GEIA-STD-0005-2	Tin Whiskers	Anduin Touw, Boeing	Published GEIA 30 June 2006	Submit to IEC 31 March 2007
GEIA-HB-0005-1	Program Mgmt Guide	Pat Amick, Boeing	Published GEIA 30 June 2006	Submit to IEC 31 March 2007
GEIA-HB-0005-2	Technical Guidelines	Stephan Meschter, BAE	Submitted GEIA 31 Jan 2007	Proposed 30 June 2007
GEIA-STD-0005-3 (in work)	Performance & Qual Testing	Tony Rafanelli, Raytheon	Proposed 30 Jun 2007	Proposed 31 Dec 2007
GEIA-HB-0005-3 (in work)	Rework / Repair	Tim Kalt, USAF	Proposed 30 Sep 2007	Proposed 31 Mar 2008
GEIA-HB-0005-4 (in work)	Reliability Assessment	John Biel, Smiths Aerospace	Proposed 30 Sep 2007	Proposed 31 Mar 2008



Partial List of LEAP Member and Consulting Organizations

- AAI Corp
- ADS Transicoil
- Aerospace Corp
- Airbus
- Air Canada
- AMETEK Rotron
- Avtech Corp
- Axsys
- BAE Systems
- Barfield
- Boeing Company
- Bombardier Aero
- Celestica
- Cie Barco
- Corfin Industries
- CSP Inc
- Curtiss-Wright
- Delta Airlines
- Diehl Avionik
- DfR Solutions
- DPACI
- EADS
- Eaton Aerospace
- Elbit Systems
- ELDEC
- FEDEX
- Fischer Technology
- Gables Engineering
- Garmin International
- General Dynamics
- Gixel
- Goodrich
- Hamilton-Sunstrand
- Harris Corp
- Hispano-Suiza
- Honeywell
- IBM
- Intel
- Internat Rectifier
- Intersil
- IMEC
- IPC
- ITB, Inc
- ITT
- Jabil Circuit
- Japan Airlines
- Kidde Aerospace
- L-3
- Lansdale Semicon
- LCIE
- Linear Tech Corp
- Lockheed-Martin
- Lufthansa Technik
- Mascorp
- Matsushita Avionic
- MBDA
- Medtronic
- Meehan Electonics
- Microsemi Corp
- MOOG
- National Semicon
- Northrop Grumman
- Orbital Sciences Corp
- ORS Labs
- Panasonic Avionic
- Parker
- Phillips Medical
- Purdue University
- QTEC
- Raytheon
- Rockwell Collins
- Rolls Royce
- Safe Flight Instr
- SBS Technologies
- Six Sigma
- Smiths Aerospace
- Space Dynamics
- Stilwell Baker
- Teldix
- Teledyne Controls
- Terma AS
- Texas Instruments
- Textron
- Thales
- Trimle
- TTI, Inc
- Tyco
- UIC
- United Tech Corp
- Univ of Alabama
- Univ of Maryland
- Univ of Missouri
- Vishay Semicon
- Vibro-Meter
- Wyle Labs
- AIA
- AMC
- American Competitive Insti
- ARINC
- BMPCOE
- BSI
- CALCE
- Defense Acq Univ
- DMEA
- DOD (USAF, Navy, Army, Coast Guard)
- Euro Space Agency
- FAA
- GAMA
- GEIA
- IEQC
- NASA
- NIST

Program Manager's Guidelines

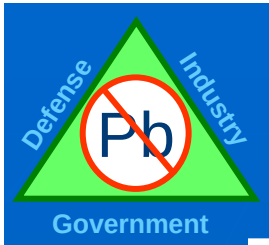


Published by GEIA
June 2006

GEIA-HB-0005-1 Team & Scope

- **Task Team Member Companies**
  - Pat Amick, Boeing - Lead
  - ACI
  - AIA
  - Bombardier
  - EADS
  - FAA
  - Lockheed-Martin
  - Raytheon
  - Parker
  - USN

- **Scope**
  - A **handbook for program management and/or systems engineering** management to use for managing the transition to lead-free (Pb-free) electronics
  - Purpose is to **illustrate what concerns should be voiced** to ensure the Pb-free transition does not have a negative impact to the product

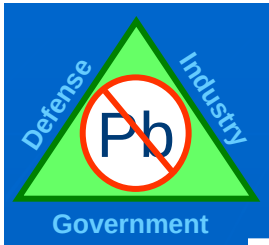


Program Management Concerns

- **Reliability**
- **Configuration Control**
- **Risk Management**
- **Detrimental Effects of Tin**
- **Rework / Repair and Maintenance**

- **Cost**
- **COTS**
- **Quality**
- **Contractual Language**
- **Program Constraints**
- **System Engineering Management Plan**

We care about what we've always cared about !!!

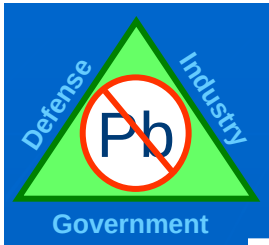


PM Concerns - Reliability

- **Understand how the transition** to Pb-free **may affect the reliability** of the program.

- **Need to understand:**
  - If units and/or systems will **include both Sn/Pb and Pb-free** assemblies, piece parts, printed wiring boards
  - Effects of **mixing Sn/Pb and Pb-free solder**
  - Effects on **package types/geometry**
  - **Reaction to** the program's **use environment**

- **Should consider a common reliability data collection** during all phases of the program to facilitate systems performance improvement.

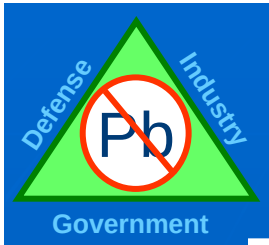


PM Concerns – Configuration Control

- **Understand** the appropriate **configuration controls necessary for the program's environment** and at **what level** (i.e., piece part, assembly, unit, system)

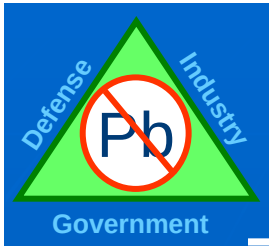
- **Ensure** that appropriate and **demonstrated processes are in place** at suppliers

- Consider requiring a **Parts, Materials, and Processes (PMP) Plan** with appropriate **Quality Control Procedures**.
  - The plan **should include sub-contractor controls** that affect the reliability of the end product.



PM Concerns – Risk Management

- **Risk identification and risk assessment** need to be performed **for the** Pb-free **transition** for the particular environmental conditions of the program.
- Risks need to be **identified early and a mitigation strategy engaged.**
- Should ensure that a **complete risk management** plan is in place.



PM Concerns – Detrimental Effects of Tin

- Pb-free tin finishes in an avionics or high performance system can have **detrimental effects to functionality** of the system as **tin whiskers** can spontaneously grow from the surfaces.

- **Understand and agree** to the supplier's plan **for either:**
  - **Eliminating use of** Pb-free **tin** in their product (through life-time buys or reprocessing piece parts),

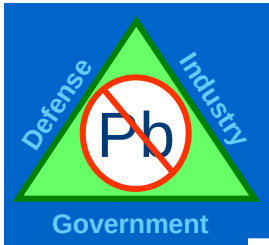
OR

  - **Accepting** Pb-free tin in their product (**and addressing and mitigating the risks**).

PM Concerns – Rework / Repair and Maintenance

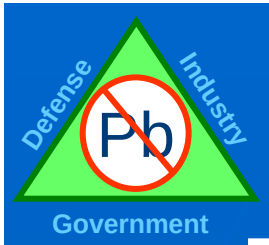
- Concern if **Sn/Pb and Pb-free solders** and/or piece parts are **used on the same assemblies**.

- Should be **aware of** the **higher risks** associated **with field rework/repair and maintenance** when standard solder materials (i.e. 60% tin/40% lead or 63% tin/37% lead) are used on Pb-free assemblies and/or piece parts or visa versa.



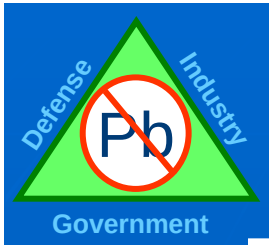
PM Concerns – Cost

- The costs of the Pb-free transition **need to be quantified** and decisions need to be made as to **who will assume the costs**.
- The PM should be aware that the **situation is likely to be dynamic** over the next several years.
- **Added costs** may come from additional **risk management determination, configuration controls, rework/repair and maintenance changes, drawing changes, possible redesign, re-qualifying/delta qualifying, etc.**



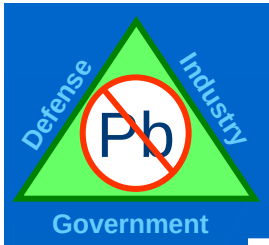
PM Concerns – COTS

- Commercial-off-the-shelf (COTS) is always a **critical concern** for a program manager.
  - The **very nature of COTS may allow Pb-free substitution** irrespective of program requirements.
  - The product **may contain COTS Pb-free soldered assemblies** as well as **Pb-free-finished piece parts**.
- **Understand the supplier's controls** to mitigate the risks associated with Pb-free finished piece parts and COTS assemblies.
- **Ensure** that the **PMP Plan** for the program is being adequately **updated and addresses how** lead-free piece parts and assemblies will be **identified and tracked**.



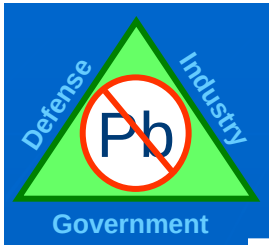
PM Concerns – Quality

- Quality is a **critical consideration** in the transition to Pb-free.
- The PM needs to be **assured** that the **final product meets the technical and operational requirements** with the specified reliability at all levels.
- This **includes flow of requirements, implementation and documentation through and to subcontractors**.



PM Concerns – Contractual Language

- Appropriate contractual language needs to be included in new contracts that **describe the customer requirements** regarding Pb-free parts.



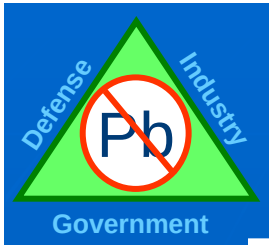
PM Concerns – Program Constraints

- The PM needs to be proactive in **understanding all of the impacts to** the program **schedule** (including all integrated master schedule line items).

- Consideration needs to be paid to **changes in the delivery schedule** due to **requalification/delta qualification** of Pb-free parts, additional **reliability testing**, **lifetime buys** of long-lead SnPb-finished piece parts, etc.

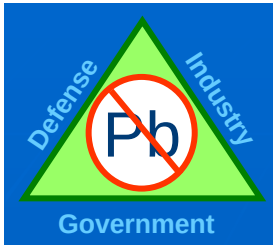
PM Concerns – SEMP

- The PM should **reassess the program's System Engineering Management Plan**, if one exists, and ensure that it has been updated to include the Pb-free transition controls for the program.



Appendices

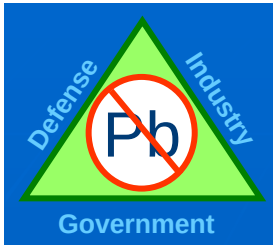
- ***Appendix A*** describes a **matrix of product tier level versus** associated **risks** with respect to a Pb-free transition.
- ***Appendix B*** contains **links** to the European Union Directives and Executive Order 13148.
- ***Appendix C*** contains a **General Program Manager Checklist** for dealing with Pb-free Issues, based on GEIA-HB-0005-1.
  - **Requirements Issues**
  - **Supplier Management Issues**
  - **Schedule Issues**
  - **Cost Issues**
  - **Configuration Control Issues**
- ***Appendix D*** contains a General **Manufacturing Process Assessment Checklist** to assess supplier compliance to GEIA-STD-0005-1.
- ***Appendix E*** describes **recommended program language** to assure performance, reliability, airworthiness, safety, and certifiability of Pb-free products.



Summary

What We Can Do ???

- **Stay informed**
- **Join AIA-GEIA-AMC LEAP and help with implementation of the Standards**
- **Use the AIA-GEIA-AMC documents to assist with the lead-free transition of your programs**
- **For Existing Programs**
  - **Consider intent** of GEIA-STD-0005-1 for use on your program
  - Assess compliance of Suppliers' lead-free processes to intent of GEIA-STD-0005-1
- **For New Programs**
  - **Establish contract language** that imposes requirements of GEIA-STD-0005-1 and GEIA-STD-0005-2
  - Assess overall compliance of Suppliers' lead-free processes to GEIA-STD-0005-1



Summary

To find out more information:

- **Rusty Rentsch,** AIA Director Life Cycle Management, 703-358-1054, rusty.rentsch@aia-aerospace.org
- **Lloyd Condra,** Boeing Technical Fellow, 206-655-8240, lloyd.w.condra@boeing.com
- **Pat Amick,** Boeing Associate Technical Fellow, 314-777-0658, patricia.j.amick@boeing.com
- **Anduin Touw,** Boeing Associate Technical Fellow, 703-455-6865, anduin.e.touw@boeing.com
- **William Procarione,** Senior Manager, 314-233-9809, william.l.procarione@boeing.com

Restriction on Hazardous Substances is considered "… the most far reaching piece of legislation ever to impact the electronics industry."

- Celestica; Janes Defense Weekly, -8-24-2005