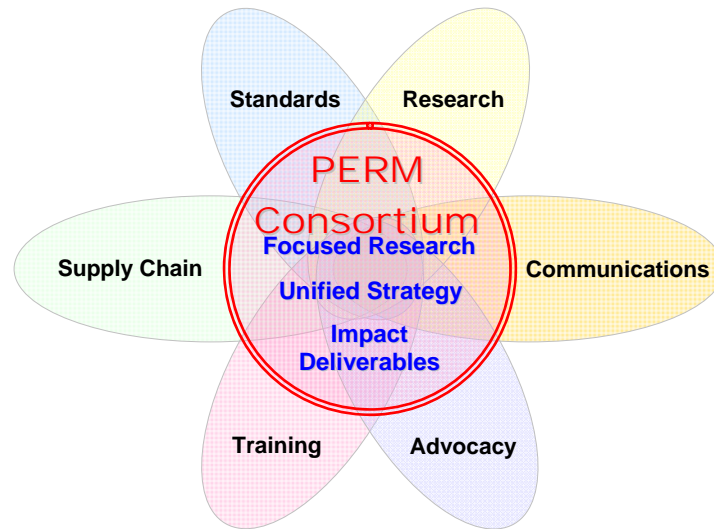


Pb-Free Electronics Risk Management (PERM) Consortium White Paper



EXECUTIVE SUMMARY:

The purpose of the Pb-Free Electronics Risk Management (PERM) Consortium is to provide overarching leadership and coordination of Pb-free electronics risk management activities for the aerospace, defense and high-performance (ADHP) communities. The goal is to respond better to the long-term challenges of Pb-free solders and finishes over a system's life cycle.

The PERM Consortium is organized to provide an executive leadership perspective and address communications, research coordination, standards, training, advocacy, supply chain, and international cooperation issues through dedicated task teams and advisory groups.

Evolving out of previous efforts of the AIA-AMC-GEIA Lead-free Electronics in Aerospace Project (LEAP) Working Group and DoD's Executive Lead Free Integrated Process Team (ELF IPT), the PERM Consortium is chartered by the Aerospace Industries Association (AIA) and includes support from DoD, DoE, FAA, NASA, industry, academia, and international members.

For further information, see www.PERMPbFree.org or email: perm@permpbfree.org

Aerospace & Defense Pb-Free Electronics Risk Management (PERM) Consortium:

BACKGROUND:

For over fifty years, the electronics industry has relied on Tin-Lead (SnPb) solder as the primary means of interconnection between electronic devices. The European Union's (EU) Restriction of Hazardous Substance (RoHS) directive and other international and domestic mandates to eliminate materials deemed hazardous to health has recently forced the electronics industry to adopt solders and termination finishes free of Lead (Pb). While aerospace and defense electronics are excluded from these Pb-free mandates, many of their component suppliers are consumer electronics companies are driven by the needs of volume customers, who demand RoHS compliance in order to enter/preserve European markets. Suppliers sometimes provide existing products in two forms, but usually only temporarily before converting to a single Pb-free (RoHS-compliant) version. New products are being introduced almost exclusively in Pb-free form. Figure 1 pictorially depicts how the aerospace and defense electronics customers depend upon the global supply chain.

Avionics, defense 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 temperature and humidity, high-altitude, high levels of shock and vibration, underwater exposure, or the extremes of space. Product lifetimes are often measured in decades, rather than in years. Contrary to most commercial practices, maintenance and repair activities are routinely performed down to 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 the direction of the original equipment manufacturer (OEM). Finally, failure of the equipment to perform may have dire consequences.

The reliability of SnPb interconnections is well known and meets the requirements of these more demanding applications. Based on the scientific information available today, there are increased reliability risks in using Pb-free in high performance electronics. These risks include the spontaneous formation of tin whiskers from Pb-free tin (Sn) based finishes, reduced Pb-free solder joint integrity, reduced reliability by cross-contamination between the different alloys, and the potential component and board damage from the higher Pb-free processing temperatures.

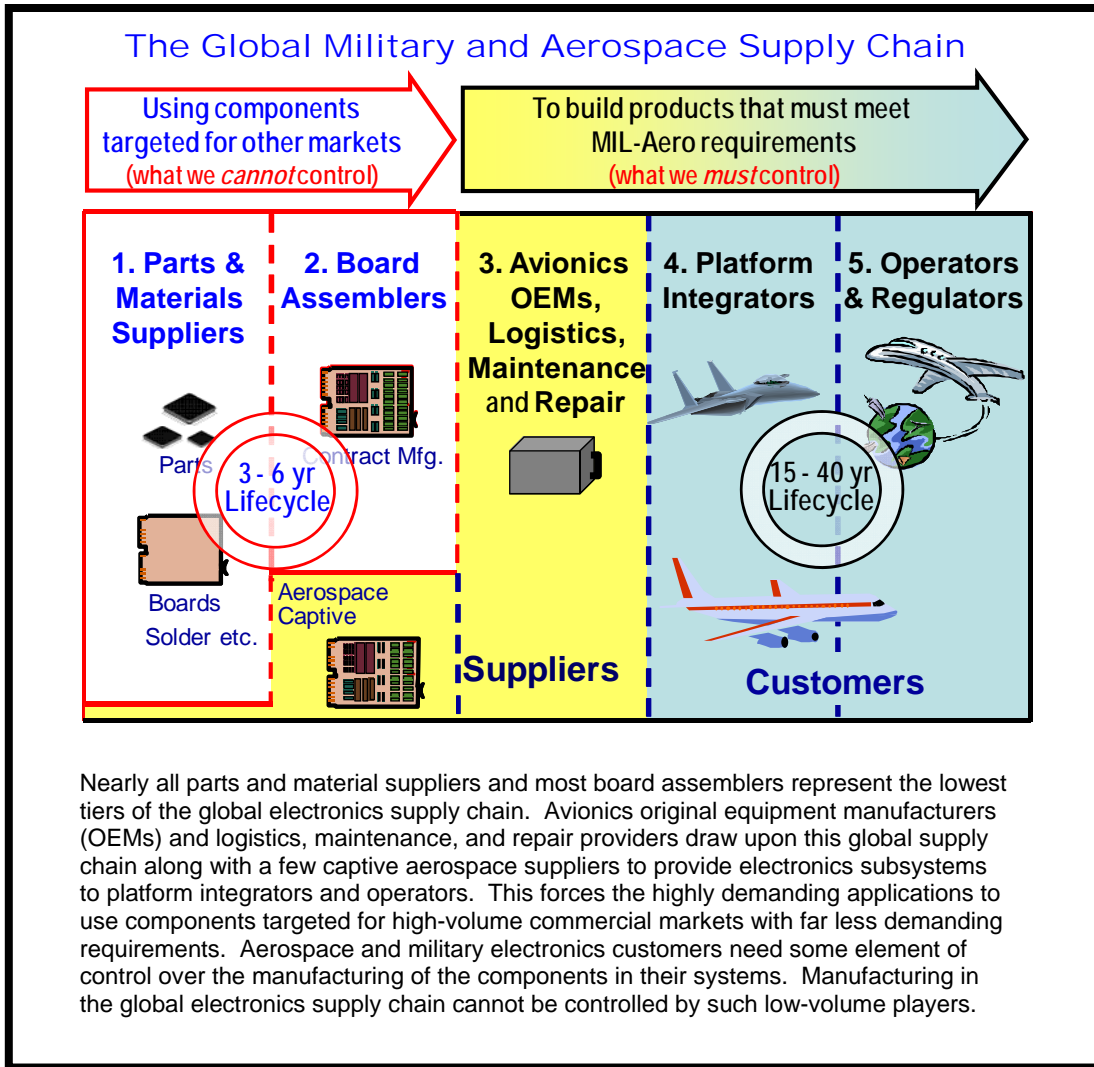


Figure 1 – The Global Military and Aerospace Supply Chain

RESPONSE:

In 2004, shared concerns regarding the impact of Pb-free technology on aerospace electronics prompted the formation of the Lead-free Electronics in Aerospace Project Working Group (LEAP-WG). This group was jointly sponsored by the Aerospace Industries Association (AIA), Avionics Maintenance Conference (AMC), and the Government Electronics and Information Technology Association (GEIA). It was an international working group that included active members from North America and Europe. Represented among the membership were most of the world's major aircraft manufacturers and defense contractors, many mid-tier suppliers, and relevant government/customer organizations.

The LEAP-WG integrated efforts with the DoD sponsored Executive Lead-Free Integrated Process Team (ELF IPT) in order to access government leadership and address the needs of the government acquisition and logistics communities. The group worked from 2004 through early 2009 to develop a set of documents that provide guidelines and standard practices for meeting the challenges of Pb-free and are acceptable for use across our industry. These documents are being issued initially in

the United States by the GEIA (now TechAmerica), and then submitted to the International Electrotechnical Commission (IEC) for adoption globally.

As of August 2009 seven standards and handbooks have been issued with one additional document still in progress and another under consideration. A list of these documents is provided below. These documents work in concert with other published Pb-free documents and address issues unique to, and within the control of, aerospace and other high performance electronics.

- 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-STD-0005-3 Performance Testing for Aerospace and High Performance Electronics Containing Lead-free Solder and Finishes
- 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-HB-0005-3 Rework and Repair Handbook To Address the Implications of Lead-Free Electronics and Mixed Assemblies in Aerospace and High Performance Electronic Systems
- GEIA-HB-0005-4 Guidelines for Performing Reliability Predictions for Lead-Free Assemblies used in Aerospace and High-Performance Electronic Applications (in review)

PB-FREE ELECTRONICS RISK MANAGEMENT (PERM) CONSORTIUM:

The LEAP WG and ELF IPT have evolved into the Pb-Free Electronics Risk Management (PERM) Consortium to provide a more formal organization that meets the needs of an expanding membership and a growing number of tasks. PERM establishes a more effective and coordinated interface with senior DoD and industry leaders for the purpose of developing, promulgating and implementing sound Pb-free policies. The goal is to respond better to the long-term challenge of Pb-free solders and finishes.

The purpose of the PERM Consortium is to provide overarching leadership and coordination of Pb-free electronics risk management activities for the aerospace, defense and high-performance (ADHP) community. The charter of the PERM is to provide guidance for the long-term overall aerospace and defense strategy, and tactics to effectively deal with the Pb-free electronics issues. A coordinated risk management approach for the transition to Pb-free electronics is needed in order to ensure the performance, reliability, maintainability, and safety characteristics required in aerospace and defense electronics.

The PERM Consortium is chartered by the Aerospace Industries Association (AIA) and includes support from DoD, DoE, FAA, NASA and industry. The PERM also has international support from non-U.S. Governments, Agencies, companies, and academia. The consortium addresses research coordination, standards, training, communications, supply chain, advocacy, and international cooperation through dedicated task teams and advisory groups. A PERM Steering Committee has been established to ensure a focused and integrated approach in meeting the consortium goals.

PERM Consortium Functional Framework

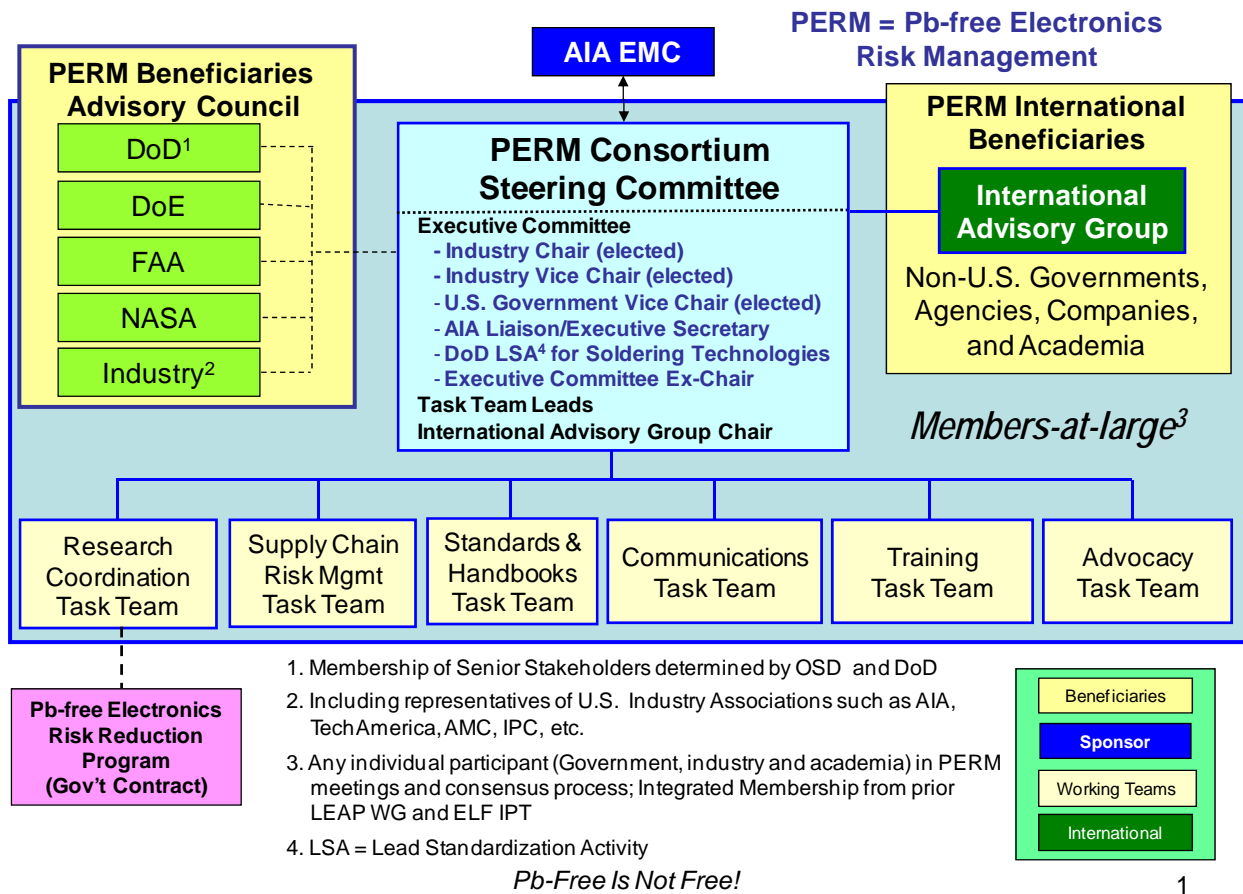


Figure 2 - PERM Consortium Functional Framework

RESEARCH COORDINATION:

The research coordination team is the top-level research facilitation activity for the A&D community with respect to Pb-free electronics. It provides an open forum to define, develop, and support coordination of research across consortia members' activities that address the critical needs of the military/aerospace industry with regard to the global transition to Pb-free electronics. The task team also serves as the Technology Review Board for the PERM Consortium and will:

- Provide peer review and vetting of relevant research and inform members of that research

- Define research gaps and recommend projects to fill those gaps, including maintenance of a research roadmap and funding needs
- Encourage communication and collaboration between consortia members on current research to reduce duplication of effort and to allow corroboration of results
- Provide assessment of relevant research to A&D applications and provide recommendations to the Standards & Handbooks and other PERM task teams as needed
- Provide coordination with the Pb-free Electronics Risk Reduction Program (Follow-on to the Pb-free Electronics Research Manhattan Project, Phases 1 & 2)

The focus of the team is to provide “actionable deliverables”; however, it is recognized that some key technical questions exist for which the current knowledge is insufficient for implementation on A&D programs. In such cases, it may be necessary to provide in-work research knowledge, which can be used provisionally, in lieu of “final published results.” It is also expected the team will provide a set of solutions and applicability considerations, rather than a specific single answer.

STANDARDS AND HANDBOOKS:

Standards and Handbooks are the cornerstone of the PERM Consortium effort serving as the bridge from the science behind the technology to the execution of the technology in Aerospace and Defense (A&D) electronics. Through Standards and Handbooks, the customers and suppliers gain insight to the technology. These documents define what can and cannot be done with respect to the implementation of Pb-free in A&D electronics—thus satisfying both sides of the contractual equation. Standards and Handbooks provide the basis for ensuring the end users continue to have electronic systems that are safe and reliable while meeting their performance objectives.

PERM will manage and/or participate in the development of national and international standards for Pb-free electronics in A&D applications. PERM will provide peer review of documents to ensure their content and quality meet the needs of the Aerospace and Defense community. PERM will facilitate coordination of draft documents in cooperation with standards bodies to ensure both government and private sector requirements are met.

TRAINING:

The PERM Training Task Team will provide all stakeholders with accurate, up-to-date information about the nature of the risks associated with Pb-free electronics and how to manage those risks. Two general categories of training are necessary to accomplish this effectively: 1) awareness training and 2) detailed training on the handling, management, and implementation of Pb-free technology. All levels of organizations within DoD, industry and regulatory authorities, from management to shop technicians, are potential recipients of awareness training. Awareness training should be designed to highlight the nature of the problem and the potential repercussions of a failure to act. Detailed training on the handling, management, and implementation of Pb-free technology is primarily designed for government and industry personnel who develop

and support aerospace and defense systems. This includes engineering, quality assurance, configuration management, supplier management, acquisition program offices, repair and maintenance personnel, and others as identified. The detailed information will also include techniques for determining the extent of the Pb-free exposure, methods for assessing the risks associated with that exposure, as well as options and strategies for mitigating those risks.

Existing material will be identified to meet those needs and made available by establishing a comprehensive repository for all training and knowledge resources. In addition, the PERM Training Task Team will facilitate the development of new material where there are gaps as well as periodic updates of training materials and organized events.

COMMUNICATIONS:

The PERM Communications Task Team will address the aerospace and defense community's need for a comprehensive and efficient system to disseminate information concerning Pb-free electronics and to provide a Pb-free research data repository. The types of information communicated will include new issues/problems caused by Pb-free electronics (i.e. bad news), research findings and solutions (i.e. good news), Pb-free publications, funding opportunities, and international legislation activities. The PERM communication system will comprise the PERM website, email updates, teleconferences, face-to-face meetings and conferences.

The PERM communication system will be a conduit for disseminating information from the PERM Management, Advisors, and Task Teams to the defense and aerospace electronic industries and critical cousins across the entire electronics industry. The result of this effort will be an efficient, bi-directional, exchange of information regarding the use and risk management of Pb-free electronics in the defense and aerospace industry. A major goal is to ensure the widest dissemination of information across the industry to ensure all related organizations and companies benefit from the efforts of the PERM.

The PERM website will be the key portal for information exchange providing up-to-date information on Pb-free issues, PERM activities, the Pb-free activities of other industry organizations and a research data repository. In addition, information will be "pushed" to a comprehensive email database of stakeholders in the defense and aerospace electronics industry, related associations, critical cousins in other industries and government. The Communications Task Team will publish periodic reports (State of the industry, technical alerts, etc.) based on input from other PERM task teams.

The Communications Task Team will facilitate and coordinate the PERM's liaison with key industry organizations (AIA, TechAmerica, NDIA, IPC, and others).

SUPPLY CHAIN RISK MANAGEMENT:

Government and industry aerospace and defense communities' supply chains are now heavily and increasingly dependent on the use of commercial electronic parts for nearly all of their systems. This increasing dependence is the greatest source of risk from Pb-free products. The objective of Pb-free supply chain risk management is to develop and provide actionable recommendations that can achieve more commonality in

requirements and processes at the systems integrator/sustainment level to reduce the probability of unknowingly accepting non-compliant electronic components and subassemblies. Recommendations will include optimizing the cost/reliability risk trade-offs across the product and requirement boundaries throughout the supply chain and developing approaches for conveying and promoting the needs of high reliability, long service life users to the materials and components end of the electronics supply chain.

The approach is to:

- Develop a representation of a generic aerospace and defense electronics supply chain that identifies the various (generic) interfaces across which requirements information and product conformance information flows
- Identify risks and best practices for risk mitigation at each interface
- Identify needs and opportunities for improvement
- Recommend actions to manage identified deficiencies and/or improve processes

ADVOCACY:

The Advocacy Task Team tracks US legislation concerning Pb in electronics and works with the International Committee to identify foreign legislation. Advocacy is chartered to reach consensus on the interests of the aerospace and defense industry in these matters. The Advocacy Team reaches this consensus through contact with sister trade associations, PERM member companies, and government organizations. The Team will be proactive in recommending voting positions on pending legislation.

The role of the Advocacy Committee is to:

- Coordinate with PERM Communications Team to best publicize the unified position PERM has taken.
- Generate positive legislation regarding the use of Pb in electronics for aerospace and defense, and attempt to block adverse legislation proposed. The result of this effort will reduce risk for military and aerospace electronics.
- Solicit input from:
 - Other PERM committees
 - AIA and TechAmerica associations
 - Branches of the federal government
 - Interested individuals
- Generate quarterly reports and position papers on the identified legislation as needed.

INTERNATIONAL ADVISORY GROUP:

It is recognized that the problems and challenges associated with the successful implementation of Pb-free technology in demanding and high reliability applications are worldwide in scope. In addition, the original drive for the evolution toward Pb-free included legislation introduced within Europe, but regulations are now increasingly more international in origin.

The purpose of the International Advisory Group (IAG) is to work with the PERM Steering Committee to define and agree on clear and realistic goals that will promote ongoing international cooperation on risk mitigation issues related to Pb-free transition and use.

There are many independent research activities across the world, both within industry and academia that address aspects of Pb-free technology. However, there is still a lack of knowledge of the true impact of Pb-free in many key areas. There is therefore an obvious need to coordinate, or at least take cognizance of, these activities, and to disseminate realistic status information as is available. The Pb-free Electronics Risk Management (PERM) consortium offers an effective platform to achieve these goals.

To this end, the IAG will interface directly with the PERM Steering Committee, the Communications Task Team and the Advocacy Task Team. The IAG will work to:

- Extend the active membership of the IAG to include as many relevant areas of academia, industry, government and regulatory authority as appropriate
- Develop a list of international contacts who would benefit from research outputs
- Provide details relevant to the PERM Steering Committee of those research activities being undertaken worldwide
- Support PERM consortium activities worldwide

SUMMARY:

With the goal of responding to the long-term challenge of Pb-free solders and finishes, the Pb-Free Electronics Risk Management (PERM) Consortium provides overarching leadership and coordination of Pb-free electronics risk management activities for the aerospace, defense and high-performance (ADHP) communities. Evolving out of previous government and industry efforts, the PERM Consortium provides a forum for leadership, communications, research coordination, standards and handbooks, training, advocacy, supply chain, and international cooperation through dedicated task teams and advisory groups. The PERM Consortium is chartered by the Aerospace Industries Association (AIA) and includes support from DoD, DoE, FAA, NASA, industry, academia, and international members.

For further information, see www.PERMPbFree.org or email: perm@permpbfree.org

A few sound bites from PERM Consortium participants:

“Access to industry expertise provides a common understanding to break through the fog of hype and fear that can otherwise cripple the ability to make decisions.” – Joel Heebink, Honeywell

“Best technical cooperation between DoD, Primes and Suppliers I have ever seen.” – Denny Fritz, SAIC.

“Participation in PERM will position our company for successful implementation and deployment in A&D Pb-free electronic assemblies (in a most timely and cost effective manner)” – Jeff Kennedy, Celestica Corporation.

“PERM provides timely access to key information not easily available from other sources.” - Vance Anderson, Defense Microelectronics Activity

“PERM – Where Industry and Government wide participation solves tomorrow’s Pb-free problems.” David Burdick, Boeing Military Aircraft

“Awareness of the Pb-free electronics risk is still a major challenge.” – Ed Morris, Lockheed Martin Corporation

“The words ‘yes, but...’ follow every statement you can make about Lead-free solder.” – Steph Meschter, BAE Systems.