Three recommendations for potential Department of Defense funded programs to advance the jointness of the DoD response to the worldwide lead-free movement have been formulated by the ELF-IPT joint government/industry lead-free roadmapping and gap analysis panel

These specific Statements of Work for the relevant programs identified by the Roadmap and Gap Analysis panel of the ELF-IPT are as follows:

Statement of Work
Tin Whisker Mitigation Demonstrations and Guidelines

July 27, 2006

1.0 Introduction

This program's task will be to investigate tin whisker formation in lead free finishes of existing fielded systems and components and to quantify the effectiveness of conventional electronic packaging trends at mitigating the risk posed by tin whiskers in military systems. The project's prime deliverables will be tin whisker evaluations of fielded functional hardware and development of manufacturing process guidelines based upon these findings. The manufacturing process guideline will take into account the transition of component finishes from lead to lead free finishes while the Defense industry continues to utilize lead based solders to minimize the risk of tin whisker growth.

Tin Lead (SnPb) solder has been the prime circuit interconnection in electronics manufacturing providing electrical conductivity and mechanical strength between circuit cards and electronic packages. International concern and legislation have resulted in programs to eliminate lead (Pb) in solders and component finishes. However, the Air Force, NASA, and other DoD departments have expressed concern over the removal of lead from solder finishes and the tin whisker risks that this practice could create in on going production of existing military and high reliability systems. To mitigate concerns posed by the use of 100 % lead free finishes and solders, the continued use of lead containing solders while working with lead free component finishes is proposed. The objective of this effort is to study and document how effective conventional conformal coatings and electronic packaging techniques have been in minimizing the formation and effects of tin whiskers to date in fielded hardware.

2.0 Project Scope

The project scope will include evaluation of solder interconnections in fielded hardware systems where pure tin finishes have been know to exist and to evaluate the effectiveness of conventional conformal coatings and electronic packaging techniques at mitigating the risks posed by the potential formation of tin whiskers. To accomplish this, the subcontractor will document pure tin finish applications in Functional Hardware (FH) and examine the hardware for tin whisker formations and for design, process, and packaging variables which have mitigated the risks. Design, packaging, and processing guidelines and best manufacturing practices for assembly and soldering of "mixed alloy" soldered hardware with lead free component finishes will be documented.

3.0 Technical Plan

The subcontractor will identify Functional Hardware assemblies which contain tin lead solders and lead free component finishes which have been fielded for varied amounts of years. The hardware will undergo visual and microscopic examination for evaluation of tin whisker formation mechanisms. The project's output will be a documented history of applications along with lessons learned from these applications.

4.0 Statement of Work

Task 1. Identification of lead free finish applications in fielded hardware

Generate a list of fielded applications of "mixed alloy" lead free component finishes that exist in various military and high reliability applications. The goal of this effort will be to define applications with 5, 10, 15, and 20 years of life.

Task 2. Perform visual and microscopic evaluations on the hardware to identify areas of tin whisker formation.

Task 3. Documentation of design, packaging and processing guidelines to minize tin whisker risk.

Task 4. Final Report – Manufacturing process guideline for "mixed alloy" solders

Develop a design, packaging, and manufacturing Process Guideline for implementing "mixed alloy" lead free finishes in high reliability applications with reduced risk. The guideline should reflect lessons learned in the performance of this subcontract.

5.0 Schedule

The project schedule will cover 12 months per the milestones and deliverables in Section 6.0.

6.0 Project Milestones and Deliverables

Task	*Deliverable*	*Acceptance Criteria*	*Due Date*
1	Report: Identification of lead free finishes in exisitng fielded hardware	• Report details specific applications which have existed with lead free finishes for varied time periods of 5,10, 15, 20 years.	1 month ARO
2	Report: Results of visual and microscopic examination on the hardware to identify areas of tin whisker formation. .	• Report documents tin whisker observations made on existing applications and also documents observations made of their specific design, packaging, and processing parameters and their tin whisker formation observations.	6 months ARO
3	Report: Documentation of design, packaging and processing guidelines to minimize tin whisker risk.	• Report documents design, packaging, and processing guidelines to minimize tin whisker risk. •	10 months ARO
4	Final Report:	• Final report documenting observations found and conclusions made of effectiveness of design, packaging, and processing parameters.	12 months ARO

Statement of Work
Reliability demonstration and processing guidelines for "mixed" alloy applications

July 27, 2006

1.0 Introduction

This program’s task will be to demonstrate the reliability of “mixed alloy “ (lead free component finishes with conventional tin lead solder alloys) in high reliability aerospace and military applications. The project’s prime deliverables will be a reliability demonstration on functional hardware and development of manufacturing process guidelines to implement “mixed alloy” assemblies. A combination of reliability test vehicles and functional hardware will be manufactured and evaluated using lead based solders and lead free component finishes. The manufacturing process guideline will take into account the transition of component finishes from lead to lead free finishes while the Defense industry continues to utilize lead based solders to minimize the risk of tin whisker growth. The target programs, whose hardware will serve as demonstration vehicles, are those that can represent the widest range of high reliability requirements.

Tin Lead (SnPb) solder has been the prime circuit interconnection in electronics manufacturing providing electrical conductivity and mechanical strength between circuit cards and electronic packages. International concern and legislation have resulted in programs to eliminate lead (Pb) in solders and component finishes. However, the Air Force, NASA, and other DoD departments have expressed concern over the removal of lead from solder finishes and the tin whisker risks that this practice could create in on going production of existing military and high reliability systems. To mitigate risks posed by the use of 100 % lead free finishes and solders, the continued use of lead containing solders while working with lead free component finishes is proposed. The objective of this effort is to study and document this combination of continued use of lead based solder while insuring compatibility with lead free component finishes.

2.0 Project Scope

The project scope will include demonstration of the reliability of “mixed alloy” solder interconnections in demonstration vehicles which provide validation of reliability predictions and assembly and test of functional hardware for testing and evaluation in actual military hardware. To accomplish this, the subcontractor will manufacture Reliability Demonstration Units (RDU’s) and Functional Demonstration Hardware (FDH) with “mixed alloy” configurations using lead free component finishes and lead based solders. Processing guidelines and best manufacturing practices for assembly and soldering of “mixed alloy” soldered hardware will be documented. Documenting the electrical performance and reliability capabilities of such hardware, and comparing their electrical performance and reliability capabilities against their tin lead (SnPb) counterparts is part of the project scope.

3.0 Technical Plan

The subcontractor will manufacture RDUs and FDH assemblies with tin lead solders and lead free component finishes. The hardware will undergo a series of functional, electrical, and Environmental Stress Screening (ESS) tests to determine if hardware manufactured with “mixed alloy” solders has the same performance as hardware soldered with Tin Lead (SnPb) solders. The project's output will be a documented reliability demonstration and processing guideline for "mixed alloy" applications.

4.0 Statement of Work

Task 1. Detailed state of the art in Mixed Alloy soldering

Review state of the art in "mixed alloy" component finishes and soldering. Generate a list of "mixed alloy" component finishes that will be introduced on component packages typically used in military applications and submit a technology initial evaluation report.

Task 2. Select component finishes, processes and Reliability Demonstration Unit (RDU) and Functional Demonstration Hardware (FDH)

Design, fabricate and assemble a RDU test vehicles using "mixed alloy" component finishes and modified lead based soldering parameters. These parameters will be used for both manufacturing assembly and repair processes.

Select a Functional Demonstration Hardware to be manufactured with "mixed alloy" component finishes and lead based solder.

Task 3. Manufacturing/rework process and functional test plan

Develop the "mixed alloy" manufacturing process to build the selected RDU and FDH assemblies. The subcontractor will determine the requirements their hardware will have to meet in order to be compliant with their customer requirements.

The RDU and FDH assemblies will be manufactured with "mixed alloy" solders in sufficient quantities to support Functional Electrical testing and Environmental Stress Screening. The subcontractor will document their manufacturing processes, identifying areas of risk and improvement.

Develop rework and repair processes to be used on the RDU and FDH assemblies with "mixed alloy" solders.

Perform rework on the RDU and FDH assemblies with "mixed alloy" solders using the rework processes developed in this task.

Develop a Demonstration Test Plan. This is a series of test and performance specifications which each assembly will have to meet.

Task 4. Demonstration Vehicle Testing

Perform functional electrical testing and Environmental Stress Screening (ESS) on the Demonstration Vehicles and reworked Demonstration Vehicles in accordance with the test plan developed in task 3.

Compare the functional electrical and Environmental Stress Screening characteristics of “mixed alloy” solder hardware versus the same hardware soldered with Tin Lead (SnPb).

If the “mixed alloy” soldered hardware does not meet the performance requirements, an analysis will be performed to determine the root cause for failure.

Task 5. Final Report – Manufacturing process guideline for “mixed alloy” solders

Develop a manufacturing Process Guideline for implementing “mixed alloy” soldering for high reliability applications which is compatible with current manufacturing and rework/repair processes for high reliability military electronics. The guideline should reflect lessons learned in the performance of this subcontract.

5.0 Schedule

The project schedule will cover 12 months per the milestones and deliverables in Section 6.0.

6.0 Project Milestones and Deliverables

Task	*Deliverable*	*Acceptance Criteria*	*Due Date*
1	Technology Initial Evaluation Report	• Report details the state of the art in lead free component finishes and lead based soldering alloys.	1 month ARO
2	Report: Select component finishes, processes, for Reliability Demonstration Unit and Functional Demonstration Hardware	• Report contains Down Selection of lead free component finishes detailed in initial report. • Subcontractor has developed process parameters for “mixed alloy” soldering and overall manufacturing process parameters. • Demonstration Demonstration Hardware has been selected.	3 months ARO
3	Report: Manufacturing/rework process and functional test plan	• Subcontractor has chosen a manufacturing and rework/repair process suitable for “mixed alloy” soldering • Reliability Demonstration Units have been manufactured in accordance with the selected manufacturing process • Performed rework/repair on RDU’s in accordance with the process developed in this task • Developed Functional Demonstration Hardware test plan which will allow comparison of “mixed alloy” vehicle testing with lead based production testing	6 months ARO
4	Report: Demonstration Vehicle testing	• Test results of functional and Environmental tests performed in accordance with the test plan developed in task 3 for both manufactured and reworked/repaired demonstration vehicles • If “mixed alloy” hardware does not meet the performance requirements of the functional test plan the subcontractor must perform an analysis to determine the root cause for failure and include the results of that investigation in this report	9 months ARO
6	Report:		12

Task	*Deliverable*	*Acceptance Criteria*	*Due Date*
	Manufacturing process guideline for “mixed alloy” solders	• Subcontractor has developed a manufacturing Process Guideline for implementing “mixed alloy” soldering processes for high reliability applications.	months ARO

Statement of Work
Supplier Chain Guidance/Test Methods To Prevent Component Mixing

July 27, 2006

1.0 Introduction

Because of the Europe’s Restriction on Hazardous Substances (RoHS) initiatives which took effect 1 July 2006, Supply Chain Management (SCM) of pure tin and Lead-Free components [(leaded, ball grid array (BGA) and chip scale packages (CSP)] for defense, avionics, missile, military, space and related applications, is crucial at all levels including suppliers and subcontractors. Without a strategic and sound SCM program in preventing the mixing of SnPb and lead-free components, long term reliability of electronics systems could be at risk. Military applications are exempt from the RoHS initiatives and therefore will continue to require leaded components. Finding qualified suppliers to convert passive and active lead-free components into SnPb should be of priority.

The objective of this project will be to develop a mitigation plan that will serve as a guideline and directive for the aforementioned industry of existing fielded systems and subsequent designs. The deliverables will include the development of a compatibility matrix for lead-free surface finishes and solder systems, a process flow guideline, analytical/screening and inspection test process for using X-ray fluorescent (XRF).

Tin Lead (SnPb) solder has been the primary material used for both surface mount and plated- thru-hole interconnects for decades. However, because of the RoHS initiatives, many lead-free materials, such as pure tin (Sn), tin silver (SnAg), tin silver copper (SnAgCu (SAC)) or SAC, tin copper (SnCu) are being used as substitutes for SnPb. Therefore, developing a database system to track and verify that all the components used in the end products are SnPb surface finishes, is paramount. Although, the original equipment manufacturers (OEMs) should depend on the suppliers and subcontractors to continue to supply SnPb hardware, however, to mitigate the risk of component mixing and using lead-free components and printed wiring boards (PWBs), where it is (Pb-Free) not intended; XRF can be used to verify the surface finish at receiving inspection.

2.0 Project Scope

The project scope will include four major tasks: **1)** Developing a Surface Finish Compatibility Matrix for SnPb & Pb-Free and Pb-Free solder systems and combination thereof, that are deemed acceptable. This information shall be based on manufacturing process qualifications and thermal fatigue test data for harsh and military environment applications (-55 to 125ºC). This approach should be based on collaborative efforts with others and leveraging from published data and on-going Pb-Free activities at various organizations such as Raytheon, LEAP, University of Maryland-CALCE, ACI, JG-PP, Rockwell Collins, ITT Industries, Boeing, Lockheed Martin, NAVAIR, etc. and the commercial industry; **2)** Developing Standardized Test Methods for Using XRF or Equivalent Tool for Incoming Part Inspection; **3**) Developing Process Flow Guidelines for Handling SnPb and Pb-Free; **4)** Creating a Database for Incoming Part Inspection.

3.0 Technical Plan

Circuit card assembly suppliers, also known as electronic manufacturing services (EMS), suppliers of black boxes, and subcontractors will utilize the tools developed in this project to identify SnPb and Pb-Free hardware in order to prevent mixing. XRF inspection techniques shall be the preferred inspection tool for detecting Pb-Free finishes. The project's outputs will be a set of guidelines to be used by high reliability/harsh environment OEMs to mitigate the risk of having Pb-Free hardware being used in a system where Pb-Free is unacceptable.

4.0 Statement of Work

Task 1. Develop Surface Finish Compatibility Matrix for SnPb & Pb-Free

Task 2. Develop Standardized Test Methods for Using XRF or Equivalent Tool for Incoming Inspection

Task 3. Develop Process Flow Guidelines for Handling SnPb and Pb-Free

Task 4. Create a Database for Incoming Part Inspection

Task 5. Final Report – Supplier Chain Guideline/Test Methods to Prevent Component Mixing

5.0 Schedule

The project schedule will cover 12 months per the milestones and deliverables outlined in section 6.0 below.

6.0 Project Milestones and Deliverables

Task	Deliverable	Acceptance Criteria	Due Date
1	**Develop Surface Finish Compatibility Matrix for SnPb & Pb-Free**	• Compile as much information as possible from the many organizations working on the same topic and share resources (collaborative effort) in order to minimize duplication	6 months [(After receiving order (**ARO**)]
2	**Develop Standardized Test Methods for Using XRF or Equivalent Tool for Incoming Inspection**	• Create a documentation for using XRF equipment with feedback from other industry users • Investigate if there exists IPC guidelines for XRF inspection criteria and determine leveraging opportunities	3 months ARO
3	**Develop Process Flow Guidelines for Handling SnPb and Pb-Free**	• Guidelines will contain a step by step process flow for handling incoming hardware with decision gates, hardware identification, etc.	
4	**Create a Database For Incoming Component Inspection**	• Develop a database to capture and record all inspected hardware by component and PWB supplier • A different part numbering system may be developed for all Pb-Free detected hardware • Database should be user friendly whereby such tool can be used for audit and history	6 months ARO

Task	Deliverable	Acceptance Criteria	Due Date
5	**Final Report – Supplier Chain Guideline/Test Methods to Prevent Component Mixing**	• Final documentation will be used by companies exempt from RoHS initiatives to insure unqualified Pb-Free components and PWB are not used • This documentation can be used as a decision tool at concept, design, engineering and manufacturing stage as an awareness and mitigation	3 months ARO