Pb-free Electronics Risks Mitigation Project

DLA Technical Briefing

24 April 2012

Presented by: AVP Technical Operations, AIA

Submitted by Pb-free Electronics Risk Mitigation (PERM) Consortium (

Discussion Topics

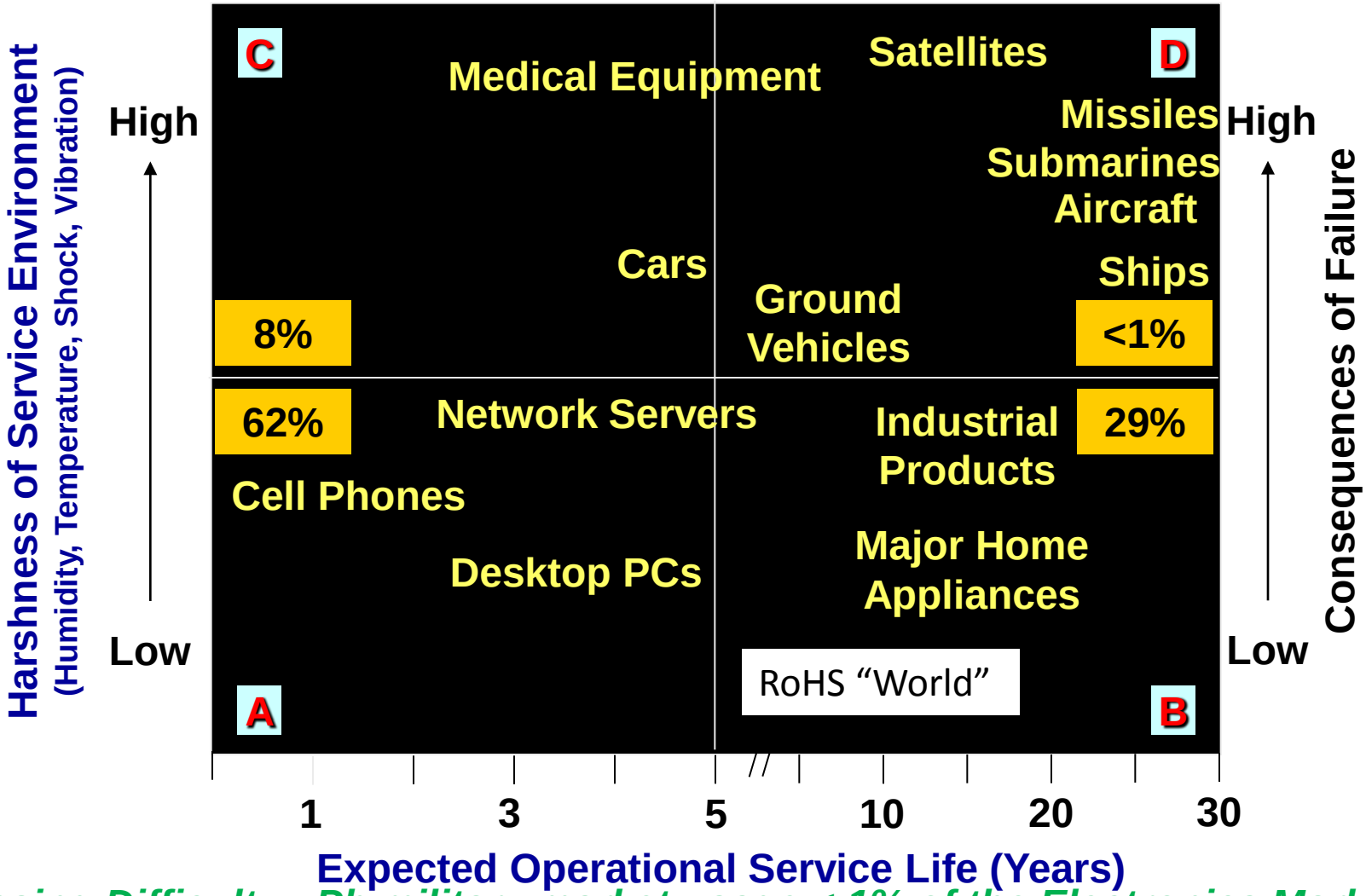
- **Pb-free Electronics Supplier Issues**

- **Pb-free Electronics Risks & Failures**
  - **Tin Whiskers**
  - **Issues with Pb-free Alloys in COTS Electronics**
  - **Unpredictable Service Life & Reliability for the Warfighter**

- **Risk Reduction Strategy**
  - **Pb-free Electronics Risk Management (PERM) Consortium**
  - **"Manhattan Project" to Scope the Problem**
  - **Pb-free Electronics Risk Reduction Program**

- **Take Away's**

Pb-free Electronics Operating Environment vs. Operational Life-time



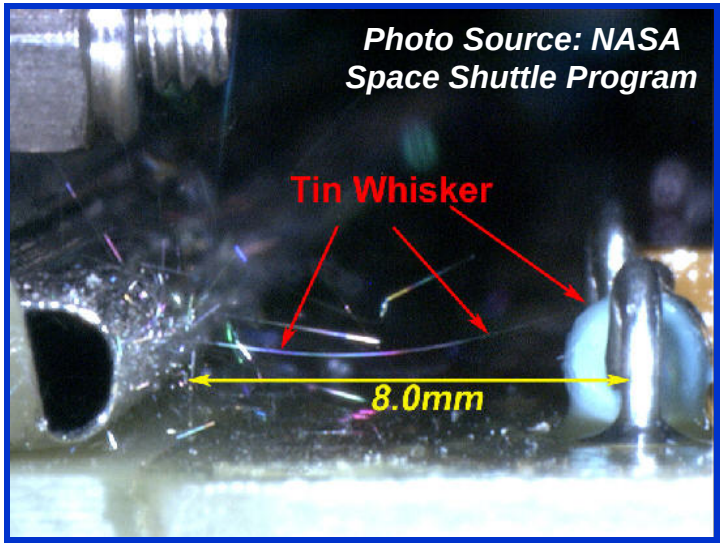
Increasing Difficulty: Pb military market usage < 1% of the Electronics Market

Pb-free Electronics Risks

EU Restriction of Hazardous Substances (RoHS) Directive banned use of lead (Pb) in commercial electronics sold in EU as of 7/1/06, impacting global COTS electronics market

Unintended Consequences

- **"Tin Whisker" Short Circuits**
  - Electrically conductive
  - Can metal vapor arc
- **Pb-free Solder Issues**
  - Fractures in high shock & vibration environments
  - Has higher melting temps
  - Incompatibilities with SnPb Solder
  - Less repairable assemblies
- **Configuration Control Nightmare!**
  - Unidentified component alloys
  - Mixed Pb & Pb-free inventory
- **Intermittent Behavior**



Electromagnetic Relay Vapor Arc Damage

Pb-Free Solder Joint

Have Tin Whiskers Caused Failures?

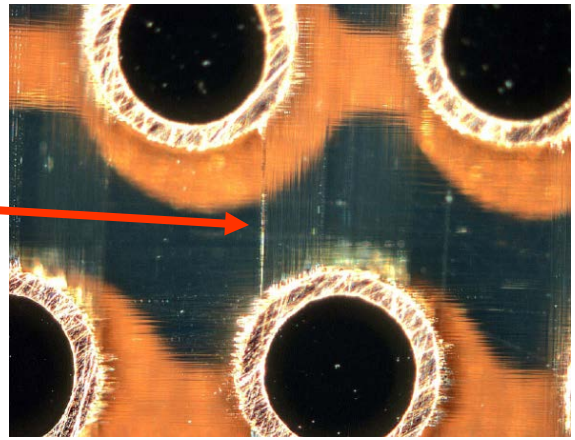
- **Multiple Documented Occurrences (NASA/Industry/Academic Publications)**
  - **Nuclear Utilities**
  - **Seven Satellites**
  - **Seven Missile Programs**
  - **Heart Pacemaker**
  - **Fighter Jet Radar**
  - **Military Aircraft**
  - **Telecom. Equip.**
  - **Heart Defibrillators**
  - **New Commercial Autos**

$1B to $5B Worth of Satellites, Missiles & Other Equipment*

Pb-free Electronics Technical Impact

- **No universally acceptable technical solutions in sight to replace SnPb in Aerospace & Defense (A&D) applications**
  - Conformal coatings only mitigate tin whiskers
  - Pb-free solder joint reliability decreased for shock; some have corrosion issues and incompatibilities with tin-lead
  - SAC305 solder dissolves copper, impacting rework and repair
  - Conductive Anodic Filament (CAF) problem is re-emerging due to higher Circuit Card Assembly processing temperatures using Pb-free solders

Conductive Anodic Filament (CAF) in Circuit Card Assembly (CCA)



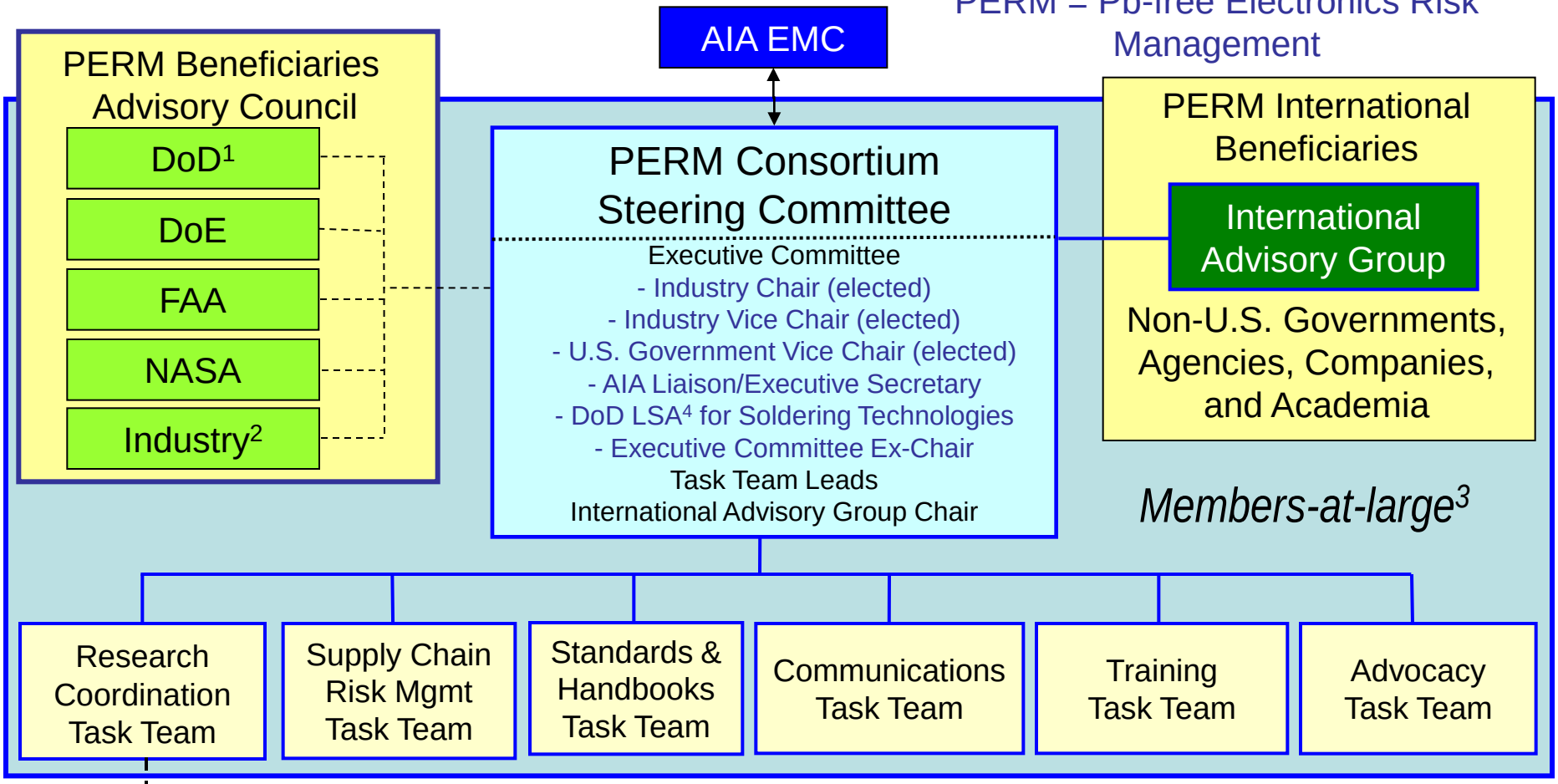
Ref: "Lead Free PCB Projects Update,"

Advanced Research of Electronic Assemblies Consortium, February 2008

Current technical approaches are all still "mitigations" and not "elimination" of the Pb-free electronics issues

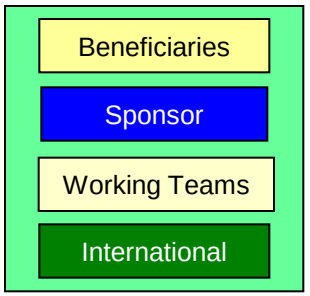
Pb-free Electronics Risk Management Consortium

PERM = Pb-free Electronics Risk Management



Lead-free Electronics Risk Reduction Project (Gov't Contract)

1. Membership of Senior Stakeholders determined by OSD and DoD
2. Including representatives of U.S. Industry Associations such as AIA, TechAmerica, AMC, IPC, etc.
3. Any individual participant (Government, industry and academia) in PERM meetings and consensus process; Integrated Membership from prior LEAP WG and ELF IPT
4. LSA = Lead Standardization Activity



GEIA Pb-free Standards and Handbooks From the LEAP WG/PERM Consortium

GEIA-STD-0005-1*	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder
Lead Free Control Plan (LFCP)	Compliance Template for compliance to GEIA-STD-0005-1
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 Testing for Aerospace and High Performance Electronic Interconnects Containing Pb-free Solder & Finishes
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 COULD NOT BE COMPLETED – INSUFFICIENT DATA*

***Revsion A of these documents presently going through ITAA ballot process**

Pb-free Electronics Manhattan Program
"Scope & Solve the Problem"

Manhattan Project | **Pb-free Electronics Project**

Manhattan Project

ONR Funded

Phase 1: Current Practice Baseline – Completed

JDMTP Funded*

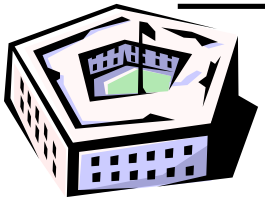
Phase 2: Technology Roadmap – Completed

* *JDMTP* = Joint Defense Manufacturing Technology Panel

2009 – 2010

DoD Pb-free Electronics Risk Reduction Program

Customers



DoD plus…

Phase 3 – Integrated Risk Reduction Projects

- **Tin Whiskers**
- **Electronics Assembly**
- **Solder Joints**
- **Electronic Component**
- **Printed Circuit Boards**

2013 – 2016 ----

Phase 1 & 2 Observations

1. **Serious technical gaps exist for Pb-free electronics that have to be overcome for use in DoD harsh environment**
2. **Quantification of degraded reliability and lifetimes is a significant gap**
3. **The technical issues are numerous, complex, and interrelated. An integrated research project will be far more effective and efficient at reducing risk than a piecemeal approach.**
4. **Phase 3 will benefit any DoD or commercial product that relies on Pb-free COTS electronics and operates in extreme or harsh environments**

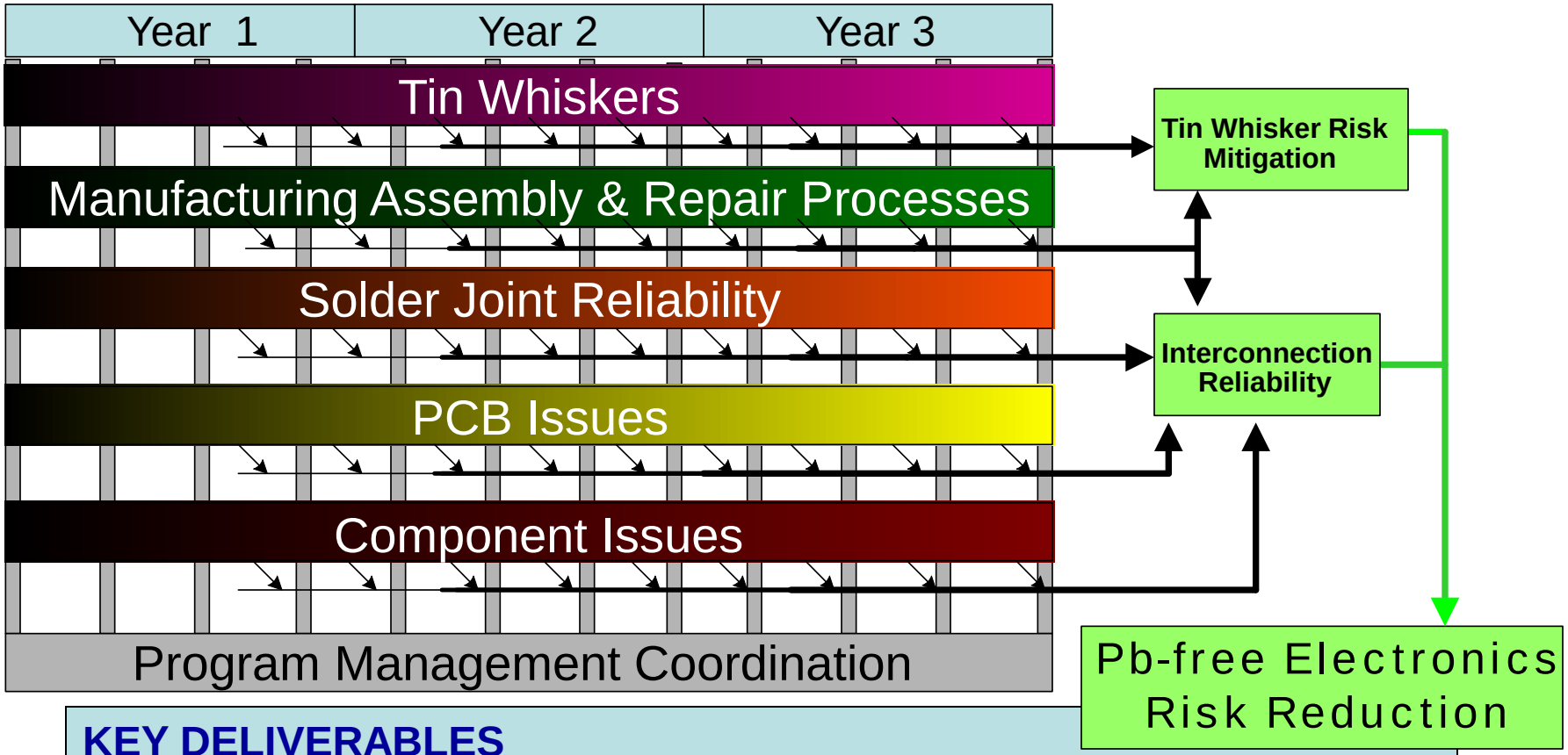
Phase 1 Baseline Practices & Knowledge Gaps

- *Design*
- *Manufacturing*
- *Sustainment*
- *Testing*
- *Reliability*

Phase 2 & 3 Risk Reduction Project Areas

- *Tin Whiskers*
- *Assembly*
- *Solder Joints*
- *Printed Circuit Boards*
- *Components*

Recommended Roadmap for Pb-free Electronics Risk Reduction



KEY DELIVERABLES

- ***Detailed Design Guidelines for Use of Pb-free COTS Electronics***
- ***Validated Life-Prediction Models based on Physics of Failure***
- ***Methodologies for Assessing New Materials***
- ***Assembly and Repair Process Definitions***

Rough Order Magnitude Cost Estimate

36-month Risk Reduction Program will enable continued use of COTS electronics in DoD products

WBS	Risk Reduction Project Area	ROM Cost in 2010 $ (M)			
		Year 1	Year 2	Year 3	TOTAL
A	Tin Whiskers	$ 6.3	$ 6.8	$ 6.5	$ 19.7
B	Assembly	$ 3.2	$ 4.0	$ 3.0	$ 10.2
C	Solder Joints	$ 13.9	$ 19.4	$ 13.3	$ 46.6
D	Components	$ 1.2	$ 2.6	$ 2.1	$ 5.9
E	Printed Circuit Boards (PCBs)	$ 3.9	$ 5.2	$ 3.5	$ 12.6
	TOTAL	$ 28.5	$ 38.0	$ 28.5	$ 95.0
	TOTAL with 10% Contract Administration Cost	$ 31.4	$ 41.8	$ 31.3	$ 104.5

Program Execution Budget Required in 2010 Dollars: $105M

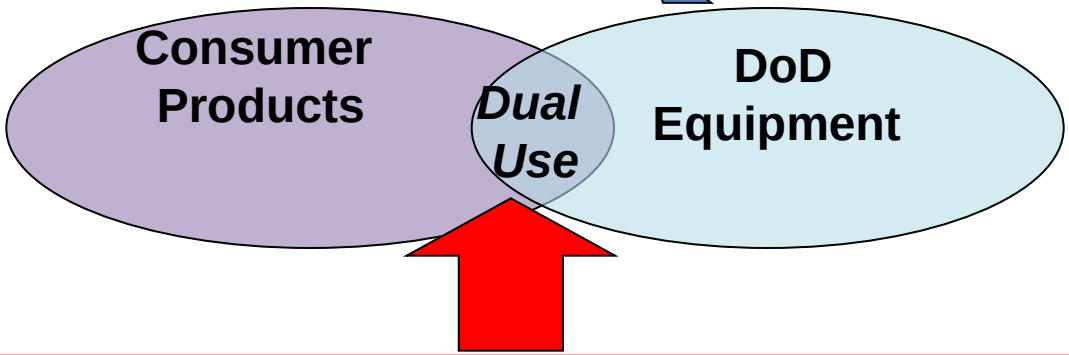
Fundamental objective is to resolve knowledge gaps for use of Pb-free electronics as quickly as possible!

DoD COTS Electronics Dependence

Commercial versus DoD Electronics Usage

- 1-2 Year Life, No repair
- Non-Safety Systems
- "Fractions of a Cent" Cost Drivers
- RoHS Compliant
- Rapidly Changing

- Complex Systems
- 10-20+ Year Service
- High Performance
- Critical Safety Items
- Rigorous Qualification

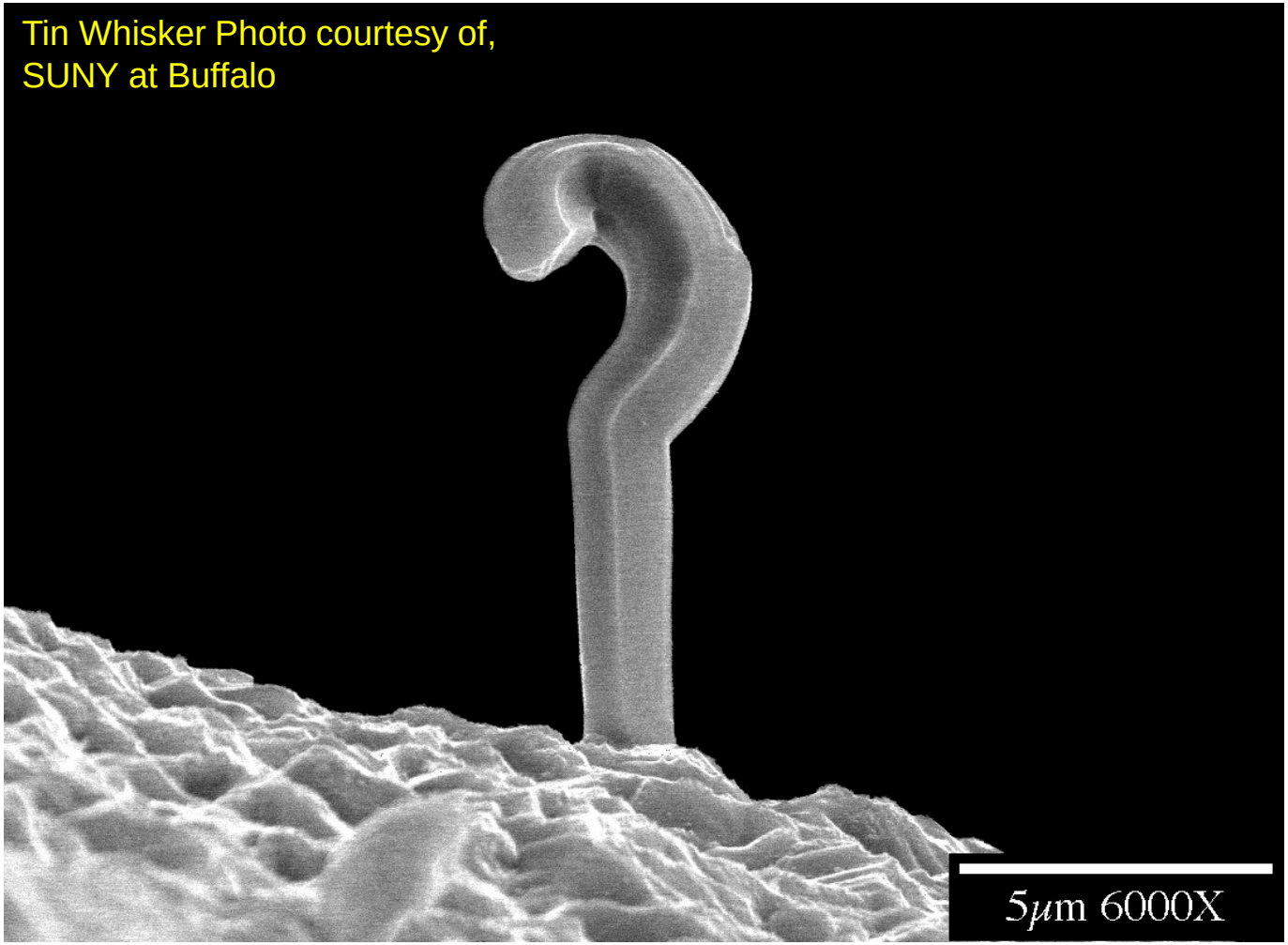


Consumer Electronics Supply Base Will Not Accommodate or Solve DoD Harsh Operating Environment Reliability Issues

Lead-Free Electronics Manhattan Project will close these gaps !

Take-Away's

- **The technical issues to use Pb-free electronics in harsh operating environments are very complex and are not easily solved**
- **The cultural issues regarding the Pb-free Electronics debacle are as complex as the technical issues**
  - ***"I have more important, immediate problems."***
  - ***"I cannot obtain funding for a research project for which there is no clear solution, no definitive schedule, and no grasp of the total funds required."***
  - ***"Show me the recent evidence that this is a problem that merits my attention." versus "We cannot share this with anyone."***
  - ***"This is everyone's problem, therefore it's no one's problem."***
- **Need to appropriate $105M funding in the FY 13 budget**

Pb-Free Is <u>Not</u> Free!!

Questions / Suggestions?