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Aerospace Lead-free Reliability

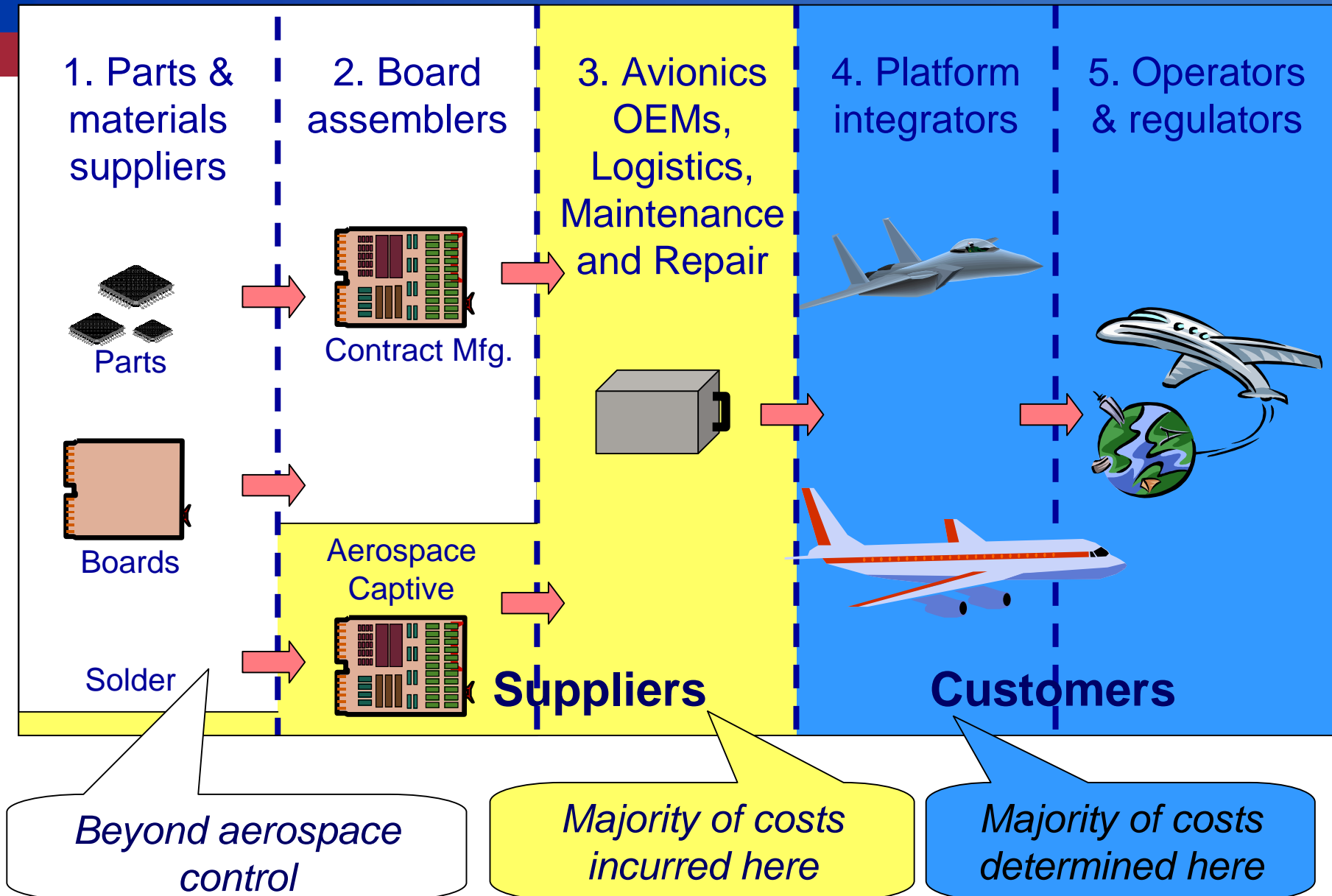
IPC APEX Reliability Summit

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The Avionics Supply Chain



Major Aerospace Technical Issues

(From an AIA Position Paper, January 2007)

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Specific aerospace risks:

- (1) unproven reliability of solder joints
- (2) degraded reliability due to “tin whiskers,”
- (3) loss of configuration control
- (4) impaired reparability

Most urgent needs:

- (1) methods to analyze, test and qualify lead-free electronics for aerospace applications;
- (2) methods to assess and quantify effects of lead-free electronics in aerospace system safety and certification analyses;
- (3) better understanding of the causes and mitigation methods for tin whiskers; and
- (4) better understanding of the reliability of lead-free solder joints especially those associated with surface mount area array packages.

AIA-AMC-GEIA Lead-free Electronics in Aerospace Project Working Group (LEAP WG)

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- **Formed in 2004 by Aerospace Industries Association (AIA), Avionics Maintenance Conference (AMC), and Government Engineering and Information Technology Association (GEIA)**

Includes all stakeholders (market segments, supply chain, geographic regions)

- **Addresses issues that are:**
 - **Unique to aerospace and military**
 - **Within control of aerospace and military**

Aerospace Issues

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Unique to Aerospace:

- Long service lifetimes
- Rugged operating environments
- High consequences of failure
- Repair at circuit card level (mixed alloys)
- Quantify reliability at design
- Strict configuration control requirements (obsolescence)



Beyond Aerospace Control (most of the time):

- Alloys on part terminations
- Alloys on printed wiring pad finishes
- Reliability tests conducted by suppliers cannot be assumed to assure reliability in aerospace applications

LEAP WG Actionable Deliverables

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GEIA-STD-0005-1, Performance Standard for Aerospace Electronic Systems Containing Lead-free Solder
Used by aerospace electronic system “customers” to communicate requirements to aerospace electronic system “suppliers”

GEIA-STD-0005-2, Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

GEIA-STD-0005-3, Reliability Testing for Aerospace and High Performance Electronics Containing Lead-free Solder
Used by aerospace electronic system “suppliers” to develop reliability test methods and interpret results for input to analyses described in GEIA-STD-0005-4

GEIA-HB-0005-1, Program Management / Systems Engineering Guidelines For Managing The Transition To Lead-Free Electronics
Used by program managers to address all issues related to lead-free electronics, e.g., logistics, warranty, design, production, contracts, procurement, etc.

GEIA-HB-0005-2, Technical Guidelines for Using Lead-free Solder in Aerospace Applications
Used by aerospace electronic system “suppliers” to select and use lead-free solder alloys, other materials, and processes. It may include specific solutions, lessons learned, test results and data, etc.

GEIA-HB-0005-3, Repair and Rework of Electronic Assemblies Containing Lead Free Solder

GEIA-HB-0005-4, Impact of Lead Free Solder on Aerospace Electronic System Reliability and Safety Analysis
Used to determine, quantitatively if possible, impact of lead-free electronics on system safety and certification analyses, using results from tests performed per GEIA-STD-0005-3

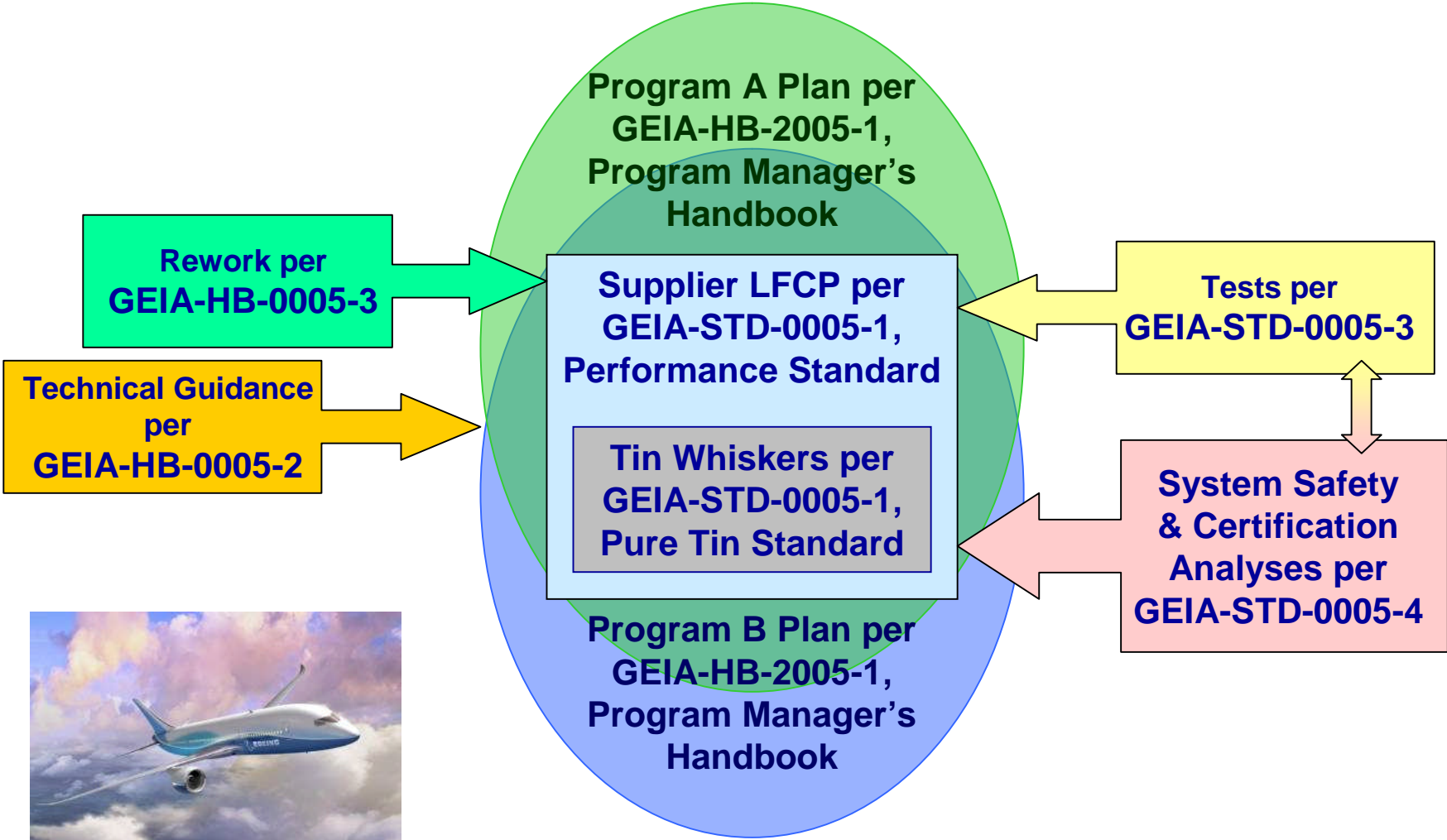
LEAP WG Actionable Deliverables

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Document Number	Title	Task Leader	GEIA Publication	IEC/PAS Publication
GEIA-HB-0005-1	Program Management/ Systems Engineering Management Guidelines for Managing the Transition to Lead-free Electronics	Pat Amick (Boeing)	30 June 2006	31 December 2006
GEIA-HB-0005-2	Technical Guidelines for Aerospace Electronic Systems Containing Lead-free Solder	Stephan Meschter (BAe Systems)	31 December 2006	30 June 2007
GEIA-STD-0005-1	Performance Standard for Aerospace and Military Electronic Systems Containing Lead-free Solder	Lloyd Condra (Boeing)	30 June 2006	31 December 2006
GEIA-STD-0005-2	Standard for Mitigating the Deleterious Effects of Tin in High-Reliability Electronic Systems	Anduin Touw (Boeing)	30 June 2006	31 December 2006
GEIA-STD-0005-3	Reliability Testing for Aerospace and High Performance Electronics Containing Lead-free Solder	Tony Rafanelli (Raytheon)	30 September 2007	31 December 2007
GEIA-HB-0005-4	Impact of Lead Free Solder on Aerospace Electronic System Reliability and Safety Analysis	John Biel (Smiths)	31 January 2008	TBD
GEIA-HB-0005-3	Repair and Rework of Electronic Assemblies Containing Lead Free Solder	Tim Kalt (US Air Force)	31 December 2007	TBD

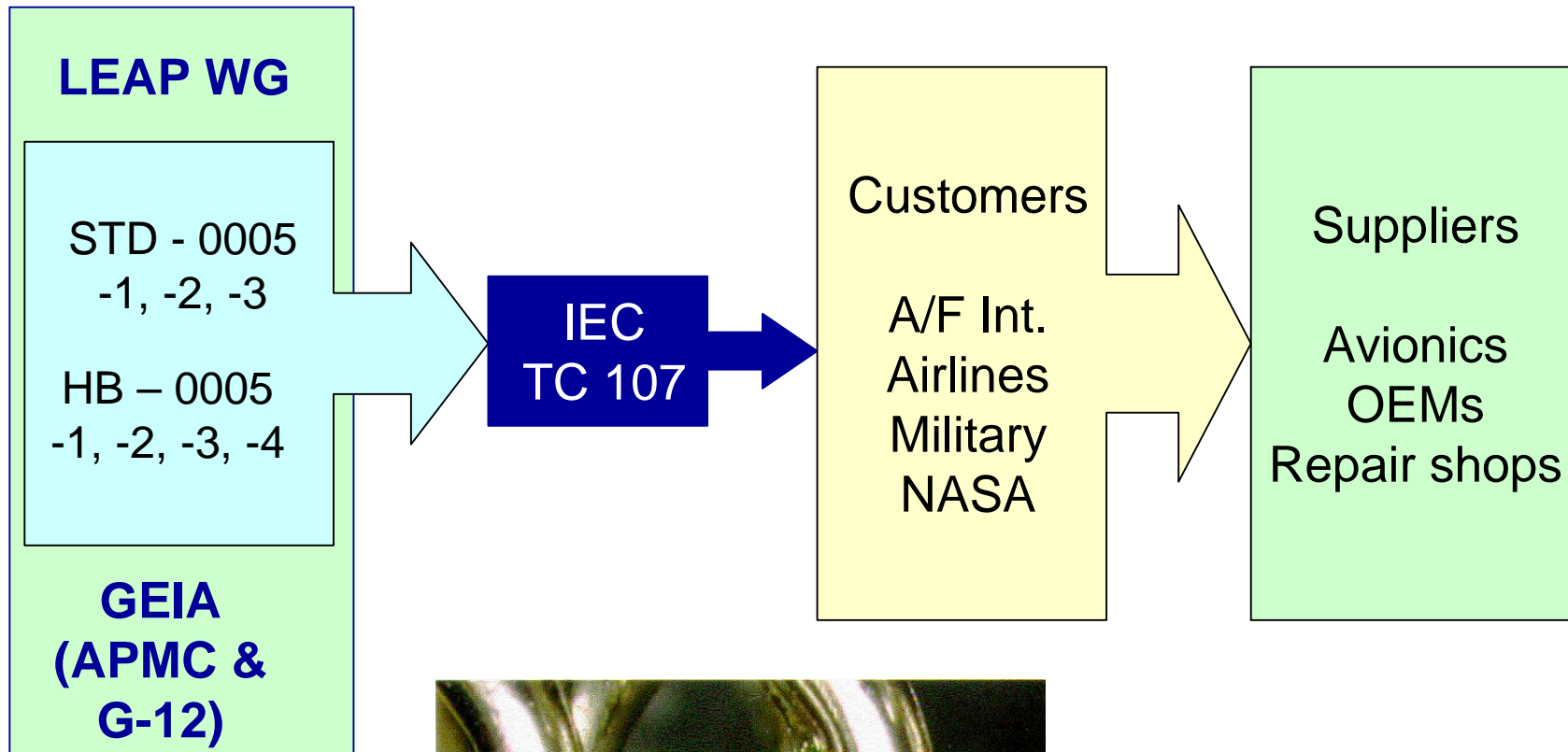
 Released documents

How the Documents Work Together



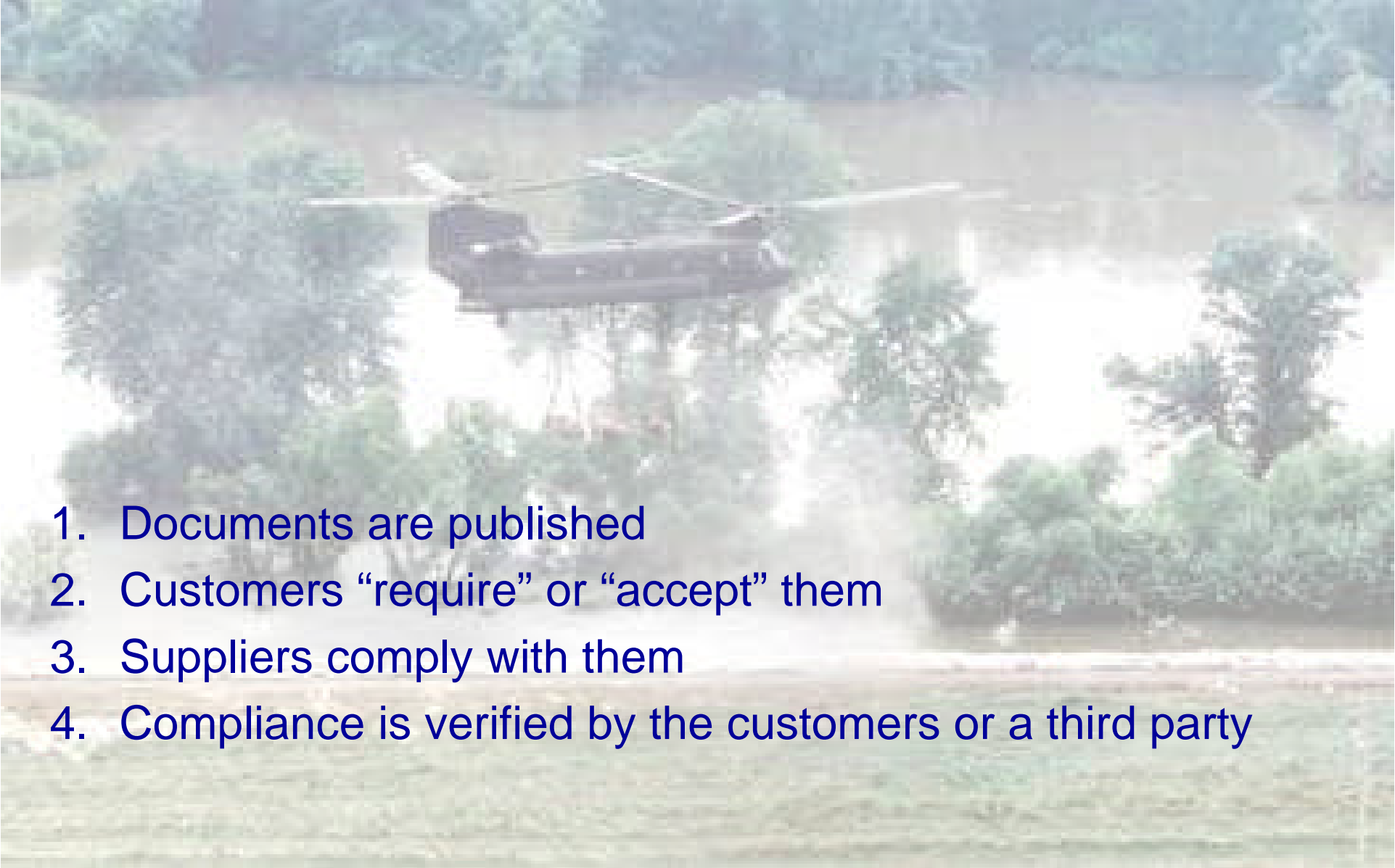
Implementation Process

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How Do We Know When We Are Finished?

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1. Documents are published
 2. Customers “require” or “accept” them
 3. Suppliers comply with them
 4. Compliance is verified by the customers or a third party
- 

Frequently-asked Question:

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I'm going to stay with PbSn as an assembly alloy. Do I still need to have a Lead-free Control Plan?

Answer:

Yes, because you almost certainly will receive components with lead-free solder balls or termination finishes, or printed wiring boards with lead-free pad finishes.

Processes to be documented may include:

- Identification of solder alloys on incoming parts and materials
- Configuration control
- Inventory control
- Removal and replacement of lead-free solder alloys
- Reliability assurance for mixed solder alloys
- Contamination control for wave solder baths
- Repair processes for replacement components with different termination alloys
- Tin whisker control
- Etc.

Test Methods (GEIA-STD-0005-3)

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Objectives:

- Define methods to test aerospace and high-performance interconnections containing lead-free solder
- Produce results usable for reliability analyses, process qualification, and product qualification, etc.
- Provide a conservative default method
 - To be used by manufacturers, repair facilities, etc. who are unable to commit resources to develop their own tests
- Provide a guideline protocol
 - To be used by manufacturers and repair facilities with the resources necessary to develop test specific to their own needs

Environments of concern:

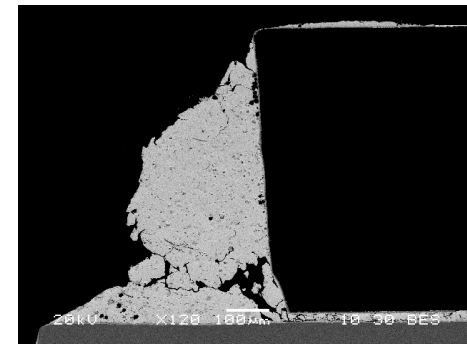
Thermal cycling

Vibration

Mechanical shock

Combined environments

Others as needed



Technical Issues (GEIA-STD-0005-3)

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Operating environments

Steady state temperature (max, min, average)

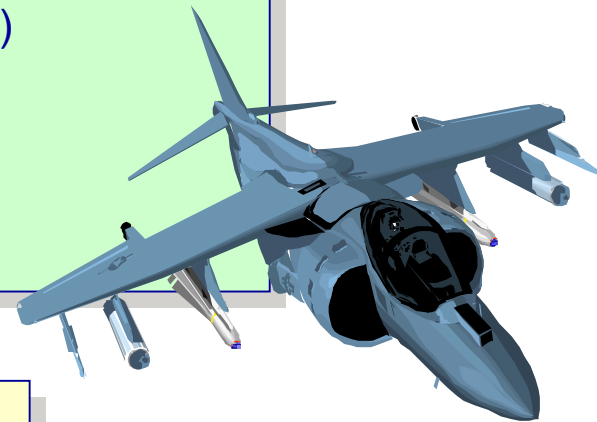
Temperature cycling (upper and lower limits, ramp rates, dwell times)

Vibration (sine, swept sign, random, coherent-incoherent)

Mechanical shock

Combined environments

Duty cycles



Material properties of solder alloys and alloy mixtures

Tensile strength

Creep properties

Young's modulus

Poisson's ratio

Yield points

Etc.

How do they vary with temperature?

Acceleration models

Thermal cycling

Steady state
temperature

Vibration

Reliability Methods (GEIA-HB-0005-4)

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Objective:

Develop analysis methods to use appropriate data (tests or in-service) to quantify reliability with respect to the effects of lead-free solder at the design stage

Results may be used for:

- System safety analyses
- System certification analyses
- System architecture
- Equipment design
- Business decisions (warranty, support costs, etc.)
- Spares provisioning



Possible metrics:

- Failure rate (constant or variable)
- Lifetime

Questions

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