Lead-Free Solder Testing for High Reliability

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Background
Solder materials used in assemblies pervade many forms of electronic platforms used by the DoD and NASA. Therefore, any change in soldering technology will have major implications for military and space operations.

Such a challenge is now facing the DoD and NASA in the push towards lead-free solder fueled by European environmental legislative actions on the use of lead and increasingly, by commercial and marketing activities overseas. Lead-free soldering is fast becoming the norm for commercial applications. Before long, there will be a push for a similar switch to lead-free solder for high-reliability electronics, as is seen in many DoD and NASA applications.

While lead-free solders are purported to reduce environmental and health risks, these solders present certain technical risks. Of concern, the reliability of most lead-free solders is not well known for high-reliability applications and the adverse environments of earth and space.

A joint partnership, under the auspices of JG-PP and, later, the Joint Council on Aging Aircraft, was formed to tackle the reliability issues surrounding lead-free electronics in high reliability applications.

Objective
The project objective is to generate comprehensive test data on the reliability of circuit cards newly manufactured and reworked with lead-free solder and subjected to simulated high-reliability (IPC Class 3) environmental conditions.

Stakeholders
NASA Centers (Kennedy Space Center, Jet Propulsion Laboratory, Marshall Space Flight Center, Johnson Space Center, Goddard Space Flight Center, Ames Research Laboratory), NASA contractors (United Space Alliance-Solid Rocket Booster, Boeing-Orbiter), major commercial and defense aerospace contractors (BAE Systems, Boeing, Lockheed Martin, Raytheon, Rockwell Collins), Air Force, Army, Navy, Marines, Dept. of Energy and more than 20 other private entities.

Benefits

- Helps maintain mission readiness by addressing issues related to component obsolescence with lead surface finishes
- Partnering and substantial in-kind contributions resulted in an estimated 5-to-1 return on NASA's investment in project.
- Project's Joint Test Protocol (http://www.teerm.nasa.gov/reports/Lead%20Free%20Solder%20JTP%20April-2004.pdf) meets NASA core testing needs (buy-in from key NASA stakeholders).

Achievements

- Completed Joint Test Protocol (http://www.teerm.nasa.gov/reports/Lead%20Free%20Solder%20JTP%20April-2004.pdf) and Potential Alternatives Report (http://www.teerm.nasa.gov/LFS%20Reliability/lfspar.pdf).
- Completed all short-term testing and published draft Joint Test Report (http://www.teerm.nasa.gov/LFS Reliability/JTR%20Executive%20Summary%20Draft%20July-14-2006.pdf). Some results and conclusions include:
  - Test vehicles assembled with lead-free materials (notably tin-silver-copper) exhibited lower reliability under some test conditions. This reduced reliability does not necessarily rule out the use of lead-free solder alloy on aerospace and defense electronics in some use environments.
  - Models for calculating the actual field lifetime of lead-free solder joints on certain component types must be developed and validated using actual test data (from this and other studies)
  - Next logical step (besides modeling) is system-level demonstration/validation of promising lead-free solders on functional Class 3 aerospace and defense electronic systems. This will also help validate any lifetime prediction models for lead-free.
- Presented data at various major electronics conferences, such as IPC APEX, Joint FAA/DoD/NASA Conference on Aging Aircraft, and SMTA
- Project won the 2005 Soldertec Lead-Free Solder award
- Passed on project data to the following organizations for inclusion in their own work products:

- IPC: Industry standard IPC-9701; Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments. In particular, data from the JCAA/JGPP LFS Project will be incorporated into Appendix B of the Guidelines for Thermal Cycle Requirements for Lead Free Solder Joints
- AIA-ARINC-GEIA Lead-free Electronics in Aerospace Project (LEAP) - GEIA-HB-0005-2 -Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead free Solder
- Lead-free solder interconnect reliability modeling is being conducted by various entities: University of Maryland Computer Aided Life Cycle Engineering (CALCE); Sandia National Laboratories; CirVibe Inc.; DfR Solutions; Electronics Packaging Solutions International Inc..

Next Steps

- Complete one remaining long-term test (-20 to +80C Thermal Cycling). This testing will likely complete when all lead-free BGA solder joints have failed.
- Publish updated (final) Joint Test Report once long-term testing is complete.

* Note –One long-term test remains to be completed.