



# JG-PP Email

Joint Group on Pollution  
Prevention

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**Pages:**

***JG-PP Lead-Free Solder Project  
Technical Teleconference Minutes  
August 8, 2001***

***JG-PP Project Lead: Robert Hill, NASA KSC***

***Telecon Chairperson: Brian Greene, CTC***

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**Comments:**

Attached please find the minutes from the August 8, 2001, Lead-Free Solder Technical Telecon. If you have questions about the minutes please contact Robert Hill, Brian Green or Tess Flynn. Please further distribute as necessary.



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**MEMORANDUM FOR RECORD**

**August 16, 2001**

**Subject: Meeting Summary and Minutes – August 8, 2001**

**Material(s) Identified:** Lead

**Process Identified:** Electronics soldering

**Methodology Phase:** I-Identification, II - Technical

**Summary:**

On August 8, 2001, technical representatives from Headquarters Air Force Material Command, Air Force Research Laboratory, Alliant Techsystems, American Competitiveness Institute, Boeing Company, Lockheed Martin, National Aeronautics and Space Administration-Kennedy Space Center, National Center for Manufacturing Sciences, Naval Air Warfare Center Weapons Division, Oklahoma City Air Logistics Center (B-2 Program), Raytheon, Rockwell-Collins, Potomac-Hudson Engineering representing HQs USMC/IL, U.S. Army Communications & Electronics Command, U.S. Army Tank-Automotive and Armaments Command, U.S. Marine Corps-Albany, and Warner Robins Air Logistics Center (F-15 Program) participated in a meeting with representatives from the Joint Acquisition Sustainment Pollution Prevention Activity and National Defense Center for Environmental Excellence/ Concurrent Technologies Corporation. The objective of the teleconference was to review the status of the technical phase of the project, including identifying system performance requirements and candidate lead-free solders.

**Prior Decisions:** Lead as used is tin-lead (Sn/Pb) solder was chosen as the target HazMat.

**Next Teleconference:** September 20, 2001, 2:00 P.M. Eastern time

**Next Meeting:** November 1, 2001 in Dallas, TX



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### Minutes

1. Mr. Brian Greene, Concurrent Technologies Corporation, called the meeting to order at 2:04 P.M. and conducted a roll call. Mr. Robert Hill, Joint Pollution Prevention Acquisition Sustainment Activity (JASPPA) chairperson, opened the teleconference call by thanking everyone for joining. He addressed concerns and confusion that have been raised on the scope of the project becoming too large making the project unwieldy. He said the full scope of the objective is to create several, perhaps six or more, different Joint Test Protocols (JTPs), each addressing a specific application and perhaps specific end items. He said a matrix would be built comprised of all of the tests in all of the JTPs to hold down duplication of effort and to make use of a building block approach in tackling this effort. He said the project will not become one huge project, but will likely be several specific projects building upon the knowledge learned in each successive project.
2. Mr. Greene then provided a brief review of the June 20, 2001 face-to-face meeting held in Dallas, TX. He characterized the meeting as a good meeting and had representatives from Raytheon, Boeing, Lockheed Martin, National Aeronautics and Space Administration (NASA), Rockwell Collins, National Center for Manufacturing Sciences (NCMS), American Competitiveness Institute (ACI), Naval Air Warfare Center Weapons Division China Lake, the B-2 System Program Office (SPO), the F-16 SPO and several others.
  - a. The attendees at the June meeting were focused on scoping the requirements in the technical phase of the project and in general laid out the performance requirements. The group identified several candidate alternatives. The group focused on circuit boards and did not address other lead using electrical equipment such as connectors.
  - b. The group reached consensus that two approaches were needed: one for new equipment manufacture that was lead free and one that addressed repair of existing systems. This became very apparent when the group discussed the higher application temperatures of the alternative lead free solders.
  - c. An action item was created from the need for a survey to determine specific performance requirements that project participants will need satisfied in qualifying alternative lead-free solder. General action items to the whole group were assigned to identify potential test requirements and any additional candidate lead-free solders. A specific action item was generated to accomplish a literature search for alternative solders and their interactions with tin-lead solder.
  - d. The survey was discussed and the group decided that a survey would be built around the depot repair needs to address the more important issues with implementing lead-free solder in today's systems. This survey form was sent out to the group with a request for comments. Thus far, only two offices at Warner Robins Air Logistics Center (WR-ALC) responded to the survey. WR-ALC confirmed the many of the tests that Mr. Jeff Bradford, Raytheon, and others initially identified tests within MIL-C-28809B and MIL-PRF-55110F. These outline basic testing needs, such as electrical parameters, vibration, shock, temperature, salt fog etc. The stakeholders at WR-ALC agreed and added some tests, such as Explosive Atmospheric testing described in MIL-E-5400 and a Dust and Sand Test described in MIL-E-5400. The F-15 SPO also added component level performance requirements, stating many of the problems they encounter are problems in assembly of



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hybrids at attach points, tin whiskers, and loss of integrity due to heat, salt atmospheric conditions and vibration. The SPO cited issues of environments within a larger environment including within the cockpit and outside of the cockpit.

3. Mr. Dave Johnson, Air Force Research Laboratory (AFRL) remarked there is a need to consider not only what is occurring on the component but what is happening inside the component as well. He cited that many of the current test requirements were built for eutectic lead solders. This group needs to provide tests to ensure performance with intermetallics and solder joint integrity. The second issue is the higher temperatures when reflowing solder in repair and the danger of melting the solder within the package. The board finishes over which the solder is applied and the lead finish affects the repair. With leadless devices, you will wind up with leads that will not last 10 thermal cycles.
  - a. Mr. Johnson went on to say AFRL has done a lot of work on leads and leadless surface mounts. Solder fatigue issues were identified during these tests. He said many lead-free solders were tests and the test assumption was the same boards would be used. Soldiers have lot of experience using 63-percent tin (Sn63) solders, but switching to lead-free solder alloys poses a potential risk that we will not get a very robust bond between the old residual intermetallic and the new alloy. Therefore, we will need a lot of testing of both low- and high-cycle fatigue solders which are leading to highly embrittled solder joints. Mechanical shock tests, thermal and vibration are at the heart of the issue.
  - b. Mr. Mike Leake, Raytheon, reminded the group that he thought a decision had been made to split the circuit card portion of the project into two approaches, one for old board designs (where we are concerned about bonding to intermetallics), and the second approach dealing with new board designs from scratch (where we would not be concerned about intermetallic bonding).
  - c. Mr. Lee Whiteman, ACI, stated he saw two issues: the preponderance of systems is in the fleet now and must eventually be addressed; the other is new lead-free system. He stated these two approaches must address how these two packages will react in the operational environment.
  
4. Mr. Johnson said component compatibility beyond lead finishes and dwell time is an issue. Most component grade plastics will last about 40 seconds dwell time with Sn63 solders, but with the higher temperatures the boards will not last that long. He said time and temperature are directly related to the board's performance. The question he said is how do you do a part-by-part review and still has survivability in military design applications?
  - a. Mr. Johnson continued that to get many lead-free solders to properly wet requires very aggressive solder paste, many of which have been banned from military use based on environmental and safety concerns. He wondered if environmental needs balanced with system performance tradeoffs should be made.
  - b. Mr. Greene asked Mr. Johnson to send an e-mail to him that lists the tests that Mr. Johnson sees a need for so they can be included in the JTP.
  - c. Mr. Johnson replied that Mr. Larry Perkins is the lead for this technology in AFRL. He and Mr. Perkins plan to attend a meeting with HQ AFMC/LGP-EV to discuss this project.



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- d. Dr. Duane Napp, NCMS, said industry is addressing the components issue with the higher temperatures, but he is not sure if the components are applicable to military use. NCMC did a lot of work at 160 °C and were able to get non-aggressive fluxes that had good commercial grade performance.
  - e. Mr. Dave Hillman, Rockwell-Collins, stated that Rockwell was also able to identify some non-aggressive commercial grade fluxes and meet military requirements for five or six lead-free materials. He added that the results from NCMS, Rockwell, and similar efforts could be leveraged to help us trim down the test matrix.
  - f. Mr. Johnson said some military end use of the packages can be very aggressive in vibration and will lead to higher wetting. Failure analysis is a very detailed issue looking for solder cracks, etc.
5. Mr. Greene queried Mr. Carl Handsy, U.S. Army Tank-Automotive and Armaments Command (TACOM), if a JTP could be started based on the scope and requirements identified to date. Mr. Handsy said a JTP could be started, and suggested one be created for new systems and another for old systems. He said that a test matrix should be created and enters the required test parameters (e.g., should a test be 50,000 cycles or 100,000 cycles), and the team could then debate the need. He said he will forward the Army's shopping list of test requirements and that everyone should do so. He said that go/no-go decision points need to be added.
- a. Mr. Hill remarked to Mr. Johnson that it is imperative that AFRL forward their test requirements in writing to support this effort.
  - b. Mr. Handsy said that Michigan State University (MSU) did a lot of work for the Big Three automobile manufacturers that included work in mixing eutectic and lead-free solders and observing fatigue and whisker growth. He went on to say that it is highly unlikely that the old systems can be repaired with currently available lead-free solders.
  - c. Mr. Johnson said his early work in the Air Force was with the Avionics Integrity Program that addressed a lot of solder joint fatigue problems that showed up when moving from leaded to leadless systems. He said the Air Force learned it had to understand the mechanical design in detail because changes drove changes in post height, the periphery around the lead, etc. He said measurements as a function of board based on size, arrangement of parts are key. They set a limit of 28 terminals on leadless packages, and anything more required lead packages. He has a huge concern of mechanical design - cutouts, placements, cold plate mounting and others.
  - d. Mr. Handsy said the MSU studies showed the same issues. If the board is nickel based (as compared to some other base), that affects the intermetallics and that must take a rational approach that says it's unwise to mix three or four technologies on the same board.
  - e. Mr. Greene assigned an Action Item to the Services to itemize and describe their technical concerns about lead-free solders, and distinguishes their concerns by new versus old system (**AI LFS.01.08.01**).
  - f. Mr. Johnson said that he, together with Mr. Larry Perkins who he described as a world class expert with half of his work on solder joint failure, will meet with HQ AFMC to discuss what the Air Force recommends for this project. Mr. Hill reminded Mr. Johnson that Mr. Gene Jeunelot is on the teleconference call and is representing HQ AFMC/LGP-EV on this effort. Mr. Johnson said he would propose the formation of a Scientific



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Advisory Board (SAB) comprised of experts from both the DoD and industry to oversee the technical test requirements to ensure the appropriate tests are considered. He said that he is uncomfortable on using the old military standards tests techniques for new realms because those tests may not adequately address the issues.

- g. Mr. Johnson said the design of the test vehicle needs to be addressed as well. He said he still has issues with the test vehicle that was used on the JG-PP Circuit Card Assembly and Materials Task Force (CCAMTF) conformal coatings project.
  - h. Several people remarked the SPOs are still using the old tests described in obsolete military standards because they understand them and can make use of the results.
  - i. Mr. Johnson said he would push for using the worse case environments, worse geometries, driving from an application base rather than an environmental base test. He said that Larry Perkins and others would help lead that effort.
6. At the suggestion of Mr. Handsy, the technical representatives were tasked to identify the range of currently used lead-containing solder formulations and applications that the Services and NASA would be trying to replace (**AI LFS.01.08.02**) (e.g., are they all eutectic [63% Sn/ 37% Pb]?).
- a. Mr. Johnson stated they have seen only eutectic solders except for the solders used within the parts themselves inside the packages.
    - i. He said it is important to worry about de-wetting
    - ii. He is not aware of anything other than Sn63
  - b. Dr. Napp said he has seen solders with 88% Pb. Some electronics solders also use silver and uses elevated temperatures above 125 °C.
  - c. Mr. Johnson said some of the alternatives are much more toxic than lead need to be addressed. He said it makes no sense to switch from lead to a more toxic substance that the EPA will like go after next.
7. Mr. Greene asked, now that we have a list of 20 solders, could we start a desktop screen of these solders now or should we wait until we get the application question resolved before starting the screening process.
- a. Dr. Napp said there is enough data out there now that might be applicable for military use.
  - b. Mr. Whiteman added that getting a vendor to supply a completely different alloy might be very difficult. Most users are comfortable with alloys like tin-silver-copper, tin-copper, and tin-silver.
    - i. Mr. John Nelson, China Lake, said to not even consider looking at solders with antimony (Sb) as a constituent. On the subject of currently used solder alloy formulations that would be replaced, he stated that Sn63/Pb37 and Sn60/Pb40 are solder formulations most often encountered. Less frequently used are Sn95/Pb5, Sn90/Pb10, Sn75/Pb25, often used inside components.
8. Mr. Johnson asked if we are saying that we can still use lead solder inside devices at all, or are we looking for replacements for lead in both multi-chip modules and hybrids as well as for joining parts to boards?



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- a. Dr. Napp first inquired whether anyone in the military who is actually joining the chip to the package, or is everything involve placing the package onto a second level, hybrid, or printed wiring board?
  - b. Mr. Pattnaik, WR-ALC, responded that the depot is involved in the whole process, from conceptual design through board build to repair. Mr. Mark Stibitz, WR-ALC, added that repair of hybrid chips at WR-ALC is necessary because parts become obsolete. The F-15 SPO said that work included some of the hybrids that will have to be done to support the F-15 to the year 2040.
  - c. Dr. Napp said he did not know of any body of work that will provide supporting data for repair work.
9. Mr. Greene assigned an action item for everyone to identify candidate lead-free solders that were emailed to the technical representatives earlier in the week (**AI LFS.01.08.03**). He said he would consolidate all responses and provide them to all via e-mail.
10. Dr. Napp asked if people would want to go higher than 125 °C to 160 °C. He asked if the military would consider this.
- a. Mr. Johnson replied yes, the military would need to. However, he stated concerns about long-term reliability with 30 to 50 years of service life. Commercial data is available for commercial applications, but military applications are not covered.
  - b. Mr. Johnson also replied that an important decision would be the appropriate cycling time for the alloys.
11. Mr. Pattnaik asked if the due date for identifying information on solder alloy interactions (AI LFS.01.06.03) and identifying candidate lead-free solders (AI LFS.01.06.06) was being extended. Mr. Greene responded that he would extend the deadlines by two weeks from today, to August 22.
12. Mr. Johnson said that AFRL's opinion is that developing a JTP for lead-free solders based on military standards originally developed for eutectic solders is not technically sound, hence his recommendation for an Science Advisory Board.
- a. Mr. Greene asked how JG-PP can facilitate the SAB goals while still meeting the JG-PP desire to develop a JTP for some solder application in the next several months.
  - b. Mr. Johnson said he would pull the SAB together and have them recommend changes to what is being proposed.
  - c. Mr. Greene asked if we could schedule a meeting.
  - d. Mr. Johnson said it would take 3 weeks for AFRL to bring the group together and begin discussions.
13. Mr. Hill assigned an action item for Mr. Johnson to have Larry Perkins put the SAB together (**AI LFS.01.08.04**).
- a. He went on to say the European Union has expressed great interest in joining this project, and that AFRL should seriously consider inviting any appropriate EU members.



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14. A question was raised on where the list of alternatives was located. Mr. Greene answered it was assembled by Joe Felty, Raytheon, and it was sent out on Tuesday, August 7, with four files attached including the list in the PowerPoint slides.
15. Mr. Pattnaik, WR-ALC, asked how many times boards can be repaired stating this is a concern for the depots.
  - a. Mr. Johnson stated attaching packages to cold plate Al is very problematic and that occurrence is common in military applications.
16. Mr. Hill briefed the group on the interest from others including the European Union. He stated he has been approached by AIA, AECMA (the European equivalent to AIA), BAE, Scandinavian countries, and by Edison House a DOD Research and Development group stationed in London, UK.
  - a. Mr. Hill said a conference is being set up in Naples, Italy and co-hosted by Edison House and the US 6<sup>th</sup> Fleet on 22 October to provide information to interested European partners in this project and others. The aim is have them share in the cost of the projects, avoid duplication of effort, and benefit from participation. He invited anyone interested to attend the conference and asked to notify him and Ms. Tess Flynn of any interest in attending.
17. Mr. Greene asked everyone to review the minutes and action items.
18. Next meeting: Mr. Hillman stated there was a need for the next meeting to use a forum where PowerPoint slides could be shared by the group.
  - a. Mr. Hill remarked perhaps that the next meeting ought to be face-to-face. After considerable dialog about conflicts, the earliest face-to-face meeting was November 1, 2001 with the location selected as Dallas, TX.
    - i. A discussion occurred about an EPA-EIA-IPC meeting. Mr. Hill will speak off line about attending that conference and present this project to the group. Mr. Dave Bergman is the point of contact. It was stated the IPC group was several years ahead of the JG-PP project, and JG-PP could benefit greatly from that effort.

A teleconference call on September 20, 2001 at 2 P.M. EDT was established

*SIGNED (Approved by R. Hill 08/20/01)*

Robert P. Hill  
JASPPA Chairman, NASA KSC

#### Attachments:

1. Action Items



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### New Action Items

#### **LFS.01.08.01**

**Date Due:** 08/22/01

**Responsibility:** All Services and NASA [e.g., AFRL (Dave Johnson), TACOM (Carl Handsy), NAWCWD (John Nelson), USMC (Don Bowie), NASA (Bob Hill)]

**Required Action:** Itemize and describe any technical concerns your Service/organization has with use of lead-free solders. Distinguish concerns by new systems (manufacturing) versus old systems (depot repair).

**Comments:**

#### **LFS.01.08.02**

**Date Due:** 08/22/01

**Responsibility:** All Services and NASA [e.g., AFRL (Dave Johnson), TACOM (Carl Handsy), NAWCWD (John Nelson), USMC (Don Bowie), NASA (Bob Hill)]

**Required Action:** Identify the range of currently used lead-containing solder formulations and applications that the Services and NASA would be trying to replace (e.g., are they all eutectic [63% Sn/ 37% Pb]?).

**Comments:**

#### **LFS.01.08.03**

**Date Due:** 08/22/01

**Responsibility:** All project technical representatives

**Required Action:** Review and comment on the suitability of the candidate lead-free solders that were emailed to the technical representatives on Tuesday, August 7. The information is contained in the four attached files. Brian Greene will consolidate all responses and provide them to all via e-mail within 2 weeks of final receipt (no later than 09/05/01).

**Comments:**

#### **LFS.01.08.04**

**Date Due:** 09/20/01

**Responsibility:** AFRL (Dave Johnson)

**Required Action:** Have Larry Perkins put together an AFRL Science Advisory Board and report the results of the Board's first meeting at the next JG-PP lead-free solder project teleconference on 09/20/01.



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### Action Items Closed at this Teleconference

#### **LFS.01.05.02**

**Date Due:** 05/23/01

**Responsibility:** All Technical Representatives

**Required Action:** Provide to Brian Greene, CTC, the name and organization of anyone within their Service, organization, or outside organization who should be involved in the JG-PP Lead-Free Solder project

**Comments:** 08/08/01 - Completed. Any new names will be accepted on a rolling basis by JASPPA.

#### **LFS.01.06.01**

**Date Due:** 07/03/01

**Responsibility:** CTC (Brian Greene), Raytheon (Joe Felty, Jeff Bradford)

**Required Action:** Develop a JTP requirements matrix/ survey form that would be sent by JASPPA to the affected weapon/space system managers for completion. The survey form will include some basic requirements from MIL SPECS (in a matrix format) and provide space for system managers to enter additional requirements.

**Comments:** 07/03/01 - Completed.

#### **LFS.01.06.02**

**Date Due:** 07/12/01

**Responsibility:** All JASPPA members

**Required Action:** Distribute to the affected managers (in airframe electronics/avionics, Army land-based electronics, space based, commercial aircraft, Navy avionics, etc.) the JTP requirements survey form developed under Action item LFS.01.06.01. The system managers will return the completed forms directly to CTC.

**Comments:** 07/10/01 - Completed.

#### **LFS.01.06.04**

**Date Due:** 08/01/01

**Responsibility:** CTC (Brian Greene)

**Required Action:** Schedule the next project technical teleconference, tentatively for August 8, 2001 at 2:00 P.M. Eastern time, and distribute an agenda.

**Comments:** 07/24/01 - Completed.



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### Open Action Items

#### **LFS.01.06.03**

**Date Due:** 08/22/01 (originally 07/30/01)

**Responsibility:** NAWCWD (John Nelson), Raytheon (Joe Felty), Rockwell-Collins (Dave Hillman)

**Required Action:** Identify (e.g., through a literature search) any lead-free and tin-lead solder interaction and report the findings at the next project meeting

**Comments:**

#### **LFS.01.06.05**

**Date Due:** 09/14/01 (originally 08/03/01)

**Responsibility:** CTC (Brian Greene)

**Required Action:** Incorporate the survey findings into a strawman JTP and distribute it before the next teleconference.

**Comments:**

#### **LFS.01.06.06**

**Date Due:** 08/22/01 (originally 07/30/01)

**Responsibility:** All Technical Representatives

**Required Action:** Identify their top lead-free solder candidates to Joe Felty, Raytheon

**Comments:**

#### **LFS.01.06.07**

**Date Due:** 09/14/01 (originally 08/03/01)

**Responsibility:** Raytheon (Joe Felty)

**Required Action:** Consolidate the candidate lead-free solders and provide them to CTC for inclusion in a draft JG-PP Potential Alternatives Report (PAR)

**Comments:**