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***JG-PP Lead-Free Solder Project  
Technical Teleconference Minutes  
September 20, 2001***

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

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

**Comments:**

Attached please find the minutes from the September 20, 2001, Lead-Free Solder Technical Telecon. If you have questions about the minutes please contact Robert Hill, Brian Greene or Tess Flynn. Please further distribute as necessary.

**MEMORANDUM FOR RECORD**

**September 25, 2001**

**Subject: Meeting Summary and Minutes – September 20, 2001**

**Material(s) Identified:** Lead

**Process Identified:** Electronics soldering

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

**Summary:**

On September 20, 2001, technical representatives from Headquarters Air Force Material Command, American Competitiveness Institute, Boeing Company, Intersil, National Aeronautics and Space Administration-Kennedy Space Center, National Center for Manufacturing Sciences, Naval Air Warfare Center Weapons Division, Northrop-Grumman, Raytheon, Potomac-Hudson Engineering representing HQs USMC/IL, and United Space Alliance 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. Project technical stakeholders determined that the project should be developed around two technical directions, 1) qualification of lead-free solder for new manufacturing, and 2) qualification of lead-free solder for rework requirements where lead solder was originally used.

**Next Teleconference:** November 1, 2001, 2:00 P.M. EST.

**Next Meeting:** Fall 2001 (date TBD for mid-November 2001) in Dallas, TX. Need everyone to respond to Mr. Robert Hill, [Robert.hill-3@ksc.nasa.gov](mailto:Robert.hill-3@ksc.nasa.gov), or Ms. Tess Flynn, [FlynnTE@kscems.ksc.nasa.gov](mailto:FlynnTE@kscems.ksc.nasa.gov), with their availability for mid-November **by October 9, 2001**. Negative response is requested.

## Minutes

1. Mr. Brian Greene, Concurrent Technologies Corporation, called the meeting to order at 2:02 P.M. and conducted a roll call.
2. Mr. Greene announced to the group that a draft Joint Test Protocol (JTP), a list of potential alternatives, and a strawman test vehicle (printed wiring board) were posted on the JG-PP Web site. He described how to reach the Web page and how to find the pull down menus to get to the documents. He encouraged all participants to download, review, and comment on these draft documents in the coming weeks. The Navy participants were not able to access the site because a computer virus resulted in the need to restrict personnel access to https sites. Mr. Greene said he would zip the files and e-mail them.
3. Mr. Mark Kwoka, Intersil, was introduced to the group. Intersil is a provider of high performance integrated circuits for both commercial and military applications. Mr. Kwoka has experience in lead finish, soldering, and solderability testing. Mr. Kwoka chairs several committees, including the Soldering Technology Committee, which is working to adopt the ANSI/IPC J-STD-002 solderability test into military standards. He also chairs the Lead-Free Component Focus Group, which is comprised of technical representatives from component manufacturers, board suppliers, and Original Equipment Manufacturers (OEMs) to evaluate the performance of lead-free components on lead-free assemblies. The Focus Group's work is almost complete and will be briefed at the Institute for Interconnecting and Packaging Electronic Circuits (IPC) meeting in Orlando on October 14. He said information about the conference is posted on the IPC Web site and should be available to all.
4. Mr. Greene thanked Raytheon for doing the majority share of the work in putting together the draft JTP, list of alternatives, and test vehicle. They thought it was prudent to assemble a draft to provide a starting point for people to use in the discussions. He said that one of the starting points for the JTP was the old JG-PP CCAMTF JTP, as well as the critical performance requirements matrix completed by several of the project stakeholders.
5. A lengthy discussion ensued on the potential design of the test vehicle. Mr. Felty said that he queried Raytheon engineers on what changes could to be made to the original CCAMTF LRSTF board to update it to reflect current circuitry and thus make it more suitable for this Lead-Free Solder project. The ease and cost of procuring the components was also a factor considered by Raytheon's engineers.
  - a. In general, the circuitry of the proposed board is divided into several functional areas: high current-low voltage, low current-high voltage, high speed digital, high frequency TLCs and LPFs, stranded wire, and an SIR pattern (dummy pin grid array socket, gull wing components, and 10-mil pads). To this board Raytheon suggests adding several new leadless chip carriers (LCCs), chip capacitors and chip resisters.
  - b. Mr. Duane Napp, National Center for Manufacturing Sciences (NSMC), said that he learned that it was important to design the boards so that failures occur that allow the effects of different solder alloys could be discriminated. He said the 44-

pin LCCs did not allow such discrimination to occur, but the 20-pin LCCs did. (The 44-pin LCCs failed at approximately 130 to 160 cycles, whereas the 20-pin LCCs failed at 1,400 cycles.) Mr. Napp also suggested including chip resistors and chip capacitors, since they fail faster than surface mount components (but fail after the LCCs).

- c. Mr. Tom Woodrow, Boeing, suggested that perhaps two boards need to be made, the first being a simple board where parts will fail quickly and predictably, thus allowing it to be used as a screening tool to reduce the number of solders for further testing. Those solders that best pass the screening (i.e., perform as well or better than conventional tin-lead solder) would then be tested on a more complex/expensive board. At a minimum, we should avoid the use of a single, complicated test board to test solder alloys whose failure is unpredictable and which may not occur at all, thereby making it impossible to distinguish any effects of the solder alloys. Mr. Felty replied that the strawman test vehicle currently shown on the Web site is a simple board with a variety of components some that would certainly fail earlier and other that might not.
  - d. Mr. Felty suggested that stakeholders comment on what other ideas they have for a test vehicle, such as which components they would like to see on the test vehicle. An effort will then need to be made to look into the cost and availability of those components.
6. Mr. Kwoka asked what the overall objective of a lead-free solder testing program would be. Mr. Felty replied that, at a minimum, the testing program should provide data indicating how well the selected lead-free solder alloys perform compared to conventional tin-lead solder under the test regimes invoked. The group then discussed potential alternatives to tin-lead solder.
- a. Mr. Woodrow further added that the near-term focus of the group should be to identify one or two appropriate alloys before proceeding.
  - b. Mr. Felty added that researchers are beginning to narrow down to a single lead-free alloy for wave soldering and two or three reflow/manual solders. Of particular note are the tin-silver-copper-bismuth alloys, which has a respectable melt temperature of 210-215 °F and performed as good as conventional tin-lead and better than tin-silver-copper based on thermo-mechanical fatigues. He qualified his list by stating he did not include any recommendations yet from the recent NCMS study.
  - c. Mr. Lee Whiteman stated that, based on work from NEMI and IPC, he would prefer if this group selected lead-free solder alloys from the tin-silver-copper family of solder pastes for surface mount and the tin-copper family for wave solder applications. He is not in favor at this time of considering tin-bismuth and tin-antimony solder alloys. Mr. Woodrow concurred that we should not consider alloys that have a significant environmental or health risk associated with their constituents, such as antimony.
  - d. Mr. Kwoka added that he has seen Nokia cellular telephone test data that shows tin-silver-copper produces stronger joints than lead solder. Mr. Woodrow replied, however, that independent testing by Boeing and the University of Auburn showed that tin-silver-copper did not perform all that well under thermo-mechanical cycling. Somebody needs to sort through the existing data to determine the validity of the tests and assess how good tin-silver-copper alloys

truly are. Mr. Napp added that testing that NCMS performed showed that some other alloys (namely tin-silver-copper-bismuth and tin-silver-copper-antimony) performed better than tin-silver-copper under thermal-mechanical fatigue. He stated that bismuth seems to positively enhance the thermo-mechanical fatigue characteristics of the solder joint. Mr. Napp further added that as the level of copper in tin-silver-copper formulations increases, the alloy melting point increases very rapidly. This means that the process temperature (e.g., reflow temperature) would have to be increased.

- e. One important question for which an answer is not apparent is, at what level of bismuth do the thermo-mechanical cycling properties of bismuth-containing alloys become adversely affected by contamination from conventional tin-lead solder? Mr. Woodrow has no direct data to answer this question, but indicated that in a Boeing study tin-lead solder did significantly decrease the thermal cycle resistance of a tin-silver-copper alloy (no bismuth). Mr. Woodrow was agreeable to sharing this data with anyone who was interested.
  - f. Mr. Kwoka stated he hopes the group can find alternative lead free solders that will perform at temperatures of 217 °F or lower.
7. A short discussion occurred on the JTP tests outlined in the current (Sept 20, 2001) version posted on the Web page.
- a. Mr. Felty's recommended JTP validation tests are vibration, mechanical shock, thermal shock, humidity, and a modified HALT (Highly Accelerated Life Test) test.
  - b. The modified HALT test is initiated by running to failure and measuring that point, then take 80% of that value and run all of the subsequent tests at the 80% level to collect the data. The HALT test is not a true "life cycle test" in that you cannot equate its results to some length of time to failure. Rather, it is a screening test to help rapidly discern differences in material performance and verify design. The combination of HALT testing with the four environmental tests would ideally eliminate the requirement for lengthy salt fog testing, and thus would greatly reduce test times and presumably testing cost.
  - c. Mr. Felty recommended that the test acceptance criteria would be more comparative than numerical; the criteria would simply state that if a particular alternative alloy performs as good or better than tin-lead solder, it passes. To test against everyone's specific requirements would likely result in a huge test matrix and very expensive program.
  - d. Mr. Felty also stated that one recommended action is to solicit help from a reliability engineer in interpreting the vibration spectra from the various military standards noted by several stakeholders in their responses identifying critical performance requirements.
  - e. Mr. Woodrow said leachability tests might be necessary if solders contain any potentially toxic materials such as bismuth or antimony. Ideally, we would not select any toxic materials for testing. Mr. Felty noted that he was aware of a new U.S.EPA-IPC-University of Tennessee study to test the leachate potential of several lead-free solder alloys. There is a potential that in the future, silver may even be considered an undesirable constituent.

8. The group briefly discussed the approach to testing, namely whether it would be comprised of phased testing.
  - a. Mr. Whiteman was in favor of phased testing, where Phase 1 would consist of screening testing on a simple board where parts will fail quickly and predictably and Phase 2 would involve more detailed testing of the surviving alloys. Ideally, only one type of board finish and component finish would be used, to eliminate variables and reduce testing cost.
  - b. Mr. Kwoka added that one advantage of phased testing is that if all the lead free solder alloys perform better than tin-lead, than the second testing phase could include testing to failure, which would help identify the best of the alloys.
  - c. Mr. Kwoka asked who would create the circuit boards used for testing. For comparison, Mr. Jeff Bradford indicated that, for the JG-PP CCAMTF project, Sandia Labs designed the board, Raytheon's Austin, Texas facility built the board, and ACI assembled them.
9. Mr. Greene agreed to supplement the responses to date on action item LFS.01.06.03 by identifying any published information on the effects of lead contamination with bismuth-containing solders. In addition, a new action item was assigned to all project representatives to review and comment on the draft potential alternatives list, the draft JTP (especially details of the tests, such as vibration frequencies, dwell times, temperatures, ramp rates, etc.), and the test board design (**LFS.01.09.01**). From this information, we then need to determine the range of testing conditions.
10. Mr. Greene suggested closing action item LFS 01.06.05. There were no objections.
11. Ms. Tess Flynn briefed the group on the European JG-PP Lead Free effort. She described the European Union/U.S. Lead-Free Solder early customer interface meeting is confirmed for October 22 in Naples, Italy and the agenda has been delivered. The purpose of involving the Europeans is to invite cost sharing on the project as well as sharing of technical performance results that the Europeans may have from their efforts . Anyone interested in reviewing the agenda or attending the meeting may contact Ms. Flynn. She mentioned Mr. Bob Hill, NASA, JG-PP Working Group Chairperson, is also attending the AECMA (European Union Aerospace Industry Association) Conference on October 18-19 where he will present the JG-PP Program. Mr. Hill will also be briefing the IPC Conference in Orlando, Florida on October 11 with Ms. Fern Abrhams regarding the IPC/EIA/EPA Life Cycle Cost Analysis Study of Lead-Free Solder.
12. The date for the next meeting was discussed. It was originally tentatively planned for November 1 at the Texas Instrument/Raytheon facility in Dallas, but Mr. Napp said he is unavailable until mid November to attend. The group examined their personal schedules for the period. All, except for Mr. Napp, said November 1 was clear for them but ran into trouble for until the week of Thanksgiving. The AFMC/LGP-EV CWG is being held the week of November 12.

As part of the minutes distribution, need everyone to respond to Mr. Robert Hill, [Robert.hill-3@ksc.nasa.gov](mailto:Robert.hill-3@ksc.nasa.gov), or Ms. Tess Flynn, [FlynnTE@kscems.ksc.nasa.gov](mailto:FlynnTE@kscems.ksc.nasa.gov), with their availability for mid-November by October 9, 2001. Negative response is requested.

13. The next teleconference call was established for November 1, 2001 at 2:00 P.M. EDT.
14. The conference call concluded at 3:35 P.M.

***SIGNED (Approved by R. Hill 09/28/01)***

Robert P. Hill  
JASPPA Chairman, NASA KSC

Attachments:

1. Action Items

## **New Action Items**

### **LFS.01.09.01**

*Date Due:* **10/11/01**

*Responsibility:* All project technical representatives

*Required Action:* Review and comment on the draft potential alternatives list, the draft JTP (especially details of the tests, such as vibration frequencies, dwell times, temperatures, ramp rates, etc.), and the test board design

*Comments:*

## **Action Items Closed at this Teleconference**

### **LFS.01.06.05**

*Date Due:* **08/03/01 (approx. one week after survey responses received)**

*Responsibility:* CTC (Brian Greene)

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

*Comments:* 09/20/01 – Strawman JTP posted to the JG-PP Web site

## **Open Action Items**

### **LFS.01.08.01**

*Date Due:* **11/1/01 (originally 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:* 09/20/01 - No responses yet

### **LFS.01.08.02**

*Date Due:* **11/1/01 (originally 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:* 09/18/01 – WR-ALC indicates that 95% of their solders are 63Sn/37Pb.

**LFS.01.08.03**

**Date Due:** 11/1/01 (originally 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:** 09/20/01 - No responses yet.

**LFS.01.08.04**

**Date Due:** 11/1/01 (originally 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.  
**Comments:** 9/20/01 - In progress

**LFS.01.06.03**

**Date Due:** 10/11/01 (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:** 08/07/01 – Literature survey from John Nelson distributed to project representatives  
09/20/01 – Action item amended to have CTC/NDCEE examine any interaction between Pb and Bi-containing solder alloys.

**LFS.01.06.06**

**Date Due:** 10/11/01 (originally 07/30/01)  
**Responsibility:** All Technical Representatives  
**Required Action:** Identify their top lead-free solder candidates to Joe Felty, Raytheon  
**Comments:** 09/19/01 – Raytheon provided their recommendations; posted to the JG-PP Web site

**LFS.01.06.07**

**Date Due:** 11/1/01 (originally 08/03/01)  
**Responsibility:** All Technical Representatives  
**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:**