



JG-PP Email

Joint Group on Pollution
Prevention

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Pages:

JG-PP Lead-Free Solder Project Technical Meeting Minutes March 7, 2002

Govt. Project Manager: Warren Assink, WPAFB

Comments:

Attached please find the minutes from the March 7, 2002, Lead-Free Solder Technical Teleconference. If you have questions about the minutes, please contact Warren Assink or Brian Greene. Please further distribute as necessary.

MEMORANDUM FOR RECORD

April 25, 2002

Subject: Meeting Summary and Minutes – March 7, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: I-Identification, II - Technical

Summary:

On March 7, 2002, technical representatives from American Competitiveness Institute, the Boeing Company, British Aerospace Systems (United Kingdom), F-15 Program, Mitsui Comtek/Senju Metals Co., NASA-Kennedy Space Center, NASA-Marshall Space Flight Center, National Center for Manufacturing Sciences, Naval Air Systems Command, Picatinny Army Arsenal, Raytheon, Robins Air Force Base, Texas Instruments, TRW/Marine Corp., U.S. Army Communications Electronic Command, and Wright Patterson Air Force Base participated in a teleconference with representatives from the Joint Group on Pollution Prevention Working Group. The objective of the teleconference was to further develop the Joint Test Protocols for Manufacturing and Repair, and discuss the short list of lead-free solder alloys, test board design, and future funding issues.

Prior Decisions:

- 5/9/01 - Lead as used is tin-lead (Sn/Pb) solder was chosen as the target HazMat.
- 6/20/01 – A Joint Test Protocol (JTP) will be developed for qualifying lead-free solder alloy used in the manufacture of lead-free printed wiring assemblies (PWAs)



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- 11/1/01 – A second JTP will be developed for qualifying lead-free solder alloy used in the repair of lead-containing PWAs.

Next Teleconference: April 26, 2002, 11:00 AM

Next Meeting: TBD



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Minutes

1. Mr. Brian Greene, National Aeronautics and Space Administration/International Trade Bridge, Inc. (NASA/ITB) and Project Integrator for the Lead-Free Solder JG-PP project, began the teleconference by asking everyone to identify themselves. He noted that some progress had been made at a small-group meeting at the APEX Conference in San Diego in January, and some of the recommendations from that meeting would be discussed today. The purpose of the teleconference was to further develop the Joint Test Protocols for Manufacturing and Repair, and discuss the short list of lead-free solder alloys, test board design, cost benefit analysis and future funding issues. Mr. Warren Assink, HQ Air Force Material Command, Wright-Patterson AFB, was introduced as the Government Project Manager, replacing Robert Hill who retired from the government.
2. Project Funding: JG-PP needs to identify soon the anticipated future cost of the Lead-Free Solder project, primary of which is the testing cost. Mr. Greene suggested that the following three matters be decided upon by the team before a rough overall cost can be determined.
 - a. The component types and number that will be on each test vehicle. This will determine board size/cost and #/cost of components as well as the cost to assemble the test vehicle. Mr. David Hillman, RockwellCollins, agreed to take on this action at the small-group meeting at the APEX conference in San Diego, CA.
 - b. The required number and type of components and final board design will determine the electrical test equipment/testing costs. Mr. Jeff Bradford, Raytheon, has offered to work up a ROM cost estimate once Mr. Hillman's information is complete and the team reaches consensus.
 - c. The team needs to reach a final decision, from the list of potential environmental/stress test conditions, which specific tests will be required. Once that has been decided and the number/type of boards identified, the test costs can be estimated.
3. Test Vehicle: The participants were alerted to a schematic drawing of a test printed wiring board prepared by Mr. Hillman that was distributed to everyone this morning. The drawing included the components that had been identified as of most interest to the team. The ROM material cost for this board is \$70/board, with the range being \$50-\$100/board.
 - a. Mr. Felty added that the test circuitry would be monitored electrically and everything would be daisy-chained together, rather than use functioning components. The monitoring would likely occur at each daisy-chained component. An alternative would be to daisy-chain around each component, but as Mr. Duane Napp, NCMS, noted, this would significantly increase the board surface complexity, and increase the risk of damage. (A daisy chain is where every other I/O on the component is skipped, and the circuit is completed by having the I/O picked up on the board.) Mr. Felty noted that currently we are proposing a ten-layer board; he would like to cut that down to reduce cost. Mr. Napp estimates that there will be at least 56 I/Os off each board if we only use a one-component daisy chain (vs. bordering it out). This becomes a very complex, and costly, data collection system.
 - c. Mr. Tom Woodrow, Boeing, stated that his preference is that each component have its own



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- channel. If the components are daisy-chained, there might be great difficulty in determining which solder joint failed. Mr. Napp agreed, and said the minimum number of channels per board would be 56.
- d. Mr. Doug Romm, TI, suggested one way to reduce the number of I/Os is to reduce the number of components from that currently shown on Mr. Hillman's schematic drawing. Mr. Lee Whiteman, ACI, said another thing to examine is the type of components. For example, he counted 3 quad flat packs and 3 ball grid arrays in the drawing. Are these flat packs or BGAs identical, or are they different in pitch and size? Secondly, are we going to include some of the chip-scale packaging, given that companies are beginning to look at these for DoD applications?
 - e. Mr. Woodrow further asked, how many boards of each type for each solder for each test do we need to ensure statistically meaningful data? Mr. Napp estimated that 25 boards per solder per test would be necessary (=75 boards, assuming 3 solder alloys). This would then be multiplied by approximately 50 I/O per board to determine the total number of measurements.
 - f. The group agreed that feedback from Mr. Hillman on why he chose the number of components that he does on his drawing would be beneficial, and did he intend for there to be any difference in the components such as size or pitch.
 - g. Mr. Greene asked for any opposition to the idea of using one component per channel with components daisy chained individually (i.e., no live devices), and there was none.
 - h. Mr. Whiteman had two final suggestions: First, each component should have a silicon die to mimic the "real" die. Second, he and Mr. Hillman could work together offline to examine what component manufacturers have to offer in daisy-chain components and their associated cost. Mr. Romm noted that TI is willing to supply components at no charge for this JG-PP testing. The only hold-up for TI is that the team needs to decide on the pin count, pitch, and exactly which package.
 - i. Finishes:
 - i. Mr. Whiteman asked whether the purpose of this JG-PP study was to (a) qualify a process and the component finish and board finish, or (b) provide a baseline for the DoD? Mr. Doug Romm, TI, stated that if the goal is to demonstrate compatibility with the different finishes, we should include in our testing the three primary finishes that component suppliers will be readily supplying the market with. These are anticipated to be nickel-palladium-gold (NiPdAu), matt tin (Sn), and tin-bismuth (SnBi). Including two or more finishes like this might help address concerns that have been voiced about whether there is any interaction between the surface finish and the solder paste.
 - ii. Mr. Clive Simmonds, BAE Systems, and Mr. Felty both recommended that the preference be to chose a surface finish that the chosen component supplier (e.g., TI, Amkor) best recommends as their production standard, rather than have this group define the finish.
 - iii. It was noted that if the group desires to test only two finishes, that NiPdAu and Sn would be best. There seems to be less customer interest in the bismuth-containing solders.
 - iv. It was clarified that there will be both plastic and ceramic components on both the



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repair and production boards.

j. Hybrids:

- i. A recommendation was made to invite a hybrid component supplier to be part of some of the future project meetings. Mr. Stibitz said that he might be able to invite a person from the Raytheon Producibility Facility.
 - ii. The group discussed the pros and cons of adding hybrids to the test board. Mr. Mark Stibitz, F-15 Program, noted that there are currently no hybrids on the test board. Beryllium oxide and aluminum are the most common types. He acknowledged that including hybrids would increase the cost, but would benefit the F-15 program. Even though the goal of this project is simply to examine the integrity of the lead-free solder joints, hybrids could potentially affect joint integrity because of their larger size (up to 2x3 inches) and the effect of that during vibration and stress. No group members were certain that other, larger surface mount components could adequately mimic a hybrid component.
 - iii. An action item was taken for Mr. Dave Hillman to work with component suppliers and possibly leverage off the EMMA program work on SnPb (POC: Mr. Lee Whiteman) to prepare a component list, with pin counts for each component type listed. Once this is completed, Mr. Hillman should work with Mr. Stibitz to determine if hybrids can be added (Action Item **LFS.02.03.01**). A related action item was assigned to the Air Force, Navy, Army and NASA technical representatives to determine if adding hybrids to the test vehicle is a requirement of theirs (**LFS.02.03.02**).
- k. A recommendation was voiced (with no objection) to insert a series of 12XX (e.g., 1206) resistors on the bottom of the test board. These components tend to show failures on thermal cycling accelerated testing, and therefore would be a good discriminator of solder performance. Mr. Felty stated that the more components that we can add that serve as good discriminators, the fewer number of different component types may be needed, thereby keeping down the board cost.
- l. It was clarified that the reason for the mix of technologies on the proposed test board was because of the depots continuing need to repair current boards for a number of more years.
- m. Mr. Doug Rom, TI, asked whether it would be better to randomly distribute the component types across the board. Mr. Felty replied that he could find engineers within Raytheon with the knowledge and equipment to optimize the placement of the components and do a design layout. Mr. Hillman's drawing was simply to give an approximation of the potential surface area required to place all the proposed components on a board.
- n. Mr. Simmonds inquired about the likely scenario under which lead-free solders will be introduced within the sustainment community. Mr. Napp replied that the depots will take and strip the SnPb leaded components and get your finish that is lead-free. It would not be advisable to have a situation where you have both SnPb and Pb-free finishes on a board because you really won't know what finish you have, and because the quantity of lead in the solder joint will be unknown and variable, depending on the component supplier used. Mr. Romm added that he was pretty sure that the goal of most component suppliers is that, if they are going to introduce a Pb-free finish, it must be compatible with both SnPb and Pb-free soldering processes. On the acquisition side, it was postulated that OEMs will



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likely be required to build their boards entirely Pb-free. If OEMs don't build entirely Pb-free, they will be stuck with the issue of receiving components that are Pb-free finished anyway.

- o. Mr. Simmonds asked about how one will know whether components can withstand the higher soldering temperatures. Mr. Felty reminded the group that the rework aspect of this project, as currently scoped, is to examine the impact of lead-free solders on the integrity of the solder joint once stressed, and not to examine whether the components internally will withstand the higher soldering temperatures. From a good experimental design standpoint, Mr. Romm stated that this study should include the following test combinations:

- SnPb component finish with SnPb solder,
- SnPb component finish with Pb-free solders,
- Pb-free component finish (probably Sn and NiPdAu) with SnPb solder, and
- Pb-free component finish (Sn & NiPdAu) with Pb-free solders.

(The board finish would be immersion silver.)

The issue of what path industry will take is another question beyond the scope of this project. It was recommended that the only thing that needs to be considered with respect to component viability at higher temperatures is the area array packages (e.g., BGAs) are more sensitive to the material set used. So we need to make sure if we are getting some in SnPb and Pb-free solder ball, that at least the material set is the same. Otherwise, there could be significant influences in joint reliability due to material set.

- p. Tin Whiskering: Mr. Tom Woodrow, Boeing, asked that, if we go with tin as a component finish, are we increasing the likelihood of a tin whisker problem? Even though the tin whisker problem seems to be much better understood and mitigation methods (e.g., use a nickel underlayer) have been identified, how well can the military community be convinced that tin whiskering is not a problem? Because if the defense community is not convinced that tin whiskering is not a problem, implementation of lead-free solder at the close of the project will be unlikely. Mr. Jeff Cannis, Amkor, noted that the scope of this project was to look at the component finishes that we will likely be prominent on the market in the U.S. in the future, of which tin will undoubtedly be one finish. In the near future, it is possible that some components will only be available in pure tin finish. It was noted (without opposition) that NEMI, Amkor, and some industry consortiums that are simultaneously examining the tin whisker issue, and there was probably not any added value in this JG-PP group tackling tin whiskering, too. Nonetheless, as Mr. Woodrow stated, we may need to be prepared at the end of our project to solidly demonstrate that the tin whiskering problem has been solved, which hopefully will be the case. Members of this JG-PP group who are part of NEMI and the other groups looking into tin whiskering will just need to coordinate those studies' results to the JG-PP project team members.

4. Candidate Solder Alloys: At a January 21, 2002 small-group meeting at the APEX electronics manufacturers conference in San Diego, California, the attendees were asked to assume for the moment that we would need to further scale down the number of alternatives, and identify which three (3) alternatives would be best to go into testing:



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Wave Solder:

Sn/0.7Cu

Sn/3.9Ag/0.6Cu (this same alloy for reflow/manual solder, too)

Reflow/Manual Solder:

Sn/3.9Ag/0.6Cu

Sn/3.1Ag/0.5Cu/3.1Bi (include because it enhances the long-term thermal cycle reliability of the solder joint, which would be of significant interest to the military community)

Baseline:

Sn/37Pb

- a. Mr. Whiteman noted that the potential disadvantage of the Bi-containing alloys in field repair is the likelihood of creating low-temperature intermetallics when used with a SnPb component.
- b. Other participants felt that the intermetallics concern is less a technical issue and more a logistics/configuration management issue that each Service will have to address on their own in the future. One potential advantage of including Bi alloys in our testing is that we will generate the data to assess if Bi alloys adversely affects joint reliability, and this will aid in setting up strict Bi-soldering guidelines, if necessary. Therefore, there was no real opposition to keeping the Bi-containing
- c. Bi-containing solder alloys were not recommended for wave soldering because of the potential fillet lifting and possible market availability.
 - i. Mr. Napp noted that the Sn/3.1Ag/0.5Cu/3.1Bi alloy has never been examined by NCMS, or anyone else to his knowledge, from the standpoint of wave soldering. Mr. Napp's recommendation was that the Sn/3.1Ag/0.5Cu/3.1Bi alloy be examined in this study for wave soldering.
 - ii. Mr. Napp also noted that, concerning fillet lifting, eutectic tin-bismuth has been used successfully in through-hole applications with exhibiting fillet lifting.
- d. Mr. Woodrow proposed (without any dissent) that a similar, but possibly better, Bi-containing solder to test for wave, reflow, and manual soldering would be a Sn/3.4Ag/1.0Cu/3.3Bi alloy from Hereaus (East Conshohocken, PA). This formulation was tested by NCMS (the "A62" alloy) and is readily available off the shelf.
- e. Mr. Romm asked whether this group should be stipulating the Bi-containing alloy formulation, or whether we should go with whatever Bi-containing alloy industry is most leaning toward. Several in the group stated that this project's objective should ideally include both conditions--i.e., we should select a commercially available and popular alloy that has already been tested and basically build off that prior work. Hereaus' Sn/3.4Ag/1.0Cu/3.3Bi alloy comes as close as any to meeting these criteria.
- f. Mr. Whiteman noted that if we select three different Pb-free wave solder alloys, three different manufacturers will likely be required to apply the wave solder because no one will want to empty a solder pot to change alloys.
- g. An action item was assigned to Mr. Hillman to determine the number of boards required for each test, the number of channels required on each board, and the subsequent total number of channels. For example, if there are 56 channels per board per solder alloy, that



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equates to 1700 channels per test per alloy, or 10,000 total channels per alloy, or approximately 40,000 total channels for all testing. That is a lot of testing for one facility to perform. Testing time could also become an issue, since the cycling tests will take 3 to 6 months. Therefore, testing at more than one facility may be necessary to maintain a reasonable testing schedule.

- h. With these recommendations, the current proposed short list of alternatives (3 alloys) becomes:

Wave Solder:

Sn/0.7Cu

Sn/3.9Ag/0.6Cu

Sn/3.4Ag/1.0Cu/3.3Bi (because (1) the Bi enhances the long-term thermal cycle reliability of the solder joint, and (2) the 3.3Bi is commercially available)

Reflow/Manual Solder:

Sn/3.9Ag/0.6Cu

Sn/3.4Ag/1.0Cu/3.3Bi

5. Joint Test Protocol: The group discussed the number of cycles and other test conditions the military requires for temperature cycling to qualify the alloys for SnPb replacement.
- a. AMCOM (in prior written correspondence) noted that they wanted to see temperature cycling at many more cycles to allow extrapolation of the data to their systems' actual use conditions. AMCOM would like to see temperature cycling data for at least two temperature ranges. The average temperature also influences the solder properties, so an additional test at one of the ranges, but with a different average temperature, would best characterize the solder joint reliability for extrapolation to various applications. At the board level, AMCOM would want something in the 500 to 1000 cycles range. If the project is testing parts, then testing should occur for at least 1000 cycles. Attempting to extrapolate from data from anything less than two accelerated temperature ranges would not be possible, and therefore any future reliability modeling could not be accomplished. The best that could be achieved would be a relative comparison of temperature cycling data between the Pb-free solder alloys and the baseline solder at one temperature cycling range, and this may not be representative of all use conditions.
- b. Mr. Felty made two points on the temperature cycling. First, he feels that the scheme proposed in the current version of the JTP to combine temperature cycling and vibration, we will see shorter time to failures, which will provide more data quicker and be more representative of real-world conditions. Second, Mr. Felty asked whether information can be gleaned from other studies (e.g., prior NCMS work) that would alleviate the need to conduct temperature cycling at more than one range. For example, the last NCMS study (published Aug 2001) examined the temperature ranges of -55C to +160C for the Pb-free solder alloys with a set of components, and 0C to 100C and -40C to 125C with BGAs.
- c. AMCOM proposed temperature cycling ranges of 0C to 100C and -20C to +80C, with some additional cycling in-between those two temperature cycling ranges.



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- d. Although 1000 temperature cycles may be enough for some Programs to certify a product, other Program may require 2000 cycles. Program Managers need to provide us their temperature cycling requirements.
 - i. Mr. Whiteman noted that, on the EMMA program, ACI examined 1200 to 2000 temperature cycles on BGAs and advanced packaging at -55C to +125C. Unfortunately, no other temperature range was examined.
 - e. The group agreed to holding a follow-up teleconference in about two weeks (tentatively March 19) with AMCOM and others to work out details on the JTP.
6. European Union/US Early Customer Interface Meeting: Ms. Tess Flynn, NASA/ITB, noted that anyone wishing to attend this meeting must reply to her no later than March 18 in order to be registered. Those that are speaking should provide their slides to Ms. Flynn by March 15.
7. Cost Benefit Analysis: As a February 11 email to Mr. Greene, Concurrent Technologies Corporation reported that the following people/facilities had returned the lead free solder baseline survey forms:
- Boeing - Reflow, Wave
 - Raytheon, McKinney, TX - Reflow, Wave
 - AMCOM (EFAL) - Manual
 - CCAD (Rotating Elec.) - Manual
 - CCAD (Engine Welding Section) - Manual
 - CCAD (Equipment Management Division) - Manual
 - CCAD (Instrument Section) - Manual
 - CCAD - Manual
 - Red River Army Depot - Manual
 - Tobyhanna Army Depot - Manual
 - Letterkenny Army Depot - Manual
- For those facilities than returned survey forms for manual soldering, the facility personnel should re-examine the material usage and waste generation sections to make sure those sections are completed. Even rough estimates for this information would help. In addition, CTC has only received two forms for wave and reflow, so other companies are encouraged to complete these forms, if applicable. If there is anyone still planning to return their forms, they should submit them to Heather Moyer at CTC very soon. Otherwise, information from survey forms that arrive late may not be able to be included in this CBA.
8. Mr. Hillman agreed to host one of the next project teleconferences. April 9 at 11:00 AM Eastern Time was tentatively set as the next teleconference date.
9. The teleconference was adjourned at approximately 12:30 p.m.



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SIGNED (Approved by W. Assink 05/01/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

New Action Items

LFS.02.03.01

Date Due: 05/10/02

Responsibility: Rockwell-Collins (Dave Hillman), F-15 (Mark Stibitz), NASA/ITB (Brian Greene)

Required Action: Dave Hillman work with component suppliers and possibly leverage off the EMMA program work on SnPb (POC: Lee Whiteman) to prepare a component list, with pin counts for each component type listed. Once this is completed, Mr. Hillman should work with Mark Stibitz to determine if hybrids can be added.

Comments:

LFS.02.03.02

Date Due: 05/17/02

Responsibility: Air Force, Navy, Army and NASA technical representatives

Required Action: Determine if adding hybrid devices to the test vehicle is a requirement of any of their programs.

Comments:

Open Action Items

LFS.01.12.01

Date Due: 01/07/02

Responsibility: Rockwell-Collins (Dave Hillman)

Required Action: Solders. Prepare a synopsis of published data on lead-free solder fatigue life testing.

Comments:

LFS.01.12.02

Date Due: One week after completion of LFS.01.12.01

Responsibility: All technical representatives

Required Action: Solders. Review Mr. Hillman's synopsis and suggest any modifications to the short list of lead-free solder alloys for both manufacturing and repair testing.

Comments:

LFS.01.12.03

Date Due: 01/07/02

Responsibility: ACI (Lee Whiteman)

Required Action: Solders. Provide information on antimony and tin/silver/antimony solder alloy

Comments: 12/28/01 – Completed. Information distributed.

LFS.01.12.04**Date Due:** 01/07/02**Responsibility:** Boeing (Tom Woodrow)**Required Action:** Solders. Provide information on leachates from toxic metals used in solder alloys to Heather Moyer at CTC for inclusion in the JG-PP Potential Alternatives Report.*Comments:***LFS.01.12.05****Date Due:** 01/07/02**Responsibility:** Raytheon (Joe Felty)**Required Action:** Solders. Provide information about toxic metals in solder alloys from the original NCMS lead free solder study to Brian Greene for distribution.*Comments:***LFS.01.12.06****Date Due:** 01/07/02**Responsibility:** All technical representatives**Required Action:** JTPs. Review the Manufacturing and Repair JTPs and provide comment to Brian Greene*Comments:***LFS.01.11.04****Date Due:** 12/11/01**Responsibility:** Raytheon (Joe Felty)**Required Action:** JTPs. Ask a statistician whether five PWAs was a statistically sufficient number of samples.*Comments:***LFS.01.11.05****Date Due:** 12/11/01**Responsibility:** Raytheon (Joe Felty)**Required Action:** JTPs. Ask a statistician what should be the general criteria for test failure (e.g., 2 out of 5; 3 out of 5)*Comments:***LFS.01.11.06****Date Due:** 12/11/01**Responsibility:** Army (Keith DeGroot), Raytheon (Joe Felty)**Required Action:** Manufacturing JTP. Contact their respective organizations to obtain worst-case vibration spectra for inclusion in the Manufacturing JTP Vibration Test.*Comments:*

LFS.01.11.08**Date Due:** 12/11/01**Responsibility:** All technical representatives**Required Action:** Manufacturing JTP. Check with respective organizations to make sure that 200 cycles is a sufficient maximum number of cycles to run Thermal Shock for the Manufacturing JTP Thermal Shock Test.**Comments:** 12/17/01 –M. Stibitz responded that 200 thermal shock cycles are sufficient for WR-ALC as long as the level of shock being used is per the MIL-STD-883 requirements.**LFS.01.11.12****Date Due:** 12/11/01**Responsibility:** Boeing (Tom Woodrow)**Required Action:** Test Board Design. Provide data from Lucent on the performance of immersion silver surface finish.**Comments:****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:** 11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.**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. Awaiting more service input.

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:** 11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.**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

11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.

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:** 11/15/01 – Progress was made at the Nov 14-15 meeting. At that meeting, a more refined list of alternatives was identified. Awaiting input from more of the stakeholders.