JG-PP Email

Joint Group on Pollution Prevention

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JG-PP Lead-Free Solder Project
Technical Meeting Minutes
April 26, 2002

Govt. Project Manager: Warren Assink, WPAFB

MEMORANDUM FOR RECORD **May 17, 2002**

Subject: Meeting Summary and Minutes – April 26, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: I-Identification, II - Technical

Summary:
On April 26, 2002, technical representatives from ATK Thiokol Propulsion, the Boeing Company, British Aerospace Systems (United Kingdom), High-Density Packaging User Group (), Mitsui Comtek/Senju Metals Co., Motorola, NASA-Kennedy Space Center, NASA-Marshall Space Flight Center, Naval Air Systems Command, Raytheon, Robins Air Force Base, Texas Instruments, TWI, 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)
- 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: June 6, 2002, 11:00 AM

Next Meeting: TBD

JG-PP Email

Joint Group on Pollution Prevention

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, indicated the conference operator would be taking the roll call as people dialed in. Mr. Bryan Howick, ATK Thiokol Propulsion, introduced himself and Robin Jenson, who leads Thiokol's ad hoc team on lead-free solder.

2. Mr. Greene reviewed the issues discussed and major decisions made at the last two project teleconferences in March 2002, in order to determine whether any further discussion of the issues is necessary.

3/7/02 Meeting Discussions and Decisions

Project Scope

- Mr. Greene stated that, in his opinion, there is a need to strike a balance between addressing all the needs the military and NASA has in being able to implement lead-free solders at the end of this project and trying to keep the scope of the cost of the project reasonable and well-defined.
- 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.
- Tin Whiskering: 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. Because groups like NEMI 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.
- Soldering Guidelines: A potential disadvantage of the Bi-containing alloys in field repair is the likelihood of creating low-temperature intermetallics when used with a SnPb component. 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 n 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 solder in.

Test Vehicle

- Each component will have its own channel, with components daisy chained individually (i.e., no live devices). There will at least 56 I/Os off each board if we only use a one-component daisy chain.

Finishes:

- Test 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.

- It was noted that if the group desires to test only two finishes, that NiPdAu and Sn would be best.
- The surface finish should be chosen by the component supplier (e.g., TI, Amkor), in line with their production standard.
- 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.

Solder Alloys:

- Proposed (without any dissent) that a Bi-containing solder similar to, but possibly better than, the 3.1Bi 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.
- 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, (2) the 3.3Bi is commercially available, and (3) is the leading candidate system for electronics originating in the Far East market)

  Reflow/Manual Solder:
  - Sn/3.9Ag/0.6Cu
  - Sn/3.4Ag/1.0Cu/3.3Bi

Joint Test Protocol:

- 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. AMCOM proposed temperature cycling ranges of 0°C to 100°C and -20°C to +80°C, with some additional cycling in-between those two temperature cycling ranges.
- 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.

JG-PP Email

Joint Group on Pollution Prevention

3/7/02 Issues Not Resolved

- Determine the pin count, pitch, and exactly which package is required so TI can supply the necessary components.

3/19/02 Meeting Decisions

- The group agreed to use 5-8°C/minute with 15 minute dwell times which is a lower ramp rate than the 20°C/minute contained in the proposal from AMCOM (Mr. Dave Locker).
- Mr. Joe Felty, Raytheon, proposed that he forward the test matrix and the HALT tests described in the 8 page report he prepared to Dave Locker, Dave Hillman, John Myer, and Mark Stibitz for their comments. Once they concurred on the overall approach that will satisfy them, a block diagram describing the test flow could be created and revisions to the design of the test boards could be accomplished. These would be forwarded to the technical group on this telecon for comment. (**AI: LFS. 02.03.03**)
- Mr. Lee Whiteman, ACI, and Mr. Mark Strickland, NASA MSFC, remarked that NASA looks at one temperature range, from -55°C to +125°C and ran the test for at least 1,000 cycles. This test satisfies NASA test requirements.
- Keep temperature shock test in JTP. Jeff Bradford asked if 3-5 temperature excursions were satisfactory and the group concurred. He asked the group if it would be OK to sequence these tests in with the others. Mark Stibitz said yes. Dave Locker concurred.
- The group thought 5 of each device would be enough. He said Weibull plots need 30 components with 5 to 10 failures to effectively test the joints.

3. The telecon participants were prompted for further comment on the past decisions.
    a. Mr. Joe Felty, Raytheon, thought the above synopsis was correct. We still need to come to resolution on the temperature cycling and the number of temperature ranges and cycles.
    b. Mr. Dave Locker, AMCOM, indicated that a real benefit to him would be to review a draft flow diagram of the testing so that AMCOM could identify ways to get some of the extra comparative temperature cycling data they need for making reliability predictions. Mr. Greene will distribute the flow diagram that Raytheon has prepared and contact Mr. Locker after his review.

4. Joint Test Protocol (JTP): Mr. Greene assigned an action item to all the technical representatives to provide him any new/additional comments on the Manufacturing JTP and Repair JTP in two weeks (Action Item **LFS.02.04.01a**). He will then prepare and redistribute the revised JTPs (AI **LFS.02.04.01b**). Mr. Strickland noted that he would try to provide input on NASA's ranges for vibration testing, along with specifics on tear-down.

5. Solder Alloys: Mr. Greene stated that he had received information that there may be more physical properties data on the 3.2 Bi compared to the 3.3 Bi alloy (i.e., Sn/3.4Ag/1.0Cu/3.3Bi). He asked whether the 3.3 Bi alloys was still OK to use, and were we "splitting hairs" to consider this 0.1 percent difference in Bi concentration.
    a. There was no disagreement among the telecon participants with Mr. Felty's feeling that, as long as we use a standard rework process, a 0.1 percent deviation in bismuth content would

have minor differences in physical properties. Mr. Hillman stated that a more important consideration be solder availability: Can we purchase the particular alloy in bar or paste form?

b. Mr. Ruben Bergman, HDP Users Group, stated that the JEDI and NEMI alloys are very similar. He expects that there will not be just one solder alloy formulation that is "best", but rather a formulation range of a particular solder alloys that is best.

c. Mr. Jeremy Pearce, Soldertec, stated that Soldertec's Web site, http://lead-free.org , contains Ms. Kay Nimmo's European lead-free solder roadmap, which includes those lead-free solder alloys currently being used in Europe. Mr. Pearce noted that for SnAgCu alloy, precise composition is more important. According to work at Helsinki University, if you are too far away from the eutectic, you get intermetallics coming out. Barring any definitive information that comes to light about the Sn/Ag/Cu alloy in the next several weeks (e.g., work by Kay Nimmo, Soldertec), consensus was to stick with the proposed Sn/3.9Ag/0.6Cu, which was also evaluated by NEMI.

d. Mr. Amitav Pattnaik, Warner-Robins AFB, mentioned a summary by Mr. William Kenyon reviewing papers presented at the APEX conference that discuss the interaction between lead and lead-free solders for repair work. Mr. Dave Hillman, RockwellCollins, agreed to recompile the pertinent papers published in the APEX 2002 Proceedings (Action Item **LFS.02.04.02**). Mr. Hillman stipulated that he was not aware of any lead vs. lead-free repair issues that have been scientifically studied—most papers have been rigorous.

e. Mr. Greene agreed to send the list of candidate solder alloys to the solder suppliers to ask which alloys they can supply in bar and paste (AI **LFS.02.04.03**).

6. Test Vehicle:

a. Mr. Hillman confirmed with the group the following test board design:
   1) Four (4) component finishes: SnPb (baseline), Sn, NiPdAu, and SnBi. Mr. Doug Romm, TI, noted that the SnBi finish is prominent in the Japanese market. Bi content is only 3 or 4%.
   2) Two (2) component sizes for each component style: Large I/O (e.g., 200-pin) and small I/O (e.g., 20-pin)
   3) Six (6) components of each finish/size/style on each test vehicle.
   4) Five (5) test vehicles per test in the DOE matrix. Thus, there will be a total of 30 of each component in the test (this will allow statistically valid Weibull plotting).
   5) Eleven (11) styles of components on the test vehicle: Ceramic LCC, Plastic LCC, DPak, TSOP, Quad Flat Pack (QFP), SOIC, Ball Grid Array (BGA), Chip Scale Package (CSP), DIP, and 0402 & 1206 chip capacitors.

b. Mr. Hillman thought that that between TI and Amkor we can obtain most of the components in the desired sizes and finishes. For example, TI can supply the NiPdAu, and Amkor probably some of the Sn and SnBi. Mr. Hillman will update the test board schematic for redistribution (AI **LFS.02.04.04**).

c. Hybrids: Mr. Hillman stated that his understanding is that the decision to add hybrids to the test vehicle could go either way right now. As long as there could be a daisy-chained facsimile of the part, we could make room for it on the board, if the group agrees. It comes

JG-PP Email

Joint Group on Pollution Prevention

down to getting the devices and seeing what they look like. Mr. Hillman and Mr. Greene will resolve the hybrid issue with Mr. Stibitz (AI **LFS.02.04.05**).

7. EU/U.S. Lead-Free Solder Early Customer Interface Meeting: Over 80 individuals from business and industry associations, government and academic organizations in Europe met with representatives from the U.S. Joint Group on Pollution Prevention/Industry Lead Free Solder project on March 27, 2002. Presenters from EU and US interests discussed issues and concerns facing all who use lead solder and are considering lead-free alternatives to meet market and environmental forces in manufacturing and electronic component suppliers. (Slide presentations are on the JG-PP Web site at http://www.jgpp.com). The objectives of the meeting were to 1) provide information exchange regarding EU and US efforts in lead-free solder technology development and 2) identify potential partnerships for determining shared lead-free solder technical needs and solutions. The meeting attendees asked questions of the U.S. JG-PP presenters and discussed the next steps to forming a working partnership to qualify lead-free solder. Many in the audience seemed to agree that European companies will have to switch to lead-free solders in a few years. The EU may wish to first focus on a particular application, such as a general purpose lead-free solder. Mention was also made of the benefits of pulling in European trade unions into the partnership. At the conclusion of the EU/U.S. meeting, an action item was assigned to the meeting's attendees to speak with the respective organizations' managers and identify in 3 weeks their interest in further developing a Lead-Free Solder project partnership.

8. Mr. Greene reviewed the progress of a few action items. Raytheon has completed their flow diagram for AI LFS.02.03.03. Action item LFS.02.03.04 was completed, although Mr. Hillman will be revising and redistributing the test board diagram. Action item LFS.02.03.02 calls for the Air Force, Navy, Army and NASA technical representatives to inquire whether adding hybrid devices to the test vehicle is a requirement of any of their programs.

9. The next Lead-Free Solder project teleconference will be Thursday, June 6 at 11:00 AM Eastern Time (1500 GMT). (Note, there is a large electronics (Surface Mount Technology Association) conference in Boston, MA, the week of June 10, and June 3 & 4 are United Kingdom holidays.)

10. The teleconference was adjourned at 12:00 p.m.

SIGNED (Approved by W. Assink 05/17/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

New Action Items

LFS.02.04.01

Date Due:	**05/14/02**
Responsibility:	Air Force, Navy, Army and NASA technical representatives
Required Action:	JTP: Provide Brian Greene any new/additional comments on the Manufacturing JTP and Repair JTP in two weeks. Brian Greene will then prepare and redistribute the revised JTPs.
Comments:	

LFS.02.04.02

Date Due:	**05/14/02**
Responsibility:	RockwellCollins (Dave Hillman); Technical representatives
Required Action:	Solder Alloys: Recompile the pertinent papers published in the APEX 2002 Proceedings that discuss complications with lead vs. lead-free repair. Technical representatives should review this information to determine whether any changes should be made to the short list of alternative alloys.
Comments:	

LFS.02.04.03

Date Due:	**05/14/02**
Responsibility:	NASA/ITB (Brian Greene)
Required Action:	Solder Alloys: Send the list of candidate solder alloys to the solder suppliers to ask which alloys they can supply in bar and paste.
Comments:	

LFS.02.04.04

Date Due:	**05/14/02**
Responsibility:	RockwellCollins (Dave Hillman)
Required Action:	Test Vehicle: Update the test board schematic for redistribution.
Comments:	

LFS.02.04.04

Date Due:	**05/14/02**
Responsibility:	RockwellCollins (Dave Hillman), F-15 (Mark Stibitz), NASA/ITB (Brian Greene)
Required Action:	Test Vehicle: Resolve the issue of adding hybrids, or a daisy-chained facsimile thereof, to the test board, and report to the team for decision.
Comments:	

Action Items Closed at this 4/26/02 Teleconference

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: 4/26/02 – Completed with the discussion of the lead-free solder alloys at the 4/26/02 telecon, and superceded by AIs LFS.02.04.02 and LFS.02.04.03. Unless any new information comes to light, the final list of alloys will be:

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, (2) the 3.3Bi is commercially available, and (3) is the leading candidate system for electronics originating in the Far East market)

Reflow/Manual Solder:
- Sn/3.9Ag/0.6Cu
- Sn/3.4Ag/1.0Cu/3.3Bi

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: 4/26/02 – Completed, and superceded by AIs LFS.02.04.02 and LFS.02.04.03. See response to AI LFS.01.06.07.
09/19/01 – Raytheon provided their recommendations; posted to the JG-PP Web site

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: 4/26/02 – Completed, and superceded by AIs LFS.02.04.02 and LFS.02.04.03. See response to AI LFS.01.06.07.

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: 4/26/02 – Completed. Agreed that 5 test vehicles per condition should be acceptable as long as a sufficient total quantity of each component types was included in the 5 vehicles. In the 3/19/02 telecon, 30 components per test condition were agreed as the number of components needed to provide statistically meaningful results. This was reconfirmed on the 4/26/02 telecon.

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: Closed 4/26/02, and superceded by AIs LFS.02.04.02 and LFS.02.04.03.
3/5/02 – Completed with an email from Dave Hillman. Dave felt that published data shows that the practical, "real-world" impact of lead contamination on solder joint performance is very low and can be controlled by the soldering process conditions. Dave recommended that we proceed with the JGPP rework/repair protocol demonstrating the low probability of Pb contamination degradation and confirming that standard solder assembly/repair/rework practices adequately address the issue.

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: 4/26/02 – Completed with the discussion of the lead-free solder alloys at the 4/26/02 telecon, and superceded by AIs LFS.02.04.02 and LFS.02.04.03. Unless any new information comes to light, the final list of alloys will be:

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, (2) the 3.3Bi is commercially available, and (3) is the leading candidate system for electronics originating in the Far East market)

Reflow/Manual Solder:

- Sn/3.9Ag/0.6Cu
- Sn/3.4Ag/1.0Cu/3.3Bi

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. See also AIs LFS.02.04.02 and LFS.02.04.03.

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: 2/6/02 – Completed via email to CTC.

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: Completed.

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: 4/26/02 – Completed. Comments received were incorporated, such as AMCOM's 2/13/02 comments. However, Brian Greene asked for additional comments to be provided under new action item LFS.02.04.01, due 05/14/02.

LFS.02.03.03

Date Due: **04/09/02**
Responsibility: Raytheon (Joe Felty)
Required Action: Provide the test matrix and HALT tests to the Dave Hillman, John Myer, Dave Locker, Mark Stibitz. Gather concurrence on the tests needed and sequences. Prepare block flow diagram and provide to Dave Hillman
Comments: Closed 4/26/02.
3/22/02 – Completed with email of updated flow chart from Jeff Bradford to Brian Greene. Jeff also submitted pdf files of MIL-STD-202 and MIL-STD-810 so the documents could be sent to members for comparison of humidity test requirements.

Open 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:

LFS.02.03.04

Date Due: **04/09/02**
Responsibility: Rockwell-Collings (Dave Hillman)
Required Action: Based on the discussions held for Action item LFS.02.03.03, and the block flow diagram, re-draft the strawman test board and provide to Brian Greene for distribution.
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: Raytheon proposed defining as electrical test failure as: 15 events above 300 ohms for any component interconnect/circuit (EMMA consortia criteria)

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: Raytheon submitted a modified version of the NAWC proposed vibration profile to Brian Greene.

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: 2/13/02 – AMCOM response: The 200 cycles for the thermal shock test in the JTP provides acceptable performance metric based on past experience qualifying and fielding Army equipment. For instance, the commonly used requirement for electronics equipment (MIL-STD-202F, Thermal Shock, method 107G) allows for a maximum 100 cycles. For general reliability characterization, thermal cycle testing over various temperature ranges and at different average temperatures will provide the primary basis for extrapolating performance to particular use conditions. Thermal shock performance depends on more thermal properties of equipment design rather than the temperature cycling characteristics.
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: At the 4/26/02 telecon, Brian Greene reviewed the proposed scope of this project as defined by the majority of stakeholders—and those issues beyond the scope of this project. These concerns include:

- Determining the magnitude and extent to which the lead-free solder issue will impact each Service and NASA (repair)
- Predictive modeling of the solders' long-term reliability (repair)
- Tin whiskering (repair)
- Developing soldering process guidelines to minimize the likelihood of creating low-temperature intermetallics when using bismuth-containing solder alloys with a SnPb component (repair)
- How will lead-free vs. lead containing parts be identified/tracked in the field (repair)

The Services and/or industry organizations will have to address these issues.

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.