JCAA/JG-PP Lead-Free Solder Project E-mail

From:	Brian Greene, Project Integrator	**Phone:**	321-867-8481
Date:	9/29/2003	**Fax:**	321-867-8479
No. of Pages:	13	**Email:**	Brian.Greene-2@ksc.nasa.gov

Lead-Free Solder Project

August 21, 2003 Teleconference Minutes

Govt. Project Manager: MSgt Richard Hricko, ASC/AAA

Comments:
Following are the minutes from the August 21, 2003 Lead-Free Solder teleconference

August 21, 2003 Meeting Attendees:

MEMORANDUM FOR RECORD

Subject: Teleconference Summary and Minutes – August 21, 2003

Next Teleconference: October 16, 2003, 11:00 AM EST

Minutes:

1. Mr. Brian Greene (ITB, Inc.) opened the teleconference by reviewing the June 17, 2003 Lead-Free Solder project meeting minutes. He proposed that the minutes be corrected as follows (per e-mailed suggestion from Mr. Jim Blanche, NASA-MSFC): In the minutes Paragraph. II Testing, 1, f. a) where it states that the thickness of the stencils will be 6 and 7 millimeters, correct it to instead read "between 6 and 7 mils (0.006 and 0.007 inches)" (just one size). No disagreement was voiced to making this change.

2. Recent Technical Topics and Recommendations. The following technical topics were reviewed and further discussed, where noted.

    a. Testing Materials

        i. Components. After it was learned that the hybrids come with a gold finish on their leads, Air Force, NASA, Rockwell Collins, and Boeing agreed in a recent meeting that hybrids needed to be pre-tinned. This will eliminate any concerns about gold embrittlement.

        ii. Solder Fluxes. Air Force, NASA, Rockwell Collins, and Boeing decided in a recent meeting that we should strive to use only low-residue (e.g. rosin-type, 6-10% solids) fluxes for all the lead-free solder alloys. The preference is to avoid RA fluxes because of the residue they can leave behind and their potential affect on Class 3. Two questions were raised: What is the likelihood of facilities being required to use RMA solder flux?, and Would it be true that a legacy program using RMA (or a new program) might not have that requirement in the future?

            a). Mr. Hillman responded that the results of our study will meet the needs of many facilities because low-residue is now the industry norm. In addition, the data could also help show such facilities using RMA the direction (low-residue) they need to be considering. Rockwell Collins has switched completely to low-residue fluxes and have started looking at not cleaning some low-residue fluxes. NASA, however, still uses RMA solder flux, although the proposed Space Addendum to IPC/EIA J-STD-001C will recommend NASA use L0 and L1 (predominantly low-residue) solder flux.

            b). Dr. Reza Ghaffarian, NASA Jet Propulsion Laboratory, responded that he would like to link the data generated using the low-residue fluxes to NASA data using RMA flux. Mr. Bob Gilbert, Florida CirTech (FCT), replied that in Japan and Asia where most of the lead-free wave soldering is being performed, they typically use a high-solids rosin flux as their no-clean. In testing that Florida CirTech has done on some of the super-low solids fluxes common in the United States may

not work with the higher temperature requirements of the lead-free alloys. FCT has developed a low solids (2-3% rosin) RMA no-clean. So this could be an option where we're supporting both RMA and no-clean at the same time. In addition, manual soldering and solder paste are usually high solids and meet the ROL1 requirement, and thus could be considered an "RMA" under the old classification. So we can select an RMA solder flux for all three categories of soldering (wave, reflow, manual). As presently proposed, most of the solder fluxes will be ROL1 or RMA. The only exception if the flux for the baseline SnPb solder. So we'll have some data to link to RMA fluxes.

c). Mr. Hillman reminded everyone that the general material selection criteria agreed upon was to go with the fluxes, etc. recommended by the solder vendor based on performance, of which low-residue, cleanable fluxes are recommended. This is embedded within the matrix in Attachment 2.

d). Boeing-Irving's standard practice is to clean boards using a semi-aqueous "Ionox" (synthetic alcohol based) cleaner.

iii. Test Board Design. Mr. Dave Hillman, Rockwell Collins, has made no significant changes (recently) to the test board design. However, Mr. Hillman and Dr. Tom Woodrow (Boeing) have been in recent discussion on the following Boeing requests for board modifications:

a). Increase the Board Size. The wedgelocks that Boeing plans to use for vibration testing require a minimum ¼-inch free space along two edges of the board. Rockwell Collin's draftsmen are looking into the implications of this request. It is likely that 1/8-inch of space will need to be added to the "short" edges of the board (the one side where the DIPS are and the other side where the breakoff coupons are).

b). Adequate Hole Diameter for Connector. It is important to determine the connector plated through hole (PTH) diameter (after plating). The hole size determines what gauge wire can be used. If the testing facilities are forced to use a wire that is too small, this might increase the risk of breakage during vibration and/or mechanical shock testing. Boeing-Phantom Works would like to use a robust wire size, such as 22-gauge (0.030-inch diameter) wire, for the vibration test. Mr. Hillman thought the holes will be 0.036 (+0.002/ -0.003), which is big enough, but he will double-check.

c). Run Traces to Pads. Dr. Woodrow would like to see traces run from the PTHs to pads on the edge of the board because of concerns about connecting multi-stranded wire (which can fray) to the hole. This would allow the option to connect the wires to either the PTHs or to the pads. Mr. Hillman stated this would be a large change to the board design at this late stage, and would be unnecessary still Rockwell Collins commonly runs wires to the PTHs. If room exists to add the tracing, Dr. Woodrow would like to see it considered.

d). Label Holes. Dr. Woodrow would like to markers placed every five PTHs so the entire length of the holes do not have to be counted. Mr. Hillman said end markers (e.g., a '1' on one end and a '19' on the other end) could be done and not be a major change to the board design. Mr. Hillman did not see the need to label every fifth PTH, while Dr. Woodrow said doing so would reduce technician error.

b. Test Procedures

i. Rework. Boeing-Irving has proposed the quantity of each component type to be reworked (see Attachment 3). Soon, Boeing-Irving will determine exactly which locations of the components will be rework.

a). Dr. Lee Whiteman, ACI, ask if tin-lead finished boards was going to be reworked with lead-free. The answer is "Yes." Will the boards be examined for tin whiskers? "Yes" (for thermal cycles).

b). The number of boards to be reworked will be 86 out of 205 total boards. The reworked boards will undergo most of the same common tests as the non-reworked boards.

ii. Pb-Free Residue Test. Boeing-Phantom Works has proposed a procedure and quantity of each component to analyze for residual lead after rework (see Attachment 4, Table 3). Two of each reworked component per board will be analyzed. The rework and lead-free residue proposals were accepted without further comment from the team.

iii. Thermal Cycle, Dwell Time. Discussion focused on the best figure for the amount of time which to expose the test boards to during thermal cycling (i.e., dwell time). The JTP currently states a 10-minute dwell time. However, there are solid reasons for using a dwell time longer than 10 minutes, such as the longer dwell time is likely to induce more stress to the joint and therefore be more likely to differentiate differences between Pb and Pb-free soldered boards for certain types of components.

- Mr. Greene noted that going with a 15-minute dwell time may only add about a month or two to the schedule, and has already been factored in to the latest schedule that he distributed (see Attachment 5).
- Mr. Mark Strickland, NASA MSFC, voiced that Dr. Wayne Johnson, Auburn Univ., for one, favors a 15-minute dwell time. Another stakeholder proposal was to run a comparative test beforehand (10-minute vs 15-minute), but this raised concerns about adverse impact on schedule. Dave Hillman noted that the statistics for such a small number of pre-test boards will not permit good data interpretation. Others also felt there is likely to be no perceptible difference in output. Mr. Hillman also added that one advantage of a 15-minute dwell time is that he (and others) have thermal cycling data for SnPb solder at 15 minutes, allowing some comparison and evaluation.
- After much discussion, the consensus of the participants was that, while either 10 minutes or 15 minutes is fine, going with a 15-minute dwell may be easier to defend technically. Mr. Greene noted that he is

inclined to not update the JTP (which was recently updated anyway) at this time, but will include the change in the Joint Test Report and any Statements of Work for testing.

iv. Thermal Cycles, -20 to +80 deg C. Dr. Tom Woodrow, Boeing, surmised that at 5,000 cycles, not enough failures may have occurred. If that occurs, his intention is to continue testing (in part because it is an in-kind contribution, anyway). Mr. Greene confirmed that the plan all along was to have a decision point at 5,000 cycles, at which time to see if the minimum desired 63% failure rate has been achieved. No one voiced objection to Boeing keeping the test boards and continuing testing if not enough failures have been observed at 5,000 cycles if it means significantly better test data and if Boeing agreed to share the longer term cycle data with the team.

c. Testing Locations

Both of the following offers of in-kind contributions were accepted without disagreement.

i. Cross-sectioning. Sandia Labs offered to cross-section one or two of the assembled test boards and take measurements as part of their in-kind contribution to the project.

ii. Electrochemical Migration Resistance Test. Boeing-Anaheim offered to perform the EMR test as one of their in-kind contributions

d. JG-PP Documents

i. Joint Test Protocol. The latest JTP version, dated June 20, 2003, is on the JG-PP Web site (http://www.jgpp.com). The recent changes to the JTP are noted in the document's Preface, which states,

"THIS REVISED JOINT TEST PROTOCOL (JTP) REFLECTS THE FOLLOWING CHANGES TO THE PREVIOUS VERSION OF THE JTP DATED FEBRUARY 14, 2003.

- JTP Section 2.1.1.2, Table 2. Test Vehicle Matrix for Manufactured PWAs: Changed "GF" to read "FR4"
- JTP Section 2.1.2.2, Table 3. Test Vehicle Matrix for Reworked PWAs: Correctly changed "GF" to read "FR4"
- JTP Section 2.3, Figure 1. Common Test Flow Diagram for Manufactured Test Boards and Figure 2. Common Test Flow Diagram for Rework Test Boards: Transposed the 'Yes' (Y) and 'No' (N) in the last decision block so it reads correctly
- JTP Section 2.4, Figure 3. Extended Test Flow Diagram for Manufactured Test Boards: Correctly changed the number of IPC boards from 35 to 45 to account for actual number needed for testing.
- JTP Section 3.3.3, Surface Insulation Resistance: Correctly changed the number of IPC boards from 35 to 45 to account for actual number needed for testing.
- JTP Section 3.3.4, Electrochemical Migration Resistance Test: Correctly changed the number of IPC boards from 35 to 45 to account for actual number needed for testing.
- Preface: Corrected some organizational names based on comments from technical representatives.

NO OTHER CHANGES HAVE BEEN MADE."

Other endorsements are still being sought for the next few weeks.

iv. Potential Alternatives Report. At Government request, Concurrent Technologies Corporation updated some sections of the PAR to tell a more complete picture of how we chose the lead-free solders and to include data on the SnCu(+Ni) wave solder alloy. Mr. Dave Markowski reported that the PAR was completed and delivered to the Government.

4. Project Schedule. The latest project schedule (as of 8/20/03) is attached (see Attachment 5). Near-term activities are to procure testing materials, and then begin building the builds. Testing should begin in February 2004. Mr. Greene alerted everyone to the growing desire to have some meetings/lab tours during the board assembly and during testing. When such assembly and testing dates are more firm, everyone will be alerted so that they can consider attending.

5. Project Funding. Mr. Greene reported that NASA's FY2003 funding is in hand and is just waiting for subcontracts to be set up through ITB. Dave Hillman, Rockwell Collins, has the first action of procuring the necessary testing materials and coordinating pre-tinning of the LCCs and hybrids. U.S. Air Force Aeronautical Enterprise Office (MSgt Hricko) and NASA Acquisition Pollution Prevention Office will be meeting soon to discuss FY2004-05 funding. One wild card will be whether the project proposal to ESTCP gets funded and how much the funding will be. Other DoD funding options exist if the ESCTP funding falls through.

6. Review Action Items. For the status of recent action items, see Attachment 1.

7. Industry News. Mr. Greene's overview of IPC's Solder Products Value Council (SPVC) Study is attached (Attachment 6)

8. Next Teleconference. The next teleconference will be October 16, 2003, 11:00 AM EST.

SIGNED (Approved by R. Hricko 09/26/03)

Rich Hricko
Govt. Project Manager, WPAFB

Attachment 1. Action Item Status

New Action Items

None

Open Action Items

LFS.03.07.11

Date Due:	**09/13/2003**
Responsibility:	Lety Campuzano-Contreras (Boeing-Irving)
Required Action:	Propose which components (by board location) will be reworked from a worst-case perspective.
Comments:	08/13/03 – In progress

LFS.03.07.12

Date Due:	**08/13/2003**
Responsibility:	Brian Greene (NASA AP2/ITB)
Required Action:	(a) Contact Dave Locker, AMCOM, to ask if he could do some simple Coffin-Manson modeling, perhaps for just one component type (e.g., 44-pin or 20-pin LCCs) for inclusion in the project's Joint Test Report, and then (b) Contact Paul Vianco, Sandia Labs, to look for synergy with Sandia's prior LCC data
Comments:	08/05/03 - Dave Locker indicated that he could do some simple Coffin-Manson modeling for inclusion in the project's Joint Test Report

LFS.03.07.03

Date Due:	**07/31/2003**
Responsibility:	Dave Hillman (Rockwell Collins)
Required Action:	Look into saving his engineering drawings of the test vehicle into an electronic format suitable for Boeing-Irving to read.
Comments:	08/21/03 – Dave reported as in progress.

LFS.03.07.07

Date Due:	**07/31/2003**
Responsibility:	Dave Hillman (Rockwell Collins)
Required Action:	Provide to ITB his labor costs for any and all extended tests that Rockwell Collins can perform.
Comments:	08/21/03 – Dave reported as in progress.

Action Items Closed 8/13/03 (at small-group teleconference)

LFS.03.07.10

Date Due:	**08/13/2003**
Responsibility:	Ed Drouet (Boeing-Anaheim)
Required Action:	Look into getting Boeing management approval to do some or all of the Electrochemical Migration Resistance test in-kind.
Comments:	**Closed**. 08/13/03 – Ed Drouet reported that the EMR boards have been ordered. 08/11/03 **–** Ed Drouet emailed that that Boeing management approved Ed to conduct Electrochemical Migration Resistance testing in-kind. Boards will have OSP finish.

LFS.03.07.13

Date Due:	**08/13/2003**
Responsibility:	Brian Greene (NASA/ITB)
Required Action:	Distribute an updated project schedule showing tentative dates and locations for site visits and other meetings.
Comments:	**Closed**. 08/13/03 **–** Updated schedule distributed with agenda for the 8/21/03 telecon.

LFS.03.07.01

Date Due:	**07/31/2003**
Responsibility:	Dave Hillman (Rockwell Collins)
Required Action:	Contact Corfin Industries to see about the feasibility and additional cost of tinning the hybrids.
Comments:	**Closed**. 08/11/03 – Dave obtained quote from Corfin. The total cost is $4,425 ($3075 [615x$5 each] +$900 +$450).

Attachment 2. Solder Summary Table

	Wave Soldering	Reflow Soldering	Manual Soldering	Dipping of LCCC20s
		3x500 grams of each alloy	2-3 rolls (1 lb each) of wire	Corfin Industries needs 300 lbs. of each alloy
Sn0.7Cu (stabilized)	SN100C Vitronics-Soltec will do at no charge	N/A	SN100C (010,011,020) Florida CirTech, Inc will provide @ no charge	N/A
Flux	TBD by Vitronics-Soltec	N/A	RMA (NoClean) 0-.05% Halide Content Florida CirTech, Inc will provide @ no charge	N/A
Sn3.9Ag0.6Cu	Vitronics-Soltec will do at no charge	ECO Solder 7100- GRN360K Senju will provide @ no charge	ECO Solder RMA02 Senju	Florida CirTech, Inc will provide @ no charge
Flux	TBD by Vitronics-Soltec	ROL1	279C(5) Senju	N/A
Sn3.4Ag1Cu3.3Bi	N/A	CL30-7780 Heraeus will provide @ no charge	Indium Corp. $290/roll	Florida Cirtech, Inc will provide @ no charge
Flux	N/A	No Clean (RMA)	No Clean (RMA)	
Sn37Pb	Kester Ultra-Pure Boeing	Kester R244 Boeing	Senju RMA98Super/ Aeromild10 Boeing	N/A
Flux	Alpha NR310 TypeORM0 Boeing	ROL0 Boeing	Senju ZR102F (ORL0) Boeing	N/A

Solder Points Contact:

Vitronics-Soltec: Denis Barbini, Ext. 207 2 Marin Way, Stratham, NH 03885 dbarbini@us.vitronics-soltec.com Bob Silveri, Ext. 205 bsilveri@us.vitronics-soltec.com	**Senju Solder:** Derek Daily 12980 Saratoga Ave., Ste. B Saratoga, CA 95070 (408) 446-7866 ddaily@sjmcb.mitsui.com
Corfin Industries: Joe Zaccari 78 Raymond Ave. Salem, NH 03079 (603) 893-9900 jzaccari@corfin.com	**Indium Corp.:** Tom Pearson 34 Robinson Rd. Clinton, NY 13323 (315) 8534900, Ext. 7564

Attachment 3.

Proposed Components to Rework

One component of each type will be reworked for a maximum of 8 components per board.

Components to be Reworked

PART NUMBER	QTY	Finish
T11-TSOP50-10.16x20.95mm-.8mm-DC	1	Sn/Pb
T11-TSOP50-10.16x20.95mm-.8mm-DC-LF	1	Sn/Cu
TQFP144-20mm-.5mm-2.0-DC-LF	1	Sn
PBGA225-1.5mm-27mm-DC-LF	1	Sn/Ag/Cu
DIP20-300MIL-TR-DC-LF	1	Sn
CABGA100-1.0mm-11mm-DC-LF	1	Sn/Ag/Cu
TQFP	1	Au/Pd/Ni
PDIP	1	Au/Pd/Ni

Attachment 4.

Boeing-Phantom Works Procedure to Quantify Lead Residue in Reworked Test PWAs

The contractor shall accomplish a post-PWA-assembly test to quantify the amount of lead (Pb) remaining in solder joints following a rework operation. This test will help determine if Pb has an effect on lead-free joint reliability. In performing the test, remove ten solder joints from each component type on the test PWAs. The components to be tested are shown in Table 3. Two components of each type will be tested for a maximum of 16 components total. Dissolve each set of ten solder joints in a mixture of nitric and hydrochloric acid. Analyze the solutions by inductively coupled plasma (ICP) spectroscopy. Calculate the combined average quantity of Pb in the joints. Upon completion of the Pb residue testing, prepare and submit a test report containing the following information:

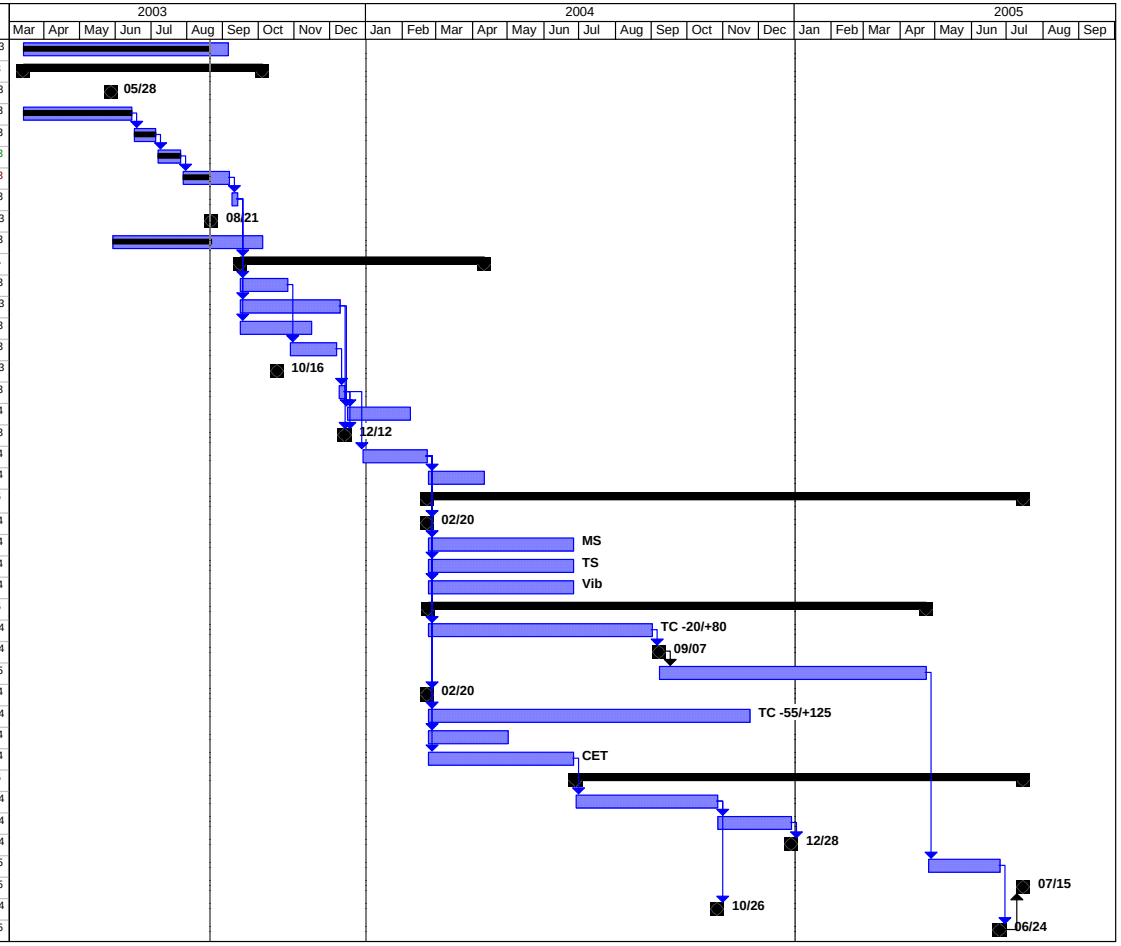
- Test description, including solder joints removed
- Test results

Components to be Tested

PART NUMBER	QTY	Finish
T11-TSOP50-10.16x20.95mm-.8mm-DC	2	Sn/Pb
T11-TSOP50-10.16x20.95mm-.8mm-DC-LF	2	Sn/Cu
TQFP144-20mm-.5mm-2.0-DC-LF	2	Sn
PBGA225-1.5mm-27mm-DC-LF	2	Sn/Ag/Cu
DIP20-300MIL-TR-DC-LF	2	Sn
CABGA100-1.0mm-11mm-DC-LF	2	Sn/Ag/Cu
TQFP	2	Au/Pd/Ni
PDIP	2	Au/Pd/Ni

Attachment 5. Project Schedule, as of 8/20/03

Task Name	Start	Finish
Joint Test Protocol (JTP) Approval	Fri 03/14/03	Thu 09/04/03
Business Phase	**Fri 03/14/03**	**Fri 10/03/03**
Mtg. - AF-NASA Business	Wed 05/28/03	Wed 05/28/03
Determine FY$2003 Cost Shares	Fri 03/14/03	Fri 06/13/03
Send out Requests For Proposals	Mon 06/16/03	Fri 07/04/03
OEM write RFPs	Mon 07/07/03	Fri 07/25/03
Proposals analyzed & negotiated	Mon 07/28/03	Fri 09/05/03
Sign subcontract agreement. Distribute PO	Mon 09/08/03	Fri 09/12/03
Project Telecon	Thu 08/21/03	Thu 08/21/03
Determine FY$2004-05 Cost Shares	Thu 05/29/03	Fri 10/03/03
Testing Preparation	**Mon 09/15/03**	**Fri 04/09/04**
Order components (Collins)	Mon 09/15/03	Fri 10/24/03
Tin LCCC20 & Hybrid component leads (Collins; Corfin)	Mon 09/15/03	Mon 12/08/03
Components received and characterized (Collins)	Mon 09/15/03	Fri 11/14/03
Order test vehicles and solders (Collins)	Mon 10/27/03	Fri 12/05/03
Project Telecon	Thu 10/16/03	Thu 10/16/03
Characterize bare boards (Collins)	Mon 12/08/03	Fri 12/12/03
Build PWAs; Rework PWAs (Boeing-Irving)	Mon 12/15/03	Fri 02/06/04
Mtg. - Testing Kickoff & View PWA Assy. (Boeing-Irving)	Fri 12/12/03	Fri 12/12/03
Test vehicle characterization (Collins)	Mon 12/29/03	Fri 02/20/04
Test vehicle cross-sectioning (Sandia)	Mon 02/23/04	Fri 04/09/04
Testing Phase	**Fri 02/20/04**	**Fri 07/15/05**
Mtg. - View Boeing PW test set-up	Fri 02/20/04	Fri 02/20/04
Mechanical Shock (Boeing PW)	Mon 02/23/04	Fri 06/25/04
Thermal Shock (tenta. Boeing PW)	Mon 02/23/04	Fri 06/25/04
Vibration (tenta. Boeing PW)	Mon 02/23/04	Fri 06/25/04
Thermal Cycle -20/+80C (Boeing PW)	**Mon 02/23/04**	**Fri 04/22/05**
5,000 Thermal Cycles	Mon 02/23/04	Tue 08/31/04
Mtg. - Prelim. Data Review (tenta. Collins)	Tue 09/07/04	Tue 09/07/04
Remaining Cycles (# cycles TBD)	Tue 09/07/04	Fri 04/22/05
Mtg. - View Collins (IA) test set-up	Fri 02/20/04	Fri 02/20/04
Thermal Cycle -55/+125C (Collins)	Mon 02/23/04	Mon 11/22/04
Extended Tests (location TBD)	Mon 02/23/04	Fri 04/30/04
Combined Environments Testing (Raytheon, TX)	Mon 02/23/04	Fri 06/25/04
Joint Test Report	**Mon 06/28/04**	**Fri 07/15/05**
JTR 1st Draft	Mon 06/28/04	Tue 10/26/04
JTR 2nd Draft	Wed 10/27/04	Tue 12/28/04
Post Draft JTR to Web	Tue 12/28/04	Tue 12/28/04
JTR Final	Mon 04/25/05	Fri 06/24/05
Deliver Final JTR	Fri 07/15/05	Fri 07/15/05
Mtg. - JTR Review (tenta. Raytheon, TX)	Tue 10/26/04	Tue 10/26/04
Mtg. - Project close-out (tenta. JFK Space Ctr.)	Fri 06/24/05	Fri 06/24/05



Task not funded as yet
Task funded but not yet started
Task funded and in progress
Task complete
Tentative meeting date

Attachment 6. IPC Solder Products Value Council (SPVC) Study

IPC-Association Connecting Electronics Industries - Solder Products Value Council (SPVC) Study Summary

IPC-Association Connecting Electronics Industries (Northbrook, IL) recently announced that its Solder Products Value Council (SPVC) has begun a study of three lead-free (tin-silver-copper) alloys in an effort to analyze the properties of the leading candidates for lead-free assembly. None of these solder alloys will be tested in the JG-PP lead-free solder alloy study, which will include Sn/3.9/0.6Cu. The three alloys being studied by the SPVC are:

- Sn/3.0Ag/0.5Cu
- Sn/3.8Ag/0.7Cu
- Sn/4.0Ag/0.5Cu

The tests performed on these alloys will be thermal shock (per NEMI protocol) and thermal cycling (0 to +100C per IPC-9701 up to 6000 total cycles), as well as some metallurgical testing. Several solder paste manufacturers will perform the testing.

Assembly of the SPVC test board should take place at the end of July 2003 with testing to begin shortly thereafter. SPVC expects the results to be published in the first quarter of 2004.

From the military/space perspective, the SPVC study appears to be a quick, somewhat limited study. Word is that they have a limited scope as far as the testing they are conducting. Their test vehicle/components are fairly basic. Their resulting data set will be a benefit to the industry, but have limited applicability to DoD and NASA customers, especially for the Class 3 type of products. The JCAA/JG-PP Lead-Free Solder Joint Test Protocol is currently more complete and comprehensive in test design than the proposed SPVC study.

Further information at http://www.circuitnet.com/articles/article_5369.shtml