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***Lead-Free Solder Project  
Meeting Minutes  
Hosted by: Harris Corporation, Melbourne, FL  
21 September 2004***

**Comments:**

Attached please find the minutes for the September 21, 2004 Lead-Free Solder Face-to-Face meeting hosted by Harris Corporation in Melbourne, Florida. Please further distribute as necessary.



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## MEMORANDUM FOR RECORD

**Subject:** – Face-to-Face, Summary and Minutes – September 21, 2004

**Next Teleconference:** December 14, 2004, WebEx, 1100 Eastern

**Next Meeting:** February 22-25, 2005, IPC/APEX, Anaheim, CA

### *Minutes:*

#### **1. Opening:**

Mr. Brad Nichols, Director of Manufacturing, Harris Corporation, opened the meeting by welcoming everyone and briefed some administrative issues particular to the Harris Corporation. Mr. Kurt Kessel also welcomed everyone and thanking them for their attendance at the meeting and their participation in the project. Mr. Kessel briefed that all the presentations will be made available through the NASA Acquisition Pollution Prevention Program website at <http://acqp2.nasa.gov> and the Joint Group on Pollution Prevention (JG-PP) website at [www.jgpp.com](http://www.jgpp.com). A notice will be sent out informing everyone when the presentations reach the websites.

#### **2. Test Vehicle Assembly:**

##### **Board Manufacturing**

Ms. Lety Campuzano-Contreras, BAE Systems, presented a status report on the board manufacturing. She began with a brief background of the project. The materials were chosen based on initial environmental, safety, and occupational health screening data as well as previous experience in Japan, Europe and other consortium using lead-free solder. Boeing Commercial Electronics-Irving, now BAE Systems Irving, agreed to assemble the test boards as their part in the consortium activities. Their facility and product were considered typical of facilities producing a highly reliable product with enough volume to simulate a higher capacity production run. The project will generate critical reliability data on circuit cards manufactured and reworked with lead-free and eutectic tin-lead solders for military and space applications as documented in the joint test protocol.

##### The physical characteristics of the boards are:

- 14.5" X 9" X 0.09"
- 6 layers
- Immersion Silver (Tg~170°C, GF-Pb-free PWAs)



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- SnPb HASL (Tg~140°C, GF-Rework PWAs)

A total of 205 boards were manufactured using surface mount and through hole components. The lead-free solder alloys used were:

- Tin-copper (stabilized) (99.3Sn-0.7Cu-0.05Ni) - wave and hand soldering
- Tin-silver-copper (95.5Sn-3.9Ag-0.6Cu) - wave, reflow and hand soldering
- Tin-silver-copper-bismuth (92.3Sn-3.4Ag-1.0Cu-3.3Bi) - reflow and hand soldering

All PLCCs were hand soldered with either SnPb, SnAgCu, or SnAgCuBi solders. Vitronics-Soltec, in New Hampshire, performed the lead-free wave solder using SnCu and SnAgCu. After wave solder the assemblies were cleaned at Kyzen in New Hampshire.

The production environment was simulated, which included:

- Full compliance to standard process control documents
- Formal planning sequence (CAAP)
- Certified operators and inspectors
- PE/QE special training for factory personnel
- Traveler used for serial number documentation.

Rework of the board was done to simulate military depot and in the field activities. Selected pairs of the following component types were removed and replaced to look at the effects on the assembly due to the additional and higher temperature and/or different solder joint metallurgy: BGA, TQFP-208, TSOP-50, DIP

## Solder Profiles

### Tin Lead Solder (SnPb)

Wave Solder SnPb (Rework & Manufactured-Control)

- Typical SnPb Profile used
- Solder Pot Temperature = 250°C
- Preheat Board T = 101°C
- Peak Temperature = 144°C
- Speed = 110 cm/min

Reflow Oven SnPb Solder (Rework & Manufactured-Control)

- Standard SnPb Profile used
- Preheat = ~120 seconds @ 140-183°C
- Peak Temperature = 225°C
- Time above reflow = 60-90 sec
- Ramp Rate = 2-3°C/sec



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AIR-VAC DRS24C.2D equipment used for SnPb Rework

- Standard SnPb Rework Profile
- Preheat = ~120 seconds @ 140-183°C
- Ball Park Temperature = 206°C
- Time above reflow = 96 seconds
- Ramp Rate = 2-3°C/sec

## Tin-Silver-Copper (SnAgCu) and Tin-Silver-Copper- Bismuth (SnAgCuBi)

Reflow Oven Lead-Free Solder (SnAgCu & SnAgCuBi)

- Based on consortium agreed requirements
- Preheat = 60-120 seconds @ 150-190°C
- Peak Temperature Target = 243°C
- Reflow:
  - 20 seconds above 230°C
  - 30-90 seconds above 220°C

Lead-Free Solder Wave Solder Profile

- Solder Pot Temperature = 265°C for *SnCu*
- Preheat Board T = 134°C
- Peak Temperature = 157°C
- Speed = 90 cm/min
  
- Solder Pot Temperature = 260°C for *SnAgCu*
- Preheat Board T = 134°C
- Peak Temperature = 161°C
- Speed = 90 cm/min

AIR-VAC DRS24C.2D equipment used for Lead-Free Rework

- Device joint target = 243°C
- Device top max target = 260°C
- Board target = 110°C
- Board Max = 150°C
- Reflow:
  - ~97 seconds above 217°C
  - ~75 seconds above 221°C
  - ~44 seconds above 235°C
- Ball temperature = 241°C
- Ramp Rate = 1.14°C/sec



## Results

The results of the board manufacturing process were documented with photos. Full photo documentation of the test vehicle build process, from start to finish, will be made available with the final JTR. In general the lead-free solders have a much more grainy appearance. When solders are mixed there is an increase in the percentage of voids. Lead-free solders don't flow as well and wetting is not as complete with any alternatives as compared with leaded solders.

## Lessons Learned

- Components are critical
  - XRF was used to verify the surface finish of components
    - Incorrect surface finish (mix lot) DIPs from vendor
  - Lead-free components have different moisture sensitivity ratings
  - Logistics: Tight control of parts was required (i.e., SnAgCu manufactured boards required a combination of tin-lead and lead-free surface finish BGAs, TSOPs, and CLCCs (only SnAgCu lead finish)
  - Because components are not marked for lead-free solder, some components were marked to differentiate between surface finish
- Solder paste printing process does not require changes when using lead-free solder
- Component placement process does not require changes for lead-free solder
- Reflow, as expected, is the major process difference
  - Lead-free solder's full liquidus temperature is approximately 38 degrees higher than SnPb; but the components and boards thermal properties have not changed
  - The decreased process window made thermal profiling a challenge
  - High temperature insulation thermocouples will be necessary for future work
  - The conveyor process was slowed down and zone temperatures increased by 20-60°C depending on oven zone
  - Visual examination in some cases is not a good indicator whether the reflow has been accomplished; have to rely on temperature and time
    - Lead-free solder joints have a grainy appearance, some are not as shiny, the foot of the lead on surface mount components are more visible, and they don't wet out like SnPb
- Wave soldering with lead-free solders was also challenging
  - Solder balls were visible every where
  - Flux material is very critical
    - Flux nozzle and fluxing parameters were changed to improve the flux function



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- Rework using lead-free solder also required profile changes because of the higher temperatures required
  - A new lead-free program (template) was required
  - Assemblies were baked before rework
  - Extra caution was required during thermal profiling because of the maximum temperature the components can withstand (260°C)
  - Continuity test, X-ray, and ERSA were performed on each BGA after rework
    - It may take years before confidence level is developed
  - Site cleaning was not as easy due to the higher temperatures
- Hand soldering is similar to SnPb after practice (learning curve)
  - Higher temperature (700°C) tips are required
  - Flux is required especially if the solder wire doesn't contain any
  - Some pads were lifted due to the higher tip temperature and because the lead-free solders do not flow as well as SnPb
- Smaller (0.37" X 0.37") polyimide labels did not withstand LF wave soldering
- Cleaning
  - Due to higher temperatures used, assemblies that were reworked required additional cleaning to remove flux under BGAs prior to endoscopic inspection
- Quality inspection
  - The solder joint appearance varied from baseline SnPb due to the different wetting characteristics
  - Additional training is required and our acceptability documents must be revised
  - Visual aids would be helpful (acceptability pictures)

## **Question and Answer**

Q) Would no-Pb have passed J-STD-001 criteria?

A) Yes, but we modified our normal criteria to accept graininess. There was a lot of discussion around the room and final caveat stating that other alloys can have differing joint shinny-ness. The point is that they look reasonably OK but we still need to complete reliability studies to determine if they will last in use.

Q) How did you determine that you had achieved 243° peak temperature.

A) We drilled into a BGA and measured at the ball. We were trying to stay under 260° and came really close to the device.

Q) How did operators like the no-Pb. How did they feel about no-Pb rework?

A) Operators liked it but had some issues with the fact that it looked different from normal Sn/Pb. Occasionally they forgot they were dealing with no-Pb and did get some pad lifting. There was some learning curve associated with application of heat and withdrawal of the tip after reflow.



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- Q) Why did you hand solder PLCCs?  
A) We had problems with parts coming to us wrong and made a decision to hand place in order to get production moving.
- Q) Did you bake the boards?  
A) No, we did an evaluation of the board materials but decided we didn't need to bake PWBs to facilitate processes. We did bake all parts except DIPs because they hadn't been properly treated as Moisture Sensitive.
- Q) What standards were rework personnel trained to?  
A) They were trained to internal Boeing specifications with acceptance document being the Boeing equivalent of IPC-610.
- Q) Where there any controls on solder tips?  
A) Yes, we controlled the tips very closely. We increased the temperature and although we ordered no-Pb tips, we found that the normal Pb bearing tips worked better.
- Q) Did you see any tin whiskers on assembly?  
A) None were visible.
- Q) Did you notice any difference in touchup?  
A) No, touchup rates were good and appeared about like our normal SnPb standard.
- Q) Were the lifted pads on low  $T_g$  boards or everywhere?  
A) They were mostly on the low  $T_g$  boards (rework boards). Most of the pad lifting occurred on boards that Engineering touched. Pads were lifted on 6 assemblies.
- Q) Do you think the production line slow down will impact production?  
A) We compensated by slowing down the line by 1 inch per minute which we think will have a negligible impact in production.



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### 3. Testing Review and Status

#### a. Thermal Cycling

Mr. Dave Hillman, Rockwell Collins, briefed the Thermal Cycling Testing (-55°C to +125°C) effort being accomplished by Rockwell Collins, Inc. Mr. Hillman began his briefing by explaining the importance of performing thermal cycle testing.

Summarizing, properly wetted solder joints do not fail in vibration due to solder joint characteristics – they fail due to improper vibration design. This is an avoidable issue (design dependence). Mr. Hillman went on to explain that the solder joint stress induced by thermal excursions is due to Coefficient of Thermal Expansion (CTE) mismatch. This is an unavoidable issue (environment dependence).

#### Parameter & Setup Description

- Rockwell Collins Testing = -55°C to +125°C Range
- +125°C Dwell = 30 minutes
- -55°C Dwell = 10 minutes
- Thermal excursion ramp rates = 5°C-10°C/minute
- Temperature PWB-to-PWB tolerances = +/-3°C
- In Accordance with IPC-9701 Guidelines
- Constant Electrical Monitoring
- Electrical interruption > 0.2µsec
- Continuity interruption >300 ohms
- Data recorded every 30 seconds

Due to design oversight, the CSP and Hybrid components were removed from the current test vehicles.

- CSP: The wrong component was shipped. The component measures .8mm from the center of each ball to the center of the next ball while the board placement measures .7mm
- Hybrid: The hybrid component is designed to be put on a circuit board with a recessed area for the hybrid, which allows the leads to meet the circuit board pads. The assembled circuit boards being used on the lead-free solder project are not recessed for the hybrids



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There were a few faulty components identified. These faulty components represent only a very small percentage of the total. All issues concerning the faulty components were resolved through mitigation. Following is a list of the faulty components and the location of each one.

Component	Part #	PWB #	Who Durnit?
TQFP 208	U3	193	Rework/Supplier
TQFP 208	U3	195	Rework/Supplier
BGA 225	U4	195	Manufacturing
TQFP 208	U3	192	Rework/Supplier
TSOP 50	U26	163	Supplier
TQFP 208	U3	191	Rework/Supplier
TQFP 208	U3	194	Rework/Supplier
BGA 225	U18	167	Manufacturing
TQFP 208	U34	59	Supplier
PDIP	U51	86	Supplier
PDIP	U8	85	Supplier
TSOP 50	U12	58	Rework/Supplier
PDIP	U23	56	Rework/Supplier
PDIP	U30	124	Supplier
TQFP 208	U34	16	Supplier
PDIP	U8	57	Supplier
PDIP	U8	57	Supplier
TQFP 208	U3	195	Rework/Supplier
PLCC	U27	192	"Ouch" Gremlins

Totals	
TQFP 208	8
PDIP	6
TSOP 50	2
BGA 225	2
PLCC	1



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Mr. Hillman identified 7 specific areas that will be evaluated during the test. They are:

- Surface Mount Versus Plated Thru Hole Technology
- Plastic LCC Versus Ceramic LCC
- PBGA Performance Versus QFP Performance
- TSOP Nonperformance (Alloy 42 lead material)
- Lead Contamination -Solder Joint Impact
- PWB Tg 170°C Versus PWB Tg 135°C (New Production Versus Legacy Production)
- Impact of Rework (PBGA, TSOP, QFP, PDIP)

## **Question and Answer**

Q) Do you have the history of all these assemblies?

A) Yes, Lety has travelers so we have data for everything. As things start to fail, we can go back and see what happened.

Q) How many cycles will you run?

A) We're going for about 3000 but there are decision points at 2000. They need n60 – don't stop until 60 % have fallen out. They are at about 250 cycles right now.

Q) Will you be taking photos periodically to see how the joint looks as it ages?

A) No, they will continue to get ugly but we won't take photos until failure analysis. Bright and shiny is no a measure of quality and no-Pb will push us past it.

Q) Will cycling age the microstructure?

A) Yes, but that happens on the bench today.

Q) Are you using an Ana-tech?

A) No, our home grown system is better because it's cheaper and is much more capable.

Q) What was the mention of Plan A and Plan B?

A) We had some drawing review problems so not all the parts fit the first boards. We've designed another board to put down CSPs and hybrids so the Plan B board matches data sets for the Plan A boards.

Q) What was the board make up?

A) 6 layers.

Q) What type Failure Analysis will you use?

A) I have quite a few co-op students and they will do lots of cross sectioning. They will use SEM and cross section and will analyze them exhaustively.



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## **b. Thermal Cycling, Vibration, Thermal Shock**

Dr. Tom Woodrow, Boeing Phantom Works, updated the group on the various tests being accomplished by Boeing.

### THERMAL CYCLING:

This testing consists of cycling the test vehicles between -20°C and +80°C with a dwell time of 10 minutes at the cold temperature limit and 30 minutes at the hot temperature limit. This test will be performed in accordance with IPC-SM-785. The longer dwell time will be used to provide a better chance of solder creep. Testing was scheduled to begin September 25, 2004 and is expected to be completed in spring of 2006 if testing is run to completion. The test vehicles will be tested to failure. This is necessary for those wanting to use the data for modeling purposes.

### THERMAL SHOCK:

This test is performed in accordance with MIL-STD-810F, Method 503.4, Procedure I. The test vehicles will be cycled from -55°C to +125°C for 1000 cycles with 15 minutes of dwell time. The testing is divided into four batches.

- The first batch is complete and contained 2-SnPb boards, 3-SAC boards, and 3-SACB boards.
- The second batch consists of: 3-SnPb boards, 2-SAC boards, 2-SACB boards, and chip resistors on break off coupons. The second batch was scheduled to be complete September 24, 2004.
- The third and fourth batches should be completed by the end of 2004.

### VIBRATION:

A “pathfinder” board was used: to verify the fixture, wiring, and that there were no problems with electronic noise, a modal analysis was done using a laser vibrometer to map mode shapes and identify resonances, a strain gauge was mounted to the board so CALCE would have strain data for validation of their models. All manufactured and rework test vehicles have been tested. The data needs to be reduced and put into a usable format.

## **Question & Answer**

Q) Will you do statistical analysis on the data?

A) Maybe, CALCE has expressed interest in capturing the data we gather which will be provided to them for their modeling work. We have not been funded to accomplish statistical analysis. That will take a lot a time and will have to be accomplished by someone with a lot of mathematical skill.



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## **c. Salt Atmosphere, Mechanical Shock, Humidity, and Lead Residue Testing**

Mr. Lee Whiteman, ACI, briefed updated the group on the various tests being accomplished by ACI and subcontractor BAE Systems.

### SALT ATMOSPHERE TEST:

The Salt Atmosphere Testing was completed September, 2004. The test is based on ASTM B117 test method for 48 hours. The following boards were tested:

- SnPb Boards: Serial Numbers 35, 36, 37
- SnAgCu Boards: Serial Numbers 104, 105, 106
- SnAgCuBi Boards: Serial Numbers 143, 144, 145

All boards passed the Salt Atmosphere Testing.

- Continuity was checked on specific packages.
- Some failures were found prior to testing
- No failures were found after testing.
- The next step is to generate the report.

### TEMPERATURE HUMIDITY TESTING:

The Temperature Humidity testing is currently being scheduled. This test will be performed in accordance with MIL-STD 810F, test method 507.4. The following boards will be tested:

- SnPb Boards, Serial Numbers 38, 39, 40
- SnAgCu Boards, Serial Numbers 107, 108, 109
- SnAgCuBi Boards, Serial Numbers 146, 147, 148

Continuity will also be check prior to the Temperature Humidity testing.

### MECHANICAL SHOCK TEST

The Mechanical Shock test procedures have been approved. The tooling is being designed and manufactured. The Anatech System is being ordered and will be delivered within 2-3 weeks. All boards necessary to perform the tests have been received. Two SnPb boards, serial numbers 25 and 61, have been identified as pathfinder boards. These boards will be used to set-up the test fixtures at BAE Systems. Currently, testing of the boards is being scheduled with BAE Systems. Once a schedule is determined, the group will be informed. The Mechanical Shock Test will be performed in two separate tests.



## Mechanical Shock Test Set 1

This test will be performed in accordance with MIL-STD 810F, Method 516.5, Procedure 1. The following boards will be used for the test:

- SnPb Boards, Serial Numbers 26, 27, 62, 63
- SnAgCu Boards, Serial Numbers 95, 96, 151, 168
- SnAgCuBi Boards, Serial Numbers 134, 135, 196, 197

## Mechanical Shock Test Set 2

This test will be performed in accordance with a modified version of MIL-STD 810F, Method 516.5, Procedure 1. These boards will be tested to failure. The following boards will be used for the test:

- SnPb Boards, Serial Numbers 28, 29, 64, 65
- SnAgCu Boards, Serial Numbers 97, 98, 170, 171
- SnAgCuBi Boards, Serial Numbers 136, 137, 198, 199

## Lead Residue Test

The metallurgy analysis will require microsectioning to determine what the intermetallics are in the lead-free solder joints. Before the analysis can be performed further discussion will be necessary. The analysis will also require an increase in funding.

## **Question and Answer**

Q) Will you do characterization on shock? If so, what G level will be used?

A) Lee. Yes.

A) Dr. Reza Ghaffarian commented that G level will be increased in accordance with the test protocol.

Q) What was duration of Salt fog?

A) It was 3 days.

Q) Were these the same boards that Tom Woodrow tested?

A) Lee. Yes.

Q) Why wouldn't you support this set of boards in same manner as Dr. Woodrow did for the vibration test? Went on to discuss that he wanted to see all data correlated by having similar testing methods of support, etc. There was lots of discussion around the room of why tool was designed to hold 4 boards like they did. No conclusion was drawn as to whether "different" was good or bad or if to change path we're headed down.



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## d. Combined Environments Test

Mr. Jeff Bradford of Raytheon briefed the status of the Combined Environments Test (CET). He began by explaining that the CET is based on a modified Highly Accelerated Life Test (HALT). Its goal is to quickly break the products and learn from the failure modes. The test is designed to identify design and process problems in a shorter time frame while using a smaller number of test samples. The test samples are stressed beyond specification and typical use environments in the following arrears:

- Thermal extremes
- Extreme thermal rates of change
- Vibration
- Combination of thermal and vibration

Perceived problems with the CET are that it is not a true life test. There is no modeling. This specific test is designed to compare lead-free solder alloy performance against the standard tin lead eutectic solder.

### Combined Environments Parameters

#### Thermal

- -55C to 125C temperature cycle
- 20C per minute ramp
- 15 minute soak

#### Vibration

- During last 10 minutes of soak period
- 10 Grms initial
- Increase 5 Grms after 100 cycles
- 20 Grms to significant failures

#### Test Vehicles

- 15 Manufacturing
- 15 Repair



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## Combined Environments Testing Steps

### Test Setup (Sep-Oct 04)

- Fabricate fixture
- Pretest inspection
- Solder cables to test vehicles

### Execute Test (Oct-Dec 04)

- Test 2 lots of 15 test vehicles at a time
- Utilize Anatech event detectors
- Post test inspection

### Failure Analysis (1Q05)

- Microsection analysis

### Data Analysis (1Q05)

### Publish Test Report (1Q05)

## CET Status

### Funding

- Received from BAE Systems
- Internal Raytheon funding committed
- Waiting for Air Force funding
- Working on fixturing and soldering cables to test vehicles  
Start Testing in October

## **Question and Answer**

Q) We've got two different vibration and shock tests both being done in different ways.  
Are we looking to compare data later.

A) Dr. Tom Woodrow answered. The intent is just to fail the part and as long as all in a given test fail and are apples to apples then we'll end up with something useful.

Strong recommendation from Mike Osterman that we characterize the shake testing so that data is consistent.



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## 4. Open discussion

Mr. Kessel opened the floor to a general discussion.

### a. **Lead-Free Transition**

- We need to be looking at what happens with no-Pb parts running through our Pb lines. CSPs are going to change to no-Pb and we'll soon be running both metallurgies even if we haven't made a choice. Integration is coming on us fast whether we're ready or not.
- Q) The European Union mandate exempts aerospace but that's subject to change at any moment. Is there a plan to try to justify continued exclusion?
- A) Mr. Denny Jarvi stated that if these solders fail then he will be going back to government agencies he represents and telling them that they will have to redevelop the Pb vendor base. Defense Logistics Agency buys parts and this group will or may drive action to fix the supplier base or to start re-qualification of specific metallurgies.
- DOD is not currently running to any consistent procurement plan. Army, Navy, AF, Coast Guard are all doing their own thing. Hoping to get some sort of final recommendation and everyone in this meeting agreed that we'll not be able to make a final statement at the end of this development cycle. Those programs participating had input and were asked 'if the alternatives passed test would they accept the conclusion and implement' but the changes in procurement policies are now driving things in a different direction. There might be some programs or services that may accept the result depending upon the use of their products. Vendors like Boeing or Raytheon could decide on a company by company basis and the Air Force would end up in no-Pb by default.
- There is concern that the component manufacturers aren't going to want to keep small lines open just to continue providing Pb parts. Even if we provide this data to program offices, we'll still have to qualify the hardware

### b. **Tin Whiskers. Action Item:**

Set up a small group telecon and use the extra parts for reflow processes in order to check for tin whiskers.

### c. **Question and Answer**

Q) Why immersion silver board finish?

A) The team used the top three likely candidate lead-free solders and the likely board finishes that it looked like industry was planning to use when the PAR and the JTP were created.

Q) Why not mount thermal shock tests to compare the data?

A) The aim of the test is to find failures, not to compare the data.



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Q) Is there any European Union work similar to this project?

A) Two we are aware of: HDPUG and solder tech. Both of these will provide their reports to their members only.

Comment: Intermetallics are being looked at by ACI and Sandia Labs and Rockwell Collins will characterize the boards. These data will be in the Joint Test Report (JTR).

## 5. Pb Free BGA Solder ball Issues

Mr. Dave Hillman presented the results of his research into the lead-free BGA solder ball issue. He asked the question, “What happens when you reflow a BGA component that contains SAC solder alloy solder balls in a Sn63 solder alloy reflow process temperature profile using Sn63 alloy solder paste?” The answer, “a very messed up solder joint.” Mr. Hillman presented several photographs of the BGA SAC Balls with the metallurgy of the Ball Grid Array. In general the joint was of poor quality with several voids and a crack across the bottom pad. SAC ball did not totally reflow and the solder broke from HASL board material. What happens is that we get SAC on top of the ball and various intermetallics below. Significant edge irregularities on the ball look like they could have caused the crinkled surfaces that Lety got on her BGA photos.

### Question and Answer

Q) Are parts being screened before we use them?

A) Yes, they are screened but you can't screen every vendor's part. Lots of questions and discussion around the room – most are put off until the shock testing is done.

## 6. Path to LFS Implementation

Mr. Brian Greene, ITB, Inc., supporting NASA AP2, presented his view of the future of the lead-free project for group comments.

Mr. Greene's initial project ideas are, a flow diagram of the project ideas appears in attachment 2:

FY 2004

- JCAA/JG-PP lead-free solder project additional component testing, CSP and Hybrid

FY 2005

- Field testing of circuit card with lead-free solder
- Tin whisker mitigation
- Reliability testing on un-filled plated-through-hole with a high aspect ratio

FY 2008

- Field testing of line replaceable units (LRU) with lead-free solder
- Dem/val non-destructive evaluation of solder joint and circuit card integrity



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Following the initial outlining of the project ideas, Mr. Greene went into detail as to the estimated milestones that would be completed for each project idea. Mr. Greene included approximations for the amount of funding that would be required to complete each project idea.

## Questions and Answer

Q) If we're going to have to keep up with the component manufacturers, what do we do while we wait for adequate data to approve the metallurgy?

A) Good observation and on the government side this will have to be addressed. The Government may have to drive it. Asked for opinions – using the 2<sup>nd</sup> slide (roadmap), Lee from ACI says we may have a shot if we could compress the roadmap to 2009.

Q) Will solder suppliers continue to supply materials?

A) Brian Bauer from Heraeus stated that the automotive safety guys cannot change now for the same reason – no data to support changing life critical applications such as air bag controllers. And, automotive is a much bigger volume of the market – he doesn't see them discontinuing Pb bearing solder manufacture for many years to come.

A) Dave Hillman stated that lots of what happens here in Aerospace depends upon the outcome of the testing. Comment around the room that it also depends upon whether the surface materials we've modeled are what industry ends up with. We really need to find some company and product that's willing to "guinea pig" a product with these materials and gather data.

Q) Does anyone know of someone that was actually flight testing no-Pb materials?

A) No response from anyone in the room.

Q) What is the definition of Pb free? What does that mean?

A) ROHS says all parts in assembly being less than 0.1% Pb (weight %). Collins took one avionics radio and broke it down to base materials. It took 4 weeks to assess a 6 board radio. He says you can get there on chrome and cadmium but you cannot get there if you have Pb in your boards and parts. ACI says even if you decide to pulverize, it took them about the same amount of time and even acid extraction does not do it well.

Comment: How will you as vendors act if your customer demands that you change? Look how slow it was for all of us to jump into SMT. Military won't change until they absolutely have to and there will have to be reams of data to support.

Response: Lee Whiteman of ACI says many forces are working in opposite directions = parts, LRU packagers, program management, scientists.

Response: Someone made the comment that there seems to be a perception that we can go this way or that, but it all assumes that we can control the part manufacturers. We have no control AND, we have no plan to identify our own PWAs so that depot guys will be able to identify that we built them with no-Pb. This lead to a



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long winded discussion of troops having to go “green” and buying no-Pb solders because they think it’s the right thing to do.

Response: Dave Hillman stated that application engineers are working with suppliers and all their drawings are calling out alloys that are acceptable.

Response: Jeff Kennedy stated that Samsung and others are receiving components with SAC balls and are sending parts out to re-ball (two heat cycles – one to remove ball and one to put new ball on). He also pointed out that nothing is called out in roadmap to detail the RF portion of the business. Parts guys in the group say everyone is focused on 2006.

Response: Bill Dieffenbacher of BAE Systems pointed out that no one is putting together a plan to discuss the issue of “last time buy” parts. We really could use an expanded roadmap to include all the aspects (such as marking) that we as a high reliability group must have. AIA is writing documents on how to deal with the new solders but not legislating configuration issues. Army says we as a group must be working to dictate what is needed from the parts suppliers.

Response: Jeff Kennedy Stated that they are changing part drawings to indicate finish, moisture, ESDS, etc. Applies to last time buys as well and they will be a real problem.

Comment: On assemblies that have Pb parts, what is the problem – military keeps on going the rest are in trouble. BUT, what if we die on this study? Then we’ll be in roughly the same position we were in with the cleaning change a decade ago.

Response: We didn’t change form, fit or function and this does. All seem to agree we’ll have data by XMAS that is useful.

Response: It’s not all as bleak as we’re talking since there are some vendors who understand configuration and why it’s important to us. Many of the vendors are shipping matte Sn now which doesn’t have the problems of SAC.

Response: TI is starting to identify parts by Pb or no-Pb and green. Also don’t assume that just because it’s no-Pb and green that is will just “work” in production. The moisture rating is really important and must be processed for. TI Military is continuing to offer SnPb on all ceramic parts. All of their plastic parts are being shipped with NiPdAu.

## Clarification Statement

TI will NOT put pure Tin on any (EP) Enhanced Plastic leadframe based components. TI EP products will have either NiPdAu or SnPb finish. The majority of TI commercial leadframe based products utilize NiPdAu finish. The remainder could have Sn or SnPb finish. TI’s goal is to be 100% Lead-Free on all plastic leadframe based components and will use NiPdAu wherever possible. All of TI’s military ceramic leadframe based components are hot dipped with SnPb.



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## 7. Future Meetings

- Teleconference: 14 Dec 04, 1100 hours Eastern, via Boeing provided WebEx
- Face-to-face: 22-25 Feb 04, 1700-1900 hours, at the IPC/APEX conference, Anaheim, CA
- TBD April Conference



## Attachment 1: Action Item Status

### Open Action Items

#### LFS.04.10.01

*Date Due:* 14 Dec 04

*Responsibility:* Kurt Kessel

*Required Action:* Research a LFS conference for the April timeframe

*Comments:*

#### LFS.04.10.02

*Date Due:* November 2004

*Responsibility:* Kurt Kessel

*Required Action:* Setup small group telecom to discuss using extra parts in reflow process to check tin whiskers

*Comments:*

#### LFS.04.10.03

*Date Due:* November 2004

*Responsibility:* Brian Greene

*Requested action:* Start the development of a logistics road map and decision tree

*Comments:*



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