Solar B EIS Structure

Meeting at University of Alabama, Huntsville

12 May 2000

Document reference MSSL/SLB-EIS/MN002

<u>Present</u>

MSSL:

Len Culhane	JLC - Chair
Wilf Oliver	WTO
Alan Smith	AS - Minutes

University of Birmingham:

Chris Castelli	CC
George Simnett	GS

NRL:

George Doschek	GD
Charlie Brown	CB
Steve Myers	SM

ISAS:

Saku Tsuneta	ST
Hirohisa Hara	HH

NASA:

Danny Johnston	DJ
Larry Hill	LH
Others	US

<u>Attachments</u>

#1 – Agenda
#2 – Objectives of the meeting
#3 – NRL concerns and comments
#4 – MSSL concerns
#5 – Concerns from MELCO

#6 – Concerns from ST

Minutes

1. Objectives of the Meeting

JLC presented the objective of the meeting

See attachment #1

2. Progress at BU since the issue of the Structure Development Plan

GS and CC made a joint presentation. GS apologised that no formal presentation had been planned and so gave a verbal account of recent progress.

BU had fabricated 4 composite panels and 2 of these had been brought to the meeting for inspection, (these measured 1' x 4' x ½", the cosmetic quality was fairly good and they were made of commercial grade material). No tests on the panels had yet been performed.

GS indicated that issues of panel bonding and inserts were being addressed. The approach to panel bonding had been changed. The earlier version had been abandon because of the problem of shear strength. The revised approach used bolted inserts.

Teleconferences between BU, MSSL and NRL were being held on a regular basis.

LH asked what stability requirements were being used.

It was noted that NRL had designed the optics assuming <1 ppm CTE and ~100 ppm/% CME.

CC stated that no formal requirements document had been provided by MSSL however he understood that this was being addressed at the present.

ST suggested that the use of a higher thermal conductivity fibre might be used

It was claimed that the SOT is getting a thermal conductivity of 20 – 30% of Al.

US asked how quality was being assured for the composite structure

CC stated that they had no heritage in composite structure fabrication and were on a fast learning curve. They had been receiving expert advice.

US made the point that composites for aircraft and space applications were quite different. He also stated that Al honeycomb structures might not be appropriate for space use (the base line for BU used Al and the samples brought to the meeting contained Al).

GS stated that although Al was being used at the moment this was more a reflection of their position on the learning curve. CFRP may be appropriate later. However he felt that they were 'well up the learning curve' with regard to fabrication.

GS stated that he hoped that a decision could be made at the meeting regarding the choice of materials

WTO felt that this was premature and a proper trade-off should be performed.

US asked whether the presence of learning curve impacted on the schedule

CC stated that a delivery of the MTM/TTM early 2001 was still planned.

GS stated that he appreciated that Quality Assurance was a serious issue.

US pointed out that vendor's data should not be trusted.

AS stated that it would be necessary to demonstrate reproducibility in the fabrication process.

CC stated that test samples would be taken (coupons etc.) and recognised that materials properties were very sensitive to the fabrication process.

US stated that they used "A" base reliability numbers to obtain a measure of the spread of material properties.

US stated that it was important to minimise the number of joints and holes. He suggested that the minimum number of parts should be fabricated.

GS stated that while this might be good in principle, practicalities had to be considered.

US stated that one uniform structure for the optical bench was very highly desirable (the BU baseline design has two joined parts for the optical bench).

GS stated that this would bring up other issues associated with using a contractor.

3. Specific Concerns

3.1 NRL – CB

CB showed again slides from the PDR (attachment 3) which had direct impact on the structure's requirements.

A report on the meeting with Swales was given. A general description of the EIS instrument had been provided to Swales and they were tasked to consider the choice of materials, and to review, comment and question the current design. These results should be available in time for the UK PDR.

ST stated that the thermal requirements should be considered in any materials trade-off study.

WTO stated that all requirements should be in place prior to a final materials trade-off.

CB stated that very high thermal conductivity composites tended to be of relatively low strength.

US stated that some strong, high thermal conductivity composites did exist.
CB stated that the initial response from Swales included:

- A honeycomb box structure could be very stiff
- Long corner joints were likely to be difficult
- The elimination of joints was highly desirable

GS stated that Saad (BU mechanical engineer) had been in contact with Swales.

- Inserts of Ti into the honeycomb would likely effect the panel performance.
- Hexcel is a good choice of material
- A launch lock was undesirable.
- Data needed from BU included

  Engineering information about joints
  Coupled load analysis
  Information about the legs

- Tapes on the outside of the structure might not be a serious problem

WTO stated that he understood that outgassing from such tapes could reduce strength.

3.2 MSSL concerns – WTO

WTO presented a comparison between aluminium and composite structures.

WTO also stated that a strategy and process for repair of panels was necessary. Damage was likely to occur after delivery. Edges should always be protected and such protection should be considered as red-tag items.

The emphasis of the presentation was the need for a comprehensive test programme.

3.3 NASA concerns – DJ

DJ mentioned his experiences with previous space instruments including HST. He made the following points:

- The subject is complex
- A long learning curve is involved when building composite based flight optical systems
- Such an endeavour is possible but is prone to many pitfalls.
- For HST water absorption was enormous. The 5 metre truss was still moving after 10 years
- One monolithic optical bench was best
- Joint design is difficult. On a bonded joint pre-cleaning is particularly important and the process control is essential
- Hexcel 954 was a good system but a material trade-off is essential
- The inside surface of the box must be sealed and should be as clean as possible.
- A clean work area should be used.
- Honeycomb is very difficult to be kept clean or to subsequently clean. A very clean environment was needed. No silicone should be allowed in the vicinity. Contamination from FPP should be considered.
- Aluminium in contact with graphite should not be used at the joint.
- A box shape was probably OK but he would prefer a cylinder.
- The structure would have to be baked out at an elevated temperature.
- Internal joints would have to be sealed against hydrocarbon contamination.
- NDE on the structure is difficult
- Damage after fabrication may be hard to spot. It may be necessary to coat the surface with a material that will show up such damage.
- Repairs are generally not too difficult
- Venting honeycomb is a problem

LH – while global low density FEM was useful, it was important to model the joints.

US – on AXAF a great deal of sub-modelling was performed.

CC stated that he appreciated the comments and advice. He also stated that BU could not build the structure alone from scratch. They needed to learn from the experiences of others. He was concerned that a materials trade-off would take to long and would like to find a baseline – 954?

SM pressed the issue regarding fabrication of the optical bench from a single piece.

CC stated that BU could not fabricate a single piece in their autoclave. The possibility of putting this out to contract was under consideration but this introduced other problems.

GS stated that he was well aware of the problems associated with contractor surveillance.

GS stated that the requirement document was now urgently required. MSSL agreed and would provide one within two weeks (see action list).

US stated that acoustic loading was uncertain and likely to be >30g. Since honeycomb was highly susceptible to acoustics, a instrument level acoustic test might be required.. The joints are likely to be highly stressed. Generally the loads are very high on this mission.

3.4 – ISAS/MELCO concerns - ST

ST presented the concerns of MELCO (attachment 6) and himself (attachment 5).

4. General Discussion

4.1 Design issues

4.1.1 Structure Performance Requirements

The structure performance requirements were discussed and the following should be included in the document to be produced by MSSL:

- Stability
- Cleanliness and contamination
- Mass
- Stiffness
- Component mountings
- Tolerances
- Temperature range
- Loads and margins
- Power requirements (re thermal control)
- Deliverables

The responsibility to select a material was with BU.

Action #1 – NRL to elaborate optics-driven structure requirements by 19 May
Action #2 - MSSL to issue a requirements document by 26 May
Action #3 – ISAS to provide details of high thermal conduction material by 15 May
Action #4 – BU to make material selection by 2 June.

4.1.2 Design of Joints

BU explained their jointing approach, which involve the use of bolted invar inserts.

US stated that NDT was always a problem.

US stated that metallic fasteners should always be added to lap joints and butt joints

DJ stated that trapped volumes should be avoided since they cause virtual leaks.

DJ was concerned about the shear strength of such joints.

ST stated that the avoidance of joints with single piece structures was preferable, even if more weight was involved.

AS stated that analysis of the BU approach must be performed in order to confirm its suitability – the BU approach should not be rejected until such an analysis was performed.

The issue of the single optical bench was again raised.

AS stated that it was the overwhelming view that the optical bench should be built as a single unit. He pointed to the remark made earlier by BU in which it invited advice and assistance.

GS again stated that the move to a single structure was more complex.

AS stated that if resource implications were the stumbling block this should be addressed in the UK with MSSL support to a bid against contingency.

DJ felt that the site of fabrication should not drive the structure design.

US stated that an outside contractor should be engaged and not sought only when there was a problem.

Action #5 – BU to investigate industrial procurement of optical bench structures by 9 June.

The meeting then discussed a number of changes to the Birmingham structure design including options such as:

- I beam
- I beam constructed from two C beams back to back
- "Ironing boards" separated by bulkheads
- Chamfered corners
- Cylindrical or square tubes fabricated as a single piece
- Closed cell foam as an alternative to honeycomb

After a prolonged discussion the following actions were taken:

Action #6 – BU to revise and reissue a structure design concept which demonstrates compliance to requirements and includes a load analysis of the joints and a load analysis of the spacecraft interface.

Action #7 – NRL (through Swales) to review BU design concept by June 16.

4.1.3 Venting of honeycomb core

GS stated that this would be achieved through the use of perforated honeycomb.

CB questioned whether it would be possible to perforate the outer skin.

This would involve the drilling of many holes and was not very desirable.

DJ suggested that as large a honeycomb core as possible should be used.

DJ stated that it all came down to the flow rates of contaminants through the holes to space.

Action #8 – BU to contact DJ regarding appropriate materials by 19 May.

4.1.4 Lay-up design and sensitivity to processing

BU stated that the angles between lay-ups was determined by the required CTE and that they could be made to an accuracy of <1 degree. The order of the lay-up is given in the Development Plan.

The question regarding what appropriate tests should be performed on the panel was raised. The following tests were suggested by the US.

- 2D interferometry
- IR tomography
- Ultrasound
- Thermography
- Inspect for delamination
- Inspect for correct curing
- Compression strength
- Shear strength

Flatness should not be a problem.

DJ noted that invar did not bond well to carbon.

4.1.5. Subsystem Interfaces

CB stated that the drawing SRA160B shows the location of the interfaces to the component subsystems. The mechanical footprints of the components are known.

4.1.6 Interface with spacecraft

The baseline design showed P2 and P3 to be fixed together via an insert. It was not thought that this was necessary.

Action #9 – BU to investigate separate inserts for P2 and P3 mountings by 9 June

DJ stated that invar does not bond well to graphite (and so Ti inserts would be more appropriate). He also stated that NASA did not use Al honeycomb because of galvanic corrosion and CTE mismatch.

WTO mentioned that the use of Al honeycomb had been standard practice within ESA for many years.

Solar-B SOT used graphite honeycomb although this was more expensive than Al.

HH stated that the vibration specification has been provided to BU.
HH stated that the Leg FE model has been provided to BU.

Action #10 – BU to calculate transfer function and determine loads at component mountings by 16 June.

ST stated that the thermal design was an important and related activity.

GS stated that a thermal design document had been released in April 00. HH had not yet received the document. It was noted that the document was most related to the position of the radiator.

Action #11 - HH to comment on thermal design document by 2 June

Tapes on the inside of the structure to control thermal balance would have to be replaced. Other options were available.

The use of a high thermal conductivity material would have an impact on the thermal design. At present the design indicated that many local heaters would be needed.

It was noted that Chris Goodall has taken over from Ian Butler in the thermal design area.

Action #12 – BU to reissue thermal design document by 16 June

4.2 Testing and Fabrication Issues

4.2.1 Contamination due to honeycomb core

This has been discussed above. It was noted that the Closed Cell foam has a low conductivity across the panel.

DJ noted that wiring within the structure need to be specifically addressed and was a contamination issue.

AS noted that the internal wiring was an MSSL responsibility and were aware of the issues involved. SoHO CDS had raised similar problems.

4.2.2 Structural panels – testing

GS stated that a test plan was in preparation at BU. The breadboard will be vibrated.

US asked how the materials characteristics will be determined to underpin the design. It was noted that such numbers were process related. Statistical data was needed and a very large sigma should be expected for such numbers.

CC stated that their approach was to use huge design margins. BU had not the time in the schedule to determine the number themselves.

US reiterated the importance of numbers based on experience.

WTO suggested that the best numbers available should be used and then a large margin applied.

Action #13 – BU (in consultation with WTO) to agree a viable approach to the determination of materials properties by 9 June.

4.2.3. Testing to determine CTE

GS stated that some tests had been performed and others were planned.

It was noted that the use of Al does not affect the CTE in the plane of the panel (dominated by the skins).

Generally the optics would require a value of <1 ppm.

CC stated that strain gauges were used to measure CTE

US noted that other measurement approaches were possible. TMA and the use of LVDT gauge.

4.2.4. Verification test matrix

WTO noted that a measurement of the structure distortion was needed.

Action #14 – BU to suggest a method of measuring distortion of the structure by 16 June.

LH noted that from the verification matrix in the development plan few tests occurred prior to the MTM and that this was inconsistent with the level of risk.

GS noted that this came about through the nature of the breadboard which should not be considered as an early prototype.

GS agreed that in light of developments it would be necessary to reissue the development plan

Action #15 – BU to reissue Structure Development Plan including a revised verification matrix and schedule by 16 June.

4.3 MTM and Breadboard Development Plan

ST asked whether BU could work with an external contractor to perform the fabrication. He noted that it had taken Matra Marconi 4 years to become competent.

GS stated that this was possible in principle but funds are not yet in place

JLC noted that such plans were under consideration and would have to be justified in terms of technical risk.

CC stated that a change to an external contractor would not destroy BU's interest to develop the composite technology in house. Indeed it could be seen as a stepping stone to this.

CC stated that they would require considerable support including money and resources.

CC felt he needed to reassure the group that BU were well aware of their lack of experience in this area and stated that "why on earth is a group with no experience in composites building this structure".

ST asked whether it was too late to go to an Aluminium structure.

GS noted that this would have a mass impact and that the schedule was very late.

JLC felt that power was likely to be a major issue.

ST requested that a performance tradeoff should be made between the two options

Action #16 – MSSL to perform a composite vs Al performance tradeoff by 16 June

LH felt that the leg attachments points could be an issue in the context of thermal control and that an analysis would be needed.

CB felt that the legs could be thermally insulated without much difficulty

DJ felt that this was a solvable problem

The possible increase of mass through changing to Al was discussed and it was felt that a value of 10-15 kg would be involved.

Cleanliness would be much less of a problem with Al. Thermal conductivity would also be much better.

Action #17 – MSSL to send a baseline Al mass to ST by May 15.

Action #18 – MSSL/BU to determine list of risks to the structure development and their abatement by 16 June.

LH asked how well BU were keeping to schedule

CC admitted that they were behind (by 30%) but noted some recent, unforeseen difficulties that had resulted in some fabrication failures.

SM noted that such materials loss could be protected against financially by going out to contract for the fabrication.

5. PDR

It was agreed that a UK PDR should be held about 2 weeks after the Japan meeting which would now hopefully occur in the week of June 19. The dates of 6-7 July were proposed and will be confirmed.

Membership of the PDR board would include

NRL representatives
NASA representatives
External specialists (UK)
PPARC representative

It was noted that the Japan meeting and subsequent PDR were very important and that by then a viable way forward must be available.

The PDR would cover all the UK elements but the US elements will be considered reviewed. The outcome of the US PDR (EIS) will be made known to the UK team by LH.

6. Actions

The following is a list of the actions taken at the meeting. Some of these actions may be duplications of actions already in place within the project.

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Action #9 – BU to investigate separate inserts for P2 and P3 mountings by 9 June
Action #10 – BU to calculate transfer function and determine loads at component mountings by 16 June.
Action #11 - HH to comment on thermal design document by 2 June
Action #12 – BU to reissue thermal design document by 16 June
Action #13 – BU (in consultation with WTO) to agree a viable approach to the determination of materials properties by 9 June.
Action #14 – BU to suggest a method of measuring distortion of the structure by 16 June.
Action #15 – BU to reissue Structure Development Plan including a revised verification matrix and schedule by 16 June.
Action #16 – MSSL to perform a composite vs Al performance tradeoff by 16 June
Action #17 – MSSL to send a baseline Al mass to ST by May 15.
Action #18 – MSSL/BU to determine list of risks to the structure development and their abatement by 16 June.

7. A.O.B.

JLC thanked UAB and NASA for hosting the meeting.