

**NASA JSC
Payload Safety Review Panel
Alpha Magnetic Spectrometer-02
Delta Phase III Flight Safety Review**

**Minutes of Meeting
August 3, 2010**

1.0 INTRODUCTION

1.1 General: The Payload Safety Review Panel (PSRP), chaired by JSC/OE/M.R. Surber, and the Station Safety Review Panel (SRP) met on August 3, 2010, with representatives of the JSC/Engineering Directorate (Jacobs), the Payload Organization (PO), at the Regents Park III Conference Facility for an Alpha Magnetic Spectrometer (AMS)-02 Delta Phase III Flight Safety Review (FSR). JSC/NA2450/P. Mensingh, K. Chavez, and R. Rehm, the supporting Payload Safety Engineers (PSEs), introduced the meeting and attendees (see Attachment 1).

1.2 Background: The PSRP held the following previous AMS-02 meetings:

- Helium Venting Technical Interchange Meeting (TIM) on 04/20/00
- Phase 0/I FSR on 01/16/01
- Vacuum Jacket Leakage Special Topic Meeting on 10/11/01
- Gauss Limit Special Topic Meeting on 10/16/01
- TIM on 01/17/03
- Phase II FSR on 05/21-25/07
- Hazard Report (HR) TIM on 10/10/07
- Non-compliance Report (NCR) TIM on 12/10/08
- Burst Disk TIM on 08/13/09
- Phase III Joint PSRP/SRP FSR on 01/12-15/10
- Joint PSRP/SRP TIM on 03/23/10
- Status TIM on 06/22/10

1.3 Scope: This meeting focused on continuation of the Phase III FSR. The PSRP reviewed six (including two closed at the 3/23/10 TIM) previous action items (AIs) associated with this payload in this meeting.

1.4 Conclusion: No agreements and no AIs resulted from this meeting. The PSRP approved and signed ten HRs for Phase III, deleted two HRs prior to the review, and left six HRs remaining open pending Safety Verification Tracking Log (SVTL) closures, corrections, and updates. The PSRP closed all four previously-open AIs. The Phase III FSR remains open pending HR approvals and final verification closures. The PSRP concurred that the hardware is approved for shipment to KSC to begin ground processing for flight.

2.0 SIGNIFICANT SAFETY DISCUSSION

2.1 AMS-02 Update: The PO indicated that payload reintegration is complete, and the system is ready for beam testing. The PO received concurrence that no Operational Control Agreement Database items (OCADs) are required for Remote Manipulator System (RMS) operations. The PO developed a plan of action with the Systems Engineering Working Group (SEWG), the Boeing External Contamination Team, and the Vehicle Integrated Performance Evaluation Team (VIPER) on outgassing concerns.

JSC/ES4-Materials and Processes has given approval to the composite-overwrapped pressure vessels (COPVs).

The remaining non-inspection items being worked actively:

- Submittal of stress and fracture reports for new hardware should close remaining ES4 concerns.
- Compatibility review will be held with Shuttle on August 6, 2010, to close remaining Shuttle concerns.
- All Task Preparation Sheets (TPSs)/AMS-02 Task Sheets (ATSS) associated with the Conseil Européen pour la Recherche Nucléaire (CERN) work should be closed within the next couple of weeks.
- Final component-level acceptance data packages (ADPs) are expected within the next two weeks.
- The payload arrives at KSC on 08/26/10.

2.2 Summary of AMS-02 Significant Anomalies and Failures: The PO considers all anomalies closed and the PSRP concurred.

2.2.1 AMS-02-A31, Xenon Leakage Detected during Thermal Vacuum Testing: As previously reported, the PO identified the location of the Xenon leak and removed the leaking section of pipe from the system. The new pipe was welded in place, and a short-term leak test, using pressure decay, showed the system operations. In addition, a dye penetrant inspection/X-ray inspection was performed at CERN. The PO performed a long-term pressure decay test of the segment over four weeks. The PO observed pressure variations over this long term test that seem consistent with system temperature variations and anticipated valve leakage potential. The PO considers this anomaly closed.

2.2.2 AMS-02-A35, Tracker Power Distribution Box 0 Non-operation during Thermal Vacuum Testing: During thermal vacuum testing (TVT) Tracker Power Distribution Box (TPDB) 0 was non-operational. Upon inspection, the PO found a loose washer (which was not a part of the design) to have penetrated conformal coating and shorted out the power feed. Testing showed no other possible cause of this anomaly, and function returned with the removal of the washer. No other anomaly could be generated during diagnostic testing, and the unit passed thermal vacuum testing. The PO considers this anomaly closed.

2.2.3 AMS-02-A41, Power Distribution System Solder Irregularities: The PO knew of cracked solder joints found on metal-oxide-silicon field effect transistors (MOSFETs) used in the Biolab payload. The AMS-02 Power Distribution System (PDS) uses a similar design in multiple areas and initiated a collaborative investigation into the potential for safety or mission success concerns for AMS. The issue appears to be caused by thermal displacements of the MOSFETs during operation with the induced loads resisted entirely by a single solder joint. The PO found that 22 circuit boards could be inspected without removing the PDS from the radiator and rechecked a total of 978 solder connections. (Side A showed signs of cracking on 12 of 489 connections (2.5%), after 18 operational months. Side B showed signs of cracking on 7 of 489 connections (1.2%), after 7 operational months.) The cracking was limited to the ESEM3 boards, which uses single solder joint. The PB2 boards (with Chootherm padding) and the ESEM1 board (double solder joints) show no signs of cracking.

Project feels risk associated with design issue is acceptable for the following reasons:

- There is no evidence that solder cracking has ever severed the electrical connection.
- The new thermal/structural analysis explains the cracking issue and confirms that both double-soldered joints and a flexible thermal interface correct the problem.

- The solder failure would cause the MOSFET to fail open, which will not propagate beyond the PDS.
- The PDS has already undergone thermal-vacuum and random vibration testing at the box level, which cannot be redone.

The PO emphasized that there is no loss of electrical connections even with the cracks, but even if there were a loss of electrical connection, it is not a safety issue. In addition, there is no increase in electromagnetic interference susceptibility due to this. The failure mode is to open, not to short. The PO indicated they have no plans to remove/replace the affected boards. EP5 indicated this plan is acceptable for safety purposes. EP5 further indicated that if the affected boards are removed/replaced, functional and acceptance testing needs to be conducted. The PO agreed.

The materials certification and fracture control assessments are in-work and in the final stages of approval. The PSRP determined that there is no need for a HR to address this issue.

2.2.4 AMS-02-A42, High Voltage Connectors: During deintegration and reintegration of high voltage cables to support the exchange of the Cryomagnet System with the Permanent Magnet System, tiny particulates of gold (flecks) were detected in the interior of the connectors. (The anomaly was the presence of the debris, not an operation anomaly). Review of manufacturer's data indicated that this was common, and the connectors should be cleaned with each mating/demating cycle. The PO did not perform this operation with each mating cycle. Testing the manufacturer's recommended method of cleaning the connector, the PO found the amount of debris was found to be reduced but still present. The PO tested an improved cleaning method by adding the use of a small brush to gently clean the connectors and found it to be very effective in removing the debris. Since then, no manifestation of high voltage arc/discharge or grounding has been detected. During operations and testing, no high voltage anomaly has been observed or detected. This anomaly is based on inspection only. Based on the lack of manifestation of loss of high voltage function or discharge, the PO left the high voltage connections that were not reopened during magnet conversion closed and staked in place. All open and unstaked connections would be cleaned using the modified cleaning process. There is no safety impact. The worst case effect of contamination would be loss of mission science data.

The PO clarified that there is not enough power for coronal effect either, and none of the connectors are extra-vehicular activity (EVA) -accessible;

Project feels risk associated with flakes is acceptable because:

- Majority of connectors were tested during thermal-vacuum test with same issue and no anomalies noted.
- Individual lines carry a maximum of 20 μ A, so available power is limited in case of a short.
- Connectors are grounded to box, which is grounded to radiator, which is grounded to USS-02.
- Circuit protection for ISS is available both in high-voltage brick and in PDS.
- Impact would be loss of science channels, not safety hazard.

2.2.5 AMS-02-A43, Tracker Thermal Control System Primary Loop Leak: During leak testing prior to final filling of the Tracker Thermal Control System (TTCS) Primary Loop, a small leak was detected that the PO traced to a Dynatube fitting. The PO retightened the fitting to the requisite 12 Nm and the leak continued. Because cutting out the fitting and welding in a new fitting would require arc welding in the proximity to sensitive electronics, the PO investigated methods of "repairing" the fitting on a flight spare fitting. The sealing surfaces of the test fitting were scored, then "smoothed" with a plastic spatula. The hardware tested a good seal with a helium leak rate of 10^{-10} mbar x l/s. A second detector also

placed the leak rate at 10^{-10} mbar x l/s as well. After a series of scoring, scuffing and other damage on the fittings, the fitting was “self healing” when a torque was applied. Higher torques enhanced the sealing effect, so the PO tested torques beyond the nominal 12 Nm. The PO performed further testing in increments to establish if the higher torques could damage the threads of the fitting, including leakage and thread inspection made at each torque level, and found no damage from the higher torques. Finally, yielding resulted at 38 Nm of torque—the centerpiece of the fitting had “flowed” into the female threads of the connector, over lapping the closest threads and anchoring itself in place. Yielding was not of the threads. (This was the event that actually got the test fitting to leak in the 10^{-4} mbar x l/sec range.) Based on the results of the testing of the fitting sealing capability and sensitivity to torquing, the PO cleaned the flight fitting and torqued it to 20 Nm, and leakage stopped. The system underwent multiple leak checks (vacuum/helium and pressure) and proof testing to 1.5 maximum design pressure (MDP). The PO filled and sealed the system. It is ready for flight. There is no safety impact from this anomaly.

2.5 Summary Overview of Safety Verification Status: The PO summarized the remaining open verifications as follows:

- 405 total verifications at the date of this meeting
- 81 still remain open
- 46 of the open verifications are KSC ground processing-related

The PO continues to work to close all verifications as soon as possible.

2.6 Safety Assessment:

2.6.1 Form 1428, Fire Detection and Suppression Reporting Form: *Not applicable to this hardware.*

2.6.2 Form 622, Reflown and Series Payload Hardware Reflight Assessment Reporting Sheet: *Not applicable to this hardware.*

2.6.3 Form 1114A, Certificate of Payload Safety Compliance: *Not discussed in the meeting.*

2.6.4 Form 906, ISS Cargo/Experiment Flight Safety Certificate Form: *Not applicable to this hardware.*

2.7 Hazard Report Discussion:

2.7.1 Removed Hazard Reports: AMS-02-F03 – Cryosystem and AMS-02-F13 – Batteries

The hazards addressed by these HRs no longer exist, with the replacement of the Cryomagnet with the Permanent Magnet.

2.7.2 Previously-approved Hazard Reports:

- AMS-02-F02 – Offgassing—no changes to the hazards were identified with the change of the magnet from what was approved at the January 11 – 13 Phase III FSR. *Approved as presented in this meeting and signed at the Phase III level.*
- STD-AMS-02-F02 – DDRS-02 1230 Form—no changes to the hazards were identified with the change of the magnet from what was approved at the January 11 – 13 Phase III FSR. *Approved as presented in this meeting and signed at the Phase III level.*

2.7.3 All Verifications Closed for HR AMS-02-F20 – Lasers:

2.7.4 HRs with Open KSC Work, Waiting for NASA Approvals:

- AMS-02-F04 – Over Press Payload Bay: *Approved as modified in this meeting and signed at the Phase III level.* The PO deleted issues associated with the cryosystem hardware that was removed

from the design. Ground processing verification tracking log (VTL) closures are the only ones remaining.

- AMS-02-F06 – Excessive Thrust/Overturning Moment: *Not approved as modified in this meeting at the Phase III level pending approval of the magnetic torque analysis.* The PO needs a verification from the Station Remote Manipulator System (RMS) Office that the magnetic torque is within the limits of the RMSs during handoff from Shuttle to Station RMSs. The PO will use a Tailoring-Interpretation Agreement (TIA) for robotics compatibility (for Station). PSRP Shuttle support indicated that the PIRN for Shuttle is not applicable because it does not comment on torque or loads. Approval of the torque analysis will be used as verification of this control.
- AMS-02-F07 – RF, Magnetic Fields: *Not approved at the Phase III level pending electro-magnetic interference (EMI) data confirmation and completion of the MAGIK analysis for verifications 2.1.2 and 1.11.1.* Verification 1.4.2 – The PIRN and analysis will be the closure for Verification 1.4.2. The PO provided a Manipulator Analysis, Graphics, and Integrated Kinematics (MAGIK) analysis that applied to Expedite the Processing of Experiments to Space Station (EXPRESS) Logistics Carrier (ELC) extra-vehicular robotic (EVR) activity. The PO needs to have the MAGIK analysis completed for AMS-02.
- AMS-02-F10 – Flammable Materials: *Not approved at the Phase III level pending verification closures.* The materials certification is in-work and needs to be completed prior to approval of this HR. Final integration inspections at KSC also have to be completed.
- AMS-02-F11 – Mechanisms: *Approved as modified in this meeting and signed at the Phase III level.* All remaining open verifications are KSC ground-processing-related activities.
- AMS-02-F12 – Mate/Demate of Connectors: *Approved as modified in this meeting and signed at the Phase III level.* The PO indicated that the Payload Operations and Integration Center (POIC) has this OCAD for demating UMA and is tracking it with no issues. All remaining open verifications are KSC ground-processing-related activities. The PO clarified that inhibit commanding from the crew or POIC is not a technical issue but a processing issue: nominal operations are to send commands to Station via POIC, but in a contingency situation, the crew can do this without POIC input.
- AMS-02-F16 – Shatterable Material Release: *Approved as modified in this meeting and signed at the Phase III level.* Changes resulted from the Tracker Plane alteration. The alterations moved the Tracker Planes outside the previous envelope to accommodate a lower magnetic field. All frangible materials are contained.
- AMS-02-F18 – Rapid Safing: *Approved as discussed in this meeting and signed at the Phase III level.* The Shuttle fit check still has to be performed.

2.7.5 Open AMS Work, KSC Work, Waiting for NASA Approvals:

- AMS-02-F01 – Structural Failure: *Not approved at the Phase III level pending open verification closures.* The PO explained that no open issues should affect ground processing at KSC. The stress report was completed with different results from the original analysis, so Verification 1.1.2 is open. A new memo to replace EA3-09-031 will be written to cover the changes associated with hardware for the Permanent Magnet configuration. The Verification Loads Analysis will be a major closure item also.
- AMS-02-F05 – Pressure Systems: *Not approved at the Phase III level pending materials compatibility assessment and fracture control approvals associated with the materials certification.* The PSRP will discuss the remaining verifications at that time. The PO summarized

the remaining open verifications for this HR; the materials certification is still needed for closure. In addition, the PO explained that the computer controls are just one level of control among several.

- AMS-02-F08 – Electrical Shock/Discharge: *Approved as modified in this meeting and signed at the Phase III level.* The remaining verifications have to be performed during ground processing at KSC.
- AMS-02-F14 – EVA Operational Hazards: *Approved as modified in this meeting and signed at the Phase III level.* The remaining verifications have to be performed during ground processing at KSC. PIRN 57213-NA-0016 is in process for verification 10.1.3 to replace PIRN 57213-NA-0008.
- AMS-02-F17 – Electrical Power Distribution Damage: *Not approved at the Phase III level pending update to maximum current trip data.* The PO will retest the maximum current draw issue at KSC during ground processing. The retest is to verify worst case current draw of AMS-02 to assure the SSRMS and SRMS current capability is not exceeded. The PO will also fill in and complete the Column for Max Trip Current in the attached table on page 8.
- AMS-02-F20 – Crew Exposure to Coherent Light: *Approved as modified in this meeting and signed at the Phase III level.* The PO removed some optical fiber cables and modified the ports with caps. JSC/Life Sciences reviewed and concurred with the modifications.

3.0 **AGREEMENTS** – The PSRP made no agreements with the PO in this meeting.

Original signed by:

JSC/NA2450/P. Mensingh
Payload Safety Engineer

Original signed by:

JSC/NA2450/W. Stauffer
Technical Writer

Original signed by:

JSC/NA2450/K. Chavez
Payload Safety Engineer

Original signed by:

JSC/NA2450/R. Rehm
Payload Safety Engineer

Status of Hazard Reports Presented

(Note: See the text of the minutes for more details.)

Number	Title	Status	Comments
STD-AMS-02-F02	Form 1230, Flight Payload Standardized Hazard Control Report	Approved/mods	2.7.2
-----	Form 1428, Fire Detection and Suppression Reporting Form	N/A	-----
AMS-02-F02	Offgassing	Approved/mods	2.7.2
AMS-02-F04	Over Press Payload Bay	Approved/mods	2.7.4
AMS-02-F06	Excess. Thrust/Overturning Moment	Not Approved	2.7.4
AMS-02-F07	RF, Magnetic Fields	Not approved	2.7.4
AMS-02-F10	Flammable Materials	Not approved	2.7.4
AMS-02-F11	Mechanisms	Approved/mods	2.7.4
AMS-02-F12	Mate/Demate of Connectors	Approved/mods	2.7.4
AMS-02-F16	Shatterable Material Release	Approved/mods	2.7.4

AMS-02-F18	Rapid Safing	Approved/mods	2.7.4
AMS-02-F01	Structural Failure	Not approved	2.7.5
AMS-02-F05	Pressure Systems	Not approved	2.7.5
AMS-02-F08	Electrical Shock/Discharge	Approved/mods	2.7.5
AMS-02-F14	EVA Operational Hazards	Approved/mods	2.7.5
AMS-02-F17	Electrical Power Distribution Damage	Not approved	2.7.5
AMS-02-F20	Crew Exposure to Coherent Light	Approved/mods	2.7.5

Previous Action Item Status

AI	Action	Status
1 (1/12/10) Assigned to: ESCG/J. Heilig HR: AMS-02-F13	Determine an engineering basis to fly the cracked FETs in the Battery Management System (BMS). If the PO decides to fly cracked FETs it must provide a FMEA. Document the failure modes of these FETs and the consequence of a failure in each. Provide statistics for Failure Open versus Failure Closed for this design or for this type of FET situation. Date: 3/1/10 Mandatory Reviewer(s): PSRP	Closed in this meeting
2 (1/12/10) Assigned to: JSC Engineering/G. Henning HR: AMS-02-F07	JSC Engineering will validate the Eddy Current Analysis in Control 3.4. Date: 2/1/10 Mandatory Reviewer(s): PSRP	Closed in this meeting
3 (1/12/10) Assigned to: ESCG/C. Tutt HR: AMS-02-F06	PO will confirm the continued applicability of Boeing Memo TM-990018-05, 9/12/99. Reference Hazard Verification 4.1. Date: 2/1/10 Mandatory Reviewer(s): PSRP	Closed 3/23/10
4 (1/12/10) Assigned to: ESCG/C. Tutt HR: AMS-02-F04	Assess leak size versus time to effect for the leak rates in the SFHe system. Date: 2/1/10 Mandatory Reviewer(s): PSRP	Closed in this meeting
5 (1/12/10) Assigned to: ESCG/L. Hill HR: All	Update SVTL to indicate pre- and post-KSC SVTLs. Date: 3/1/10 Mandatory Reviewer(s): PSRP	Closed 3/23/10
1 (3/23/10) Get from DMS	Provide PO input that clearly defines LCC constraint to be included as a formal concurrence memo from the NASA PSRP to KSC. Mandatory Reviewer(s): PSRP	Closed in this meeting

AI Status Explanation:

AI1 (01/12/10): Closed—The PO removed the hardware associated with this AI during the re-design after removal of the cryocooling system. This AI no longer applies.

AI2 (01/12/10): Closed— The PO removed the hardware associated with this AI during the re-design after removal of the cryocooling system. This AI no longer applies.

AI3 (01/12/10): Closed—The PSRP closed this AI at the 03/23/10 TIM.

AI4 (01/12/10): Closed— The PO removed the hardware associated with this AI during the re-design after removal of the cryocooling system. This AI no longer applies.

AI5 (01/12/10): Closed— The PSRP closed this AI at the 03/23/10 TIM. The PO continues to provide updates to the VTL as they close verifications.

AI1 (03/12/10): Closed—All previous launch commit criteria were associated with the cryo-magnet, and since it is not part of the hardware, there are no launch commit criteria. AMS-02 will launch unpowered in the payload bay.

ATTACHMENT 1

Payload Safety Review Attendance Log

Payload: AMS-2 Delta Phase III Flight Safety Review

Meeting Date: August 3-4, 2010

Mail Code	Name	Phone 281	X
CHAIRMAN			
OE	Surber, M.	483-4626	X
SUPPORT PERSONNEL			
CB	Rickard, J.	483-3760	X
DA8/USA	Knutson, D.	483-4405	X
EA441	Henning, G.N.	483-0533	X
MO2/USA	Wood, W.	280-6844	X
MO2	Kunkel, S.	483-4356	X
NE14	Guidry, R.	244-5510	X
NE14	Moreland, D. W.	483-5549	X
SM	Spann, R.	483-3807	X
NT	Nobles, D.	335-2129	X
ARES	P.C. Nielsen	226-4893	X
EP4/Jacobs	Manha, W.	483-6439	X
ESCG/JACOBS	Barton, Q.	461-5501	X
ESCG/JACOBS	Ross, S.	461-5710	X
ES4/Jacobs	Martinez, A.N.	461-5428	X
ESCG/JACOBS	Russell, D.	461-5144	X
ESCG/JACOBS	Runnells, J.	461-5019	X
NA2450/GHG	Chavez, K.	335-2364	X
NA2450/GHG	Mensingh, P.	335-2363	X
NA2450/GHG	Rehm, R.	335-2374	X
NA2450/JES	Stauffer, P. W.	335-2402	X

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