JSC 27296 (Revision B)
LMSEAT 31947 (Revision B)

PROJECT PLAN FOR THE ALPHA MAGNETIC SPECTROMETER (AMS)

Engineering Directorate

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Revision B

August 18, 2004

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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PROJECT PLAN FOR THE ALPHA MAGNETIC SPECTROMETER

Technical Work Plan HECEABS2

Prepared by

Lockheed Martin Space Operations

Houston, Texas

Contract NAS 9-19100

Prepared for

Engineering Directorate

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LYNDON B. JOHNSON SPACE CENTER

HOUSTON, TEXAS

August 2004

PROJECT PLAN FOR THE ALPHA MAGNETIC SPECTROMETER

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August 2004

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August 2004

DOCUMENT CHANGE/REVISION LOG

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Baseline	10/24/97	Baseline	All
	7/15/98	Updated Appendix A, Master List of Documents	Appendix A
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	8/1/00	Revision A	All
	8/18/04	Revision B – Move from SA to EA Changed title to Project Plan for AMS	All

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ACRONYMS AND ABBREVIATIONS

^{0}C	DEGREES CENTIGRADE
ACOP	AMS CREW OPERATIONS POST
ADP	ACCEPTANCE DATA PACKAGE
AMS	ALPHA MAGNETIC SPECTROMETER
AMS-01	AMS PRECURSOR FLIGHT ON STS-91
AMS-02	AMS OPERATIONAL FLIGHT ON ISS
AP	ATTACHED PAYLOAD
APCU	ASSEMBLY POWER CONVERTER UNIT
APO	AMS PROJECT OFFICE
CDR	CRITICAL DESIGN REVIEW
CG	CENTER OF GRAVITY
CITE	CARGO INTEGRATION TEST EQUIPMENT
CMP	CONFIGURATION MANAGEMENT PLAN
CMR	COLD MASS REPLICA
CMS	CONFIGURATION MANAGEMENT SYSTEM
COTS	COMMERCIAL OFF THE SHELF
DCU	DATA CONVERSION UNIT
DOE	DEPARTMENT OF ENERGY
EA	JSC ENGINEERING DIRECTORATE
EC	JSC CREW & THERMAL SYSTEMS DIVISION
ECAL	ELECTROMAGNETIC CALORIMETER
EDCC	ENGINEERING DRAWING CONTROL CENTER
EEE	ELECTRONIC, ELECTRICAL, AND ELECTROMECHANICAL
EMC	ELECTROMAGNETIC COMPATIBILITY
EMI	ELECTROMAGNETIC INTERFERENCE
ES	JSC STRUCTURAL ENGINEERING DIVISION
ESTL	ELECTRONIC SYSTEMS TEST LABORATORY
EV	JSC AVIONICS SYSTEMS DIVISION
EVA	EXTRAVEHICULAR ACTIVITY
FEM	FINITE ELEMENT MODEL
FIT	FUNCTIONAL INTERFACE TEST
FRGF	FLIGHT RELEASABLE GRAPPLE FIXTURE
FSE	FLIGHT SUPPORT EQUIPMENT
GCAR	GOVERNMENT CERTIFICATION ACCEPTANCE REQUEST
GFE	GOVERNMENT FURNISHED EQUIPMENT

GHE	GROUND HANDLING EQUIPMENT
GSE	GROUND SUPPORT EQUIPMENT
HLIF	HRF LAUNCH INTEGRATION FACILITY
HOSC	HUNTSVILLE OPERATIONS SUPPORT CENTER
HQ	HEADQUARTERS
HRF	HUMAN RESEARCH FACILITY
ICD	INTERFACE CONTROL DOCUMENT/DRAWING
IDRD	INCREMENT DEFINITION AND REQUIREMENTS DOCUMENT
IMS	INVENTORY MANAGEMENT SYSTEM
IRD	INTERFACE REQUIREMENTS DOCUMENT
ISS	INTERNATIONAL SPACE STATION
ITA	INTERNAL TASK AGREEMENT
IVA	INTRAVEHICULAR ACTIVITY
IVT	INTERFACE VERIFICATION TEST
JIPT	JOINT INTEGRATED PRODUCT TEAM
JSC	LYNDON B. JOHNSON SPACE CENTER
KSC	JOHN F. KENNEDY SPACE CENTER
KIT	KSC INTERFACE TEST
LEPS	LOW ENERGY PARTICLE SHIELD
LMSMSS	LOCKHEED MARTIN SPACE MISSION SYSTEMS AND SERVICES
LMSO	LOCKHEED MARTIN SPACE OPERATIONS
MA	JSC SPACE SHUTTLE PROGRAM
MAPTIS	MATERIALS AND PROCESSES TECHNOLOGY INFORMATION SYSTEM
MDF	MANIPULATOR DEVELOPMENT FACILITY
MDL	MASTER DOCUMENT LIST
MIP	MISSION INTEGRATION PLAN
MIT	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MLP	MOBILE LAUNCH PLATFORM
MSFC	GEORGE C. MARSHALL SPACE FLIGHT CENTER
MO	SPACE SHUTTLE FLIGHT OPERATIONS & INTEGRATION OFFICE
MVP	MASTER VERIFICATION PLAN
NA	JSC SAFETY AND MISSION ASSURANCE DIRECTORATE
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NBL	NEUTRAL BUOYANCY LABORATORY
NC	JSC PAYLOAD SAFETY

NPSL	NASA PARTS SELECTION LIST
NSTS	NATIONAL SPACE TRANSPORTATION SYSTEM
OB	JSC ISS VEHICLE OFFICE
OC	JSC ISS OPERATIONS & UTILIZATION OFFICE
OE	JSC ISS SAFETY & MISSION ASSURANCE/PROGRAM RISK OFFICE
OIU	ORBITER INTERFACE UNIT
OM	JSC ISS PROGRAM INTEGRATION OFFICE
OPF	ORBITER PROCESSING FACILITY
OZ	JSC ISS PAYLOADS OFFICE
PAS	PAYLOAD ATTACH SYSTEM
PCB	PAYLOAD CONTROL BOARD
PDIP	PAYLOAD DATA INTERFACE PANEL
PDL	PAYLOAD DATA LIBRARY
PDR	PRELIMINARY DESIGN REVIEW
PFR	PORTABLE FOOT RESTRAINT
PGSC	PAYLOAD AND GENERAL SUPPORT COMPUTER
PIA	PAYLOAD INTEGRATION AGREEMENT
PIB	PLANNING AND INTEGRATION BRANCH
PIH	PAYLOAD INTEGRATION HARDWARE
PMP	PROJECT MANAGEMENT PLAN
POC	PAYLOAD OPERATIONS CENTER
PRD	PROGRAM REQUIREMENTS DOCUMENT
PRP	PRESSURIZED PAYLOAD
PTCS	PAYLOAD TEST AND CHECKOUT SYSTEM
PTRS	PROJECT TECHNICAL REQUIREMENTS SPECIFICATION
PVGF	POWER VIDEO GRAPPLE FIXTURE
RECON	RECONFIGURATION
RICH	RING IMAGING CHERENKOV COUNTER
ROEU	REMOTELY OPERATED ELECTRICAL UMBILICAL
SAIL	SHUTTLE AVIONICS INTEGRATION LABORATORY
SAR	SYSTEM ACCEPTANCE REVIEW
SESL	SPACE ENVIRONMENT SIMULATION LABORATORY
SML	STRUCTURES AND MECHANICS LABORATORY
SRD	SYNCHROTRON RADIATION DETECTOR
SSPF	SPACE STATION PROCESSING FACILITY
STA	STRUCTURAL TEST ARTICLE

STD	STANDARD
STE	SPECIAL TEST EQUIPMENT
STS	SPACE TRANSPORTATION SYSTEM
SVMF	SPACE VEHICLE MOCKUP FACILITY
SWG	STRUCTURES WORKING GROUP
TBD	TO BE DETERMINED
TIP	(NASA) TRAINING IMPLEMENTATION PLAN
ToF	TIME OF FLIGHT
TPS	TASK PERFORMANCE SHEET
TRD	TRANSITION RADIATION DETECTOR
TWP	TECHNICAL WORK PLAN
UMA	UMBILICAL MECHANISM ASSEMBLY
UPP	UNPRESSURIZED PAYLOAD
USS	UNIQUE SUPPORT STRUCTURE
UF	UTILIZATION FLIGHT
UMA	UMBILICAL MECHANISM ASSEMBLY
VATF	VIBRATION - ACOUSTIC TEST FACILITY
VC	VACUUM CASE
WBS	WORK BREAKDOWN STRUCTURE

PREFACE

In May 2004, the Alpha Magnetic Spectrometer (AMS) project was moved from the Space and Life Sciences Directorate to the Engineering Directorate. At this time a decision was made to remove the Program Requirements Document portion of this document and change the name to "Project Plan for the Alpha Magnetic Spectrometer". All previous revisions were titled "Program Requirements Document and Project Management Plan for the AMS Payload Integration Hardware". This new document describes the project plan and documentation references for the AMS payload and describes the Payload Integration Hardware (PIH) required for the mission on the International Space Station (ISS).

A precursor flight (AMS-01) was accomplished on the Space Shuttle during the Shuttle STS-91 flight and was addressed with the previous versions of this document. The AMS-01 was successfully operated for approximately 8.5 days during the flight.

This Revision B of the Project Plan is directly related to the three (3) year operational flight (AMS-02) on the International Space Station initiated with Flight UF4.1 (currently).

1.0 INTRODUCTION

1.1 DOCUMENT PURPOSE

This Project Plan establishes the overall program requirements for the project management of the Alpha Magnetic Spectrometer (AMS-02) payload. NASA/JSC hardware development responsibility is limited to the Payload Integration Hardware as described in this document. This document complies with the intent of requirements defined by NMI-8010.1 Rev A and designated as Class C payloads, EA-WI-023, EA-WI-025, and the intent of the Implementing Arrangement Between the Department of Energy (DOE) and NASA (Signed September 20, 1995). The AMS Project Manager of the Engineering Directorate, Lyndon B. Johnson Space Center (JSC) is the controlling authority for this document.

The purpose of the Project Plan for the AMS-02 payload is as follows:

- Identify AMS-02 payload program participants and major responsibilities
- Delineate program requirements necessary for the design, development, fabrication, testing, verification, delivery, and operations of AMS-02 payload flight and ground support hardware, and associated integration hardware.
- Establish the hardware and software design criteria and verification requirements for the AMS-02 flight systems and associated software.

1.2 DOCUMENT SCOPE

This document establishes the project control, design, safety, reliability, quality assurance, test facility, integration test and shipping requirements for the AMS-02 payload. NASA/JSC hardware development is limited to the Payload Integration Hardware (PIH) as described in this document. It does not address the internal AMS-02 Experiment configuration. It does address the configuration of the AMS-02 interfaces to the Space Shuttle and International Space Station.

These requirements apply to new flight hardware and to modifications of previously flown flight hardware.

1.3 AMS-02 PAYLOAD DESCRIPTION

In this document “AMS” will refer to the total complement of activities, hardware, software, test, integration and operation of the Alpha Magnetic Spectrometer. The flight hardware is referred to as the “AMS Payload” and is comprised of two parts: the “AMS Experiment” provided by the international AMS Experiment Collaboration and the “AMS Payload Integration Hardware

(PIH)" provided by the JSC Engineering Directorate with the support of Lockheed Martin Space Operations (LMSO). Also in this document, AMS-01 and AMS-02 are used and they refer specifically to the configuration as it was for STS-91 (AMS-01) and for the Space Station (AMS-02). The term AMS will be used in a more general case but specifically includes the Space Station configuration.

The AMS Experiment is a state-of-the-art particle physics detector containing a large, cryogenic superfluid helium, superconducting magnet that will be designed, constructed, tested and operated by an international team organized under United States Department of Energy (DOE) sponsorship. The AMS Experiment will use the unique environment of space to advance knowledge of the universe and potentially lead to a clearer understanding of the universe's origin. Specifically, the science objectives of the AMS are to search for cosmic sources of antimatter (i.e., anti-helium or heavier elements), dark matter and dark energy. Reference is made to Figure 1-1 and Figure 1-2 for graphic descriptions of the AMS payload.

Although not considered an AMS goal, the experiment provides the potential benefit of a permanent and accurate measurement of the radiation environment in outer space, which is needed to access the amount of radioprotection required for extended manned interplanetary flights. In addition, AMS will provide the first operational experience with a superconducting cryogenic magnet in space and greatly extend the knowledge base regarding superfluid cryogenic systems operation in space. These are enabling technologies for the potential use of magnetic shielding as a method of radioprotection during extended manned space flight.

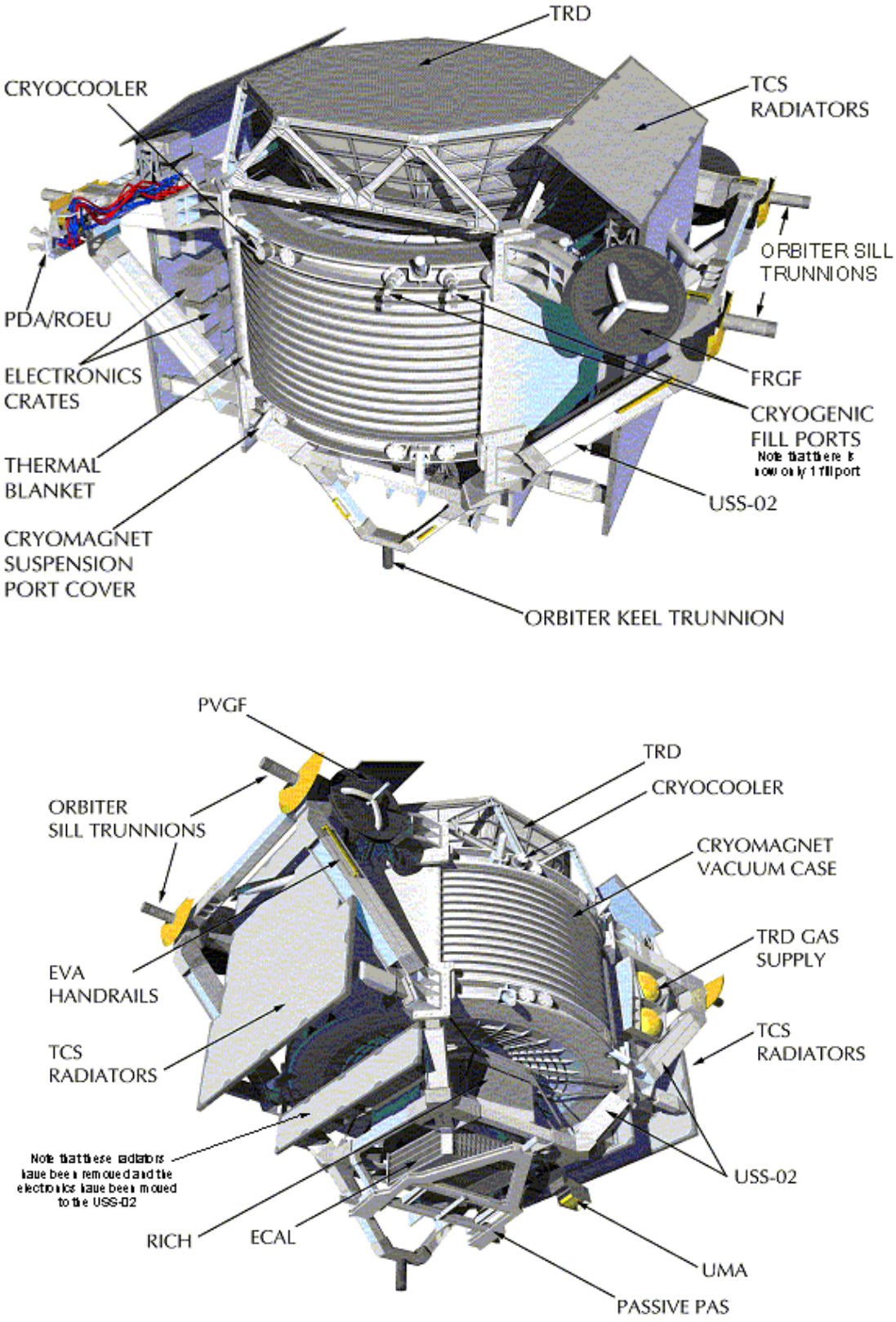

FIGURE 1-1 AMS-02 PAYLOAD

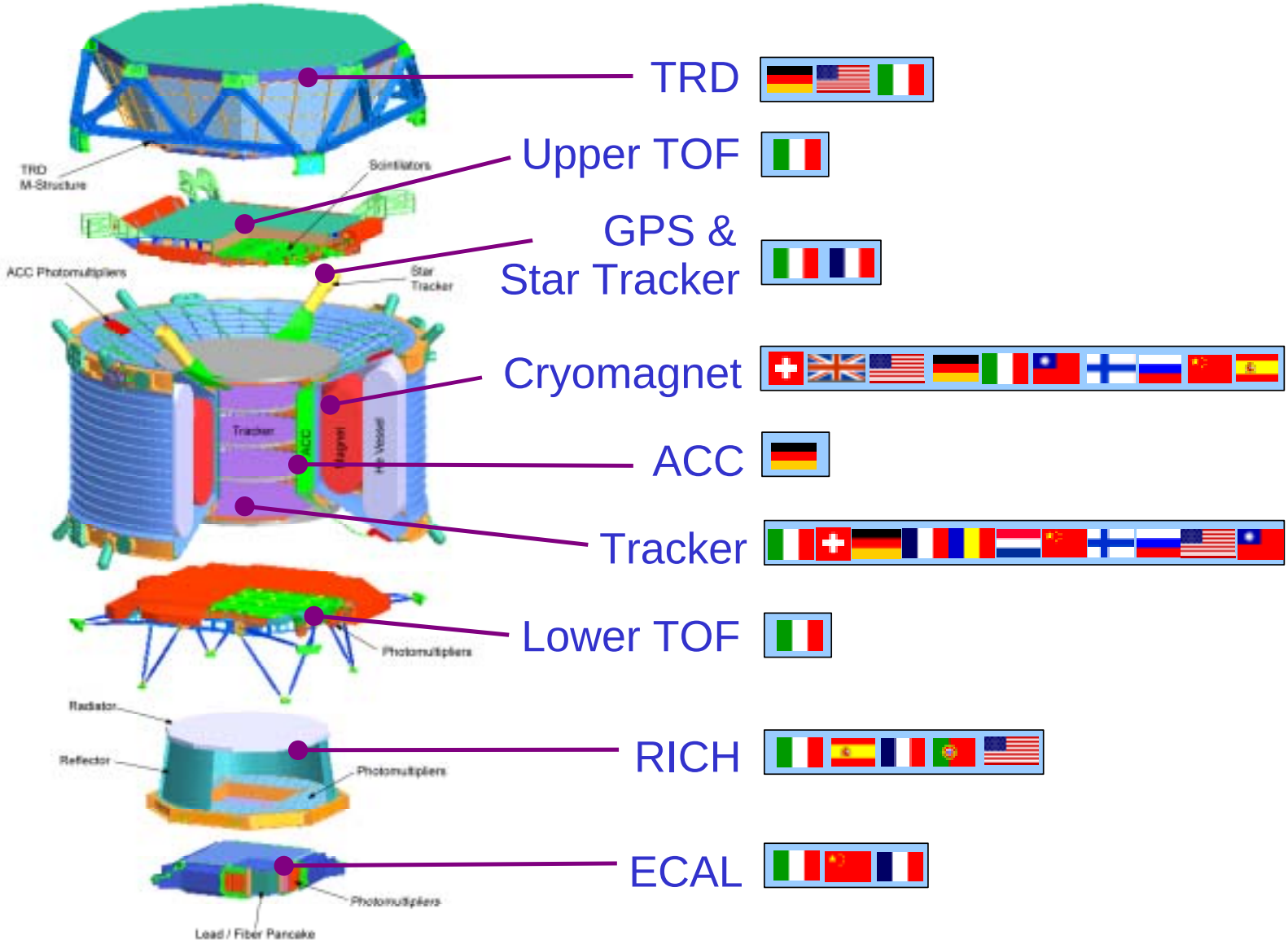

FIGURE 1-2 AMS EXPERIMENT GENERAL ASSEMBLY

2.0 PROGRAM, MILESTONES AND HARDWARE DELIVERABLES

2.1 ORGANIZATION

The AMS payload program organization is shown in Figure 2-1. The Engineering Directorate, Lyndon B. Johnson Space Center (JSC) is responsible for the project management of the AMS payload. The Johnson Space Center has been delegated responsibility for implementing the AMS program by the NASA Headquarters Exploration Systems Directorate. JSC has subsequently delegated the responsibility to the Engineering Directorate. The Engineering Directorate has established the AMS Project Office in EA1. The AMS Project Office (APO) will serve as the AMS representative and will act as the single point of contact between the AMS program and the ISS and Shuttle programs. The AMS Project Office is the AMS representative to all other NASA organizations providing equipment, materials, and services for the AMS program.

2.2 RESPONSIBILITIES

The AMS Project Office is responsible for the payload integration activities for the AMS payload (AMS-02). The APO will develop and specify the requirements and procedures for ground test and verification of the AMS payload. The AMS project office will provide verification to the Payload Integration Function of the ISS and they will integrate it into the overall documentation and requirements for the Space Station integrated payloads for the UF4.1 Space Shuttle flight (currently). This will include the integrated Shuttle requirements and agreements, physical integration on the Space Station, and Space Station operations requirements. The APO will ensure that NASA provides the appropriate flight payload accommodations, engineering support, mission peculiar hardware and software, AMS to carrier integration support, payload safety certification, facilities for final assembly at KSC, testing and checkout, NASA control center accommodations for AMS operation and monitoring, and provide AMS housekeeping and science data to the DOE-sponsored team as required for the mission.

Responsibilities of the AMS participants and NASA are listed in Table 2-1. The "Responsibility" column designates the organization(s) singular or joint control and/or the development of the document or function described. The "Support" column designates organizations that are required to contribute to development and implementation of the documents and/or functions and/or are expected to contribute to review of the appropriate documents. Further detail can be found in paragraphs 2.2.1 through 2.2-10 of this document.

The NASA/JSC on-site facilities that are required to support AMS activities are listed in Table 2-2. Each facility used by the APO will be coordinated with the appropriate Division on an as required/as available basis by the use of a Test Request (for Engineering Divisions) or an Internal Task Agreement (ITA) for other divisions. The majority of this work will be in support of the PIH; however, there will be some limited testing that will include components of the experiment hardware.

2.2.1 EA Project Office and LMSO Project Management Responsibility

As shown in Table 2-1, the EA AMS Project Office has the responsibilities for the overall project management with products and tasks provided by LMSO as defined in their Technical Work Plan (TWP). These items include major project planning documentation like the Configuration Management Plan, AMS to PIH ICD, the Project Plan for AMS, and the Project Technical Requirements Specification. These documents define the scope, specifications, and implementation of the project at EA. These items also include the major project certification products like the GCAR, road to CoFR, Master Verification Plan verification acceptance data, and Safety Data Packages. The APO, with the support of LMSO, is responsible for the development of all of these documents and pushing the project down the road to CoFR.

The APO will, however, need support from various other organizations to complete this process. All of the support organizations will be required to review and concur with the documentation. Where appropriate, specific organizations will be asked to review verification and safety documentation. This includes review of test plans, test procedures, test reports, safety data packages, verification plans, and verification data.

2.2.2 APO and LMSO Payload Integration Responsibility

As shown in Table 2-1, the EA AMS Project Office has responsibilities for all payload integration with the support of LMSO as defined in their TWP. These items include the integration support of the payload into the Space Shuttle and ISS. This includes the interface/integration electrical and software design, and in some cases full development. Examples of this include the interface design drawings between the ISS and AMS and between the Shuttle and AMS. It also includes the Digital Data Recording System – 02, DDRS-02 Flight Support Equipment (FSE), the EVA connector panel, which provides the interface between the UMA and the experiment hardware, and the Interface Panel A, which provides the interface

between the ROEU and the experiment hardware. It includes the full development of all payload integration hardware and its ground support equipment and special test equipment. This includes the USS-02, the Vacuum Cases, the Primary Support Stand, Primary Lifting Fixture, Multi-purpose lift fixtures, etc. A full list of the PIH and associated GSE/STE can be found in the PTRS and the WBS. LMSO will develop all necessary drawings using the EDCC. LMSO will provide quality, materials, design and stress signatures on all drawings. LMSO and EA will compile all necessary data to show that the PIH and GSE/STE meet all applicable quality and safety requirements.

The APO will need support from various other organizations to complete this process.

The Structural Engineering Division (ES) will provide manufacturing consultation and review of the requirements, mechanical design and drawings for all of the mechanical integration hardware. The Vacuum Case and some other hardware will be manufactured external to JSC. The Unique Support Structure (USS) and a large number of other pieces of integration hardware could be manufactured, integrated and tested at JSC. The Division will also advise and test materials as needed for the all of the integration hardware and work with the APO on fracture control and support other analysis. This work will use facilities in JSC Buildings 9, 10 and White Sands Test Facility. ES will consult and review the integrated mechanical design, develop the integrated stress analysis, and welding plans for the PIH and GSE. This Division will also review several aspects of AMS Payload verification testing. These tests will include static, vibration, acoustic, and modal testing. The Division will work with the APO to define the test requirements and will review the test plans, procedures and operations. This work could use facilities in JSC Buildings 49 and 13. (Note: ES chairs the NASA/ES Structures Working Group, which is one of the approvals for ISS Payload Safety).

The Crew and Thermal Systems Division (EC) will review the AMS Payload thermal verification testing including thermal and thermal vacuum testing. The Division will work with the APO to develop requirements and modeling. For thermal, thermal vacuum, and other testing the Division will review the test plans, procedures and operations. The Division will assist the APO in defining the requirements for thermal blankets and the Division will provide support to EA and LMSO for the design, development, test and installation of some of the blankets for flight. This work will use facilities in Buildings 7, 32 and 33.

The Avionic Systems Division (EV) will support the APO for some of the verification testing of AMS Payload data systems. This will include testing of high rate data, 1553 data, low rate data

and commands. For this avionics testing in the Division's laboratories, the Division will be responsible for the test plans, procedures and operations. This work will use facilities in Buildings 14, 16 and 44.

The Energy Systems Division (EP) will provide support for all pressure and vacuum systems in the AMS Payload. EP will also provide support for all battery systems. This support includes review of the systems to ensure that they meet with all appropriate safety requirements.

The Safety and Mission Assurance Directorate (NA) will provide all on-site quality support to PIH that is either being manufactured or tested on-site. In addition, NA will help to certify that all PIH has met all of its requirements and will review all appropriate documentation, inspect hardware and certify the hardware through the NASA JSC quality system.

The AMS collaboration will provide input to interface documentation to ensure that all PIH meet the necessary experiment requirements and specifications.

KSC will ensure that all GSE meets all KSC requirements and specifications.

2.2.3 AMS Collaboration Responsibility

As shown in Table 2-1, the AMS collaboration has several responsibilities. These items include development and certification of all of the experiment components, the magnet system (with the exception of the Vacuum Cases), the experiment electronics, the Thermal Control System, and the AMS Crew Operations Post (ACOP).

The APO, with support of LMSO, will review and write requirements to the AMS collaboration for all safety critical aspects of the experiment hardware. The APO and LMSO will make recommendations to the AMS collaboration to support mission success issues, but will not impose requirements.

2.2.4 AMS, APO, and LMSO Responsibility

As shown in Table 2-1, the AMS collaboration, EA AMS Project Office and LMSO have several responsibilities associated with develop of integrated payload documentation. These items include all overall payload drawings, stress, fracture, thermal, and materials analysis. Each detector group within the AMS collaboration will provide all of the stated information to LMSO for incorporation into the overall payload data set. LMSO will provide all of the PIH

information, combine it with the experiment data, and provide it for review to the review teams from within JSC.

2.2.5 OC Responsibility

As shown in Table 2-1, OC has several responsibilities. These items include all IDRD products and annexes, and the Mission Integration Plan. The APO, LMSO, AMS, and OZ will provide input data to this process.

2.2.6 OZ Responsibility

As shown in Table 2-1, OZ has several responsibilities. These items include all of the documentation to fully define the interface between the ISS and AMS. This includes the PIA, ISS Hardware and Software ICDs.

The PIA support team will provide adequate review and comments to the PIA. The APO, with LMSO support, in cooperation with NA will provide adequate data to complete all ISS ICDs.

2.2.7 MSFC Responsibility

As shown in Table 2-1, MSFC has several responsibilities. These include support at the Huntsville Operations Support Center (HOSC).

EA and LMSO, in cooperation with AMS and OZ, will also provide all adequate data to integrate payload operations into the HOSC.

2.2.8 MSFC and LMSO Responsibility

As shown in Table 2-1, MSFC and LMSO have the following responsibilities. MSFC is responsible for maintaining the PDL, while LMSO, with the help of AMS and OZ, is responsible for entering AMS specific data into the PDL.

2.2.9 DA & OZ Responsibility

As shown in Table 2-1, DA and OZ have the following responsibilities. These include all mission planning, training and Mission Control Center Support for the AMS Mission.

EA AMS Project Office and LMSO, in cooperation with AMS, will also provide all adequate data to develop necessary mission planning data, training data and MCC requirements and data. The APO and LMSO will also provide support during the mission at the JSC Payload Operation

Control Center (POCC). The AMS payload team will provide representatives to the JSC POCC. In addition the AMS team will set up a remote POCC which will be used approximately three months after launch through the end of mission.

2.2.10 Space Shuttle Flight Operations & Integration Office (MO) Responsibility

As shown in Table 2-1, MO has several responsibilities. These items include all of the documentation to fully define the interface between the Shuttle and AMS, including the Shuttle ICD and MIP.

The APO and LMSO in cooperation with NA, OC and OZ will provide adequate data to complete all documentation.

2.3 PROGRAM SCHEDULES

The AMS Master Schedule is developed in accordance with the AMS Work Breakdown Structure (WBS). The AMS WBS and Master Schedule are controlled by the AMS Project Manager as described in the AMS Configuration Management Plan (JSC-27542). The AMS Master Schedule will include major project milestones that will be coordinated with the AMS collaboration. The AMS Master Schedule will be posted electronically (see URL below) so that all AMS team members will have ready access.

http://www4.jsc.nasa.gov/eaprojects/ea-projects/flightgfe/ams_02/html/Schedules.htm

The WBS can be found in Appendix A and it can also be found electronically at the following address by following the “Documents” link.

http://www4.jsc.nasa.gov/eaprojects/ea-projects/flightgfe/ams_02/html/ams_02.htm

The controlling ISS milestones are jointly controlled between ISS and AMS and will be in accordance with SSP 57057, “ISS Payload Integration Template.”

2.4 DELIVERABLES

The hardware and software deliverables are fully described in the Project Technical Requirements Specification (PTRS) (JSC 29789); however, a list of the hardware and software

deliverables is included in section 4 of this document as well. The documentation deliverables are defined in Section 4.

2.5 ROAD TO CoFR

Since the primary goal of the JSC AMS Project is to successfully launch and operate the AMS payload on the ISS, one of the most important tasks defined in this plan is a road to Certification of Flight Readiness (CoFR). The road to CoFR can be found in Figure 2-2 and is supplemented by the project deliverable hardware and documentation found in Section 4. The project will develop and maintain a detailed Work Breakdown Structure and master schedule. The WBS will define all of the tasks required of the AMS Payload to successfully develop and certify hardware and software for the CoFR process. The master schedule will map to the WBS and will be maintained to identify schedule margin and risks. Project reporting will include all applicable cost, schedule, and risk reporting to ensure that issues are identified and dealt with as early as possible. Processes and plans will be coordinated within the NASA AMS team on a regular basis. In addition, schedule and risk issues will be coordinated with the AMS collaboration on a regular basis.

The AMS payload and collaboration are extremely complex. There are three main sets of requirements that must be met in order to certify the payload for flight. These sets include:

1) NASA Developed Payload Integration Hardware (PIH) System Requirements and Integrated Payload Requirements
2) AMS Payload Safety Requirements
3) AMS Experiment Component Mission Assurance Requirements

The first set of requirements, including the NASA Developed PIH System Requirements and Integrated Payload Requirements, is fully defined in the AMS PTRS. The verification of these requirements will be tracked via the Master Verification Plan (MVP). These requirements are defined early in the project and are driven by the requirements for integration on the ISS and STS. The PIH requirements are also driven by the requirements of the experiment components. The PIH and any Integrated Payload requirements cannot be closed until all of the necessary analysis, testing or inspections have been performed. This verification matrix will be tracked until all items are closed prior to Certification of Flight Readiness (CoFR).

The second set of requirements is developed as part of the payload safety process. Because AMS is a payload, it must go through the Payload Safety Review Process. This includes phased reviews for both flight and ground safety. The Safety Data Packages that are developed to support these phased reviews include a complete description of the entire payload and identification of hazards in Hazard Reports. Safety requirements can be added to the payload during any of these reviews and are tracked via the Hazard Reports and associated verification tracking logs. Any safety verification item that has not been closed by the Phase III safety review will be tracked on a verification tracking log until all items have been closed prior to CoFR.

The third set of requirements is defined by the AMS Experiment Component teams and is not the responsibility of the NASA AMS Project Office. NASA does have some insight into these requirements and will create a third verification matrix that will be tracked until all items are closed prior to CoFR. This verification matrix will be tracked by the AMS CCB. The AMS experiment team has a vested interest in ensuring that their experiment functions as expected. Although the team does not use a traditional NASA approach to mission assurance, their methodology has successfully worked over many years on ground based experiments and on the AMS-01 mission on STS-91. The AMS experiment methodology includes numerous acceptance tests at the component and sub-system level. It includes functional testing at various subcomponent levels and at the fully integrated system level. It also includes functional tests during a full-up thermal vacuum test.

The Engineering Directorate will produce the AMS PIH hardware via a standardized development and certification process. This development process involves project scope/requirements baselining; conduct of formal design reviews; and formal certification planning with full customer involvement. The AMS PIH hardware is accepted with a formal Systems Acceptance Review (SAR) or equivalent. An acceptance data package (ADP) is also provided and reviewed for each unit of hardware. This development and acceptance process provides the basis for the AMS PIH CoFR subendorsement along with the additional integration activities defined below. For reference, the basic process for certification of ISS payload hardware is described in SSP 52054.

Throughout the life cycle of the PIH hardware, major design reviews are held culminating with the System Acceptance Review (SAR). The purpose of the SAR is to demonstrate that the hardware/software is complete and in compliance with the specifications. This is done by examination of end items, documentation, and data that support verification. Once approval

signatures are given, the hardware is deemed ready for turnover, launch, deployment, and any further integration.

The Acceptance Data Package (ADP) will also assist in satisfying subendorsement statements. The ADP provides a history of the configuration and quality assurance status of the PIH hardware component (based on serial number). It is prepared as part of the hardware or software acceptance/delivery criteria and maintained throughout the hardware/software life cycle, including integrated testing, ground processing, launch site processing, on-orbit, post-landing and maintenance/modification/refurbishment activities. The ADP data can be used for assurance purposes and to facilitate integration, operational, or refurbishment/modification activities conducted by the receiving organization (NASA or contractor). The data package will reflect the status of the hardware/software at the time of acceptance by the receiving organization and delivered concurrently with the hardware/software delivery.

Completion of SAR will verify that hardware meets functional and performance requirements in accordance with SSP 52054 and certified to the design requirements of the AMS PTRS.

All flight hardware will be built per the completed SAR data applicable PTRS. All waivers, deviations, and nonconformances, or other exceptions have been captured in the ADP. Completion of SAR will identify constraints with open items and actions. Open items subsequent to SAR will be tracked by the project manager and status/closure reported to support CoFR roll-up. ADP and SAR will identify resolution of nonconformances. Any failures will be identified in GFE PRACA beginning with flight fabrication.

Figure 2-1 AMS PAYLOAD PROGRAM ORGANIZATION

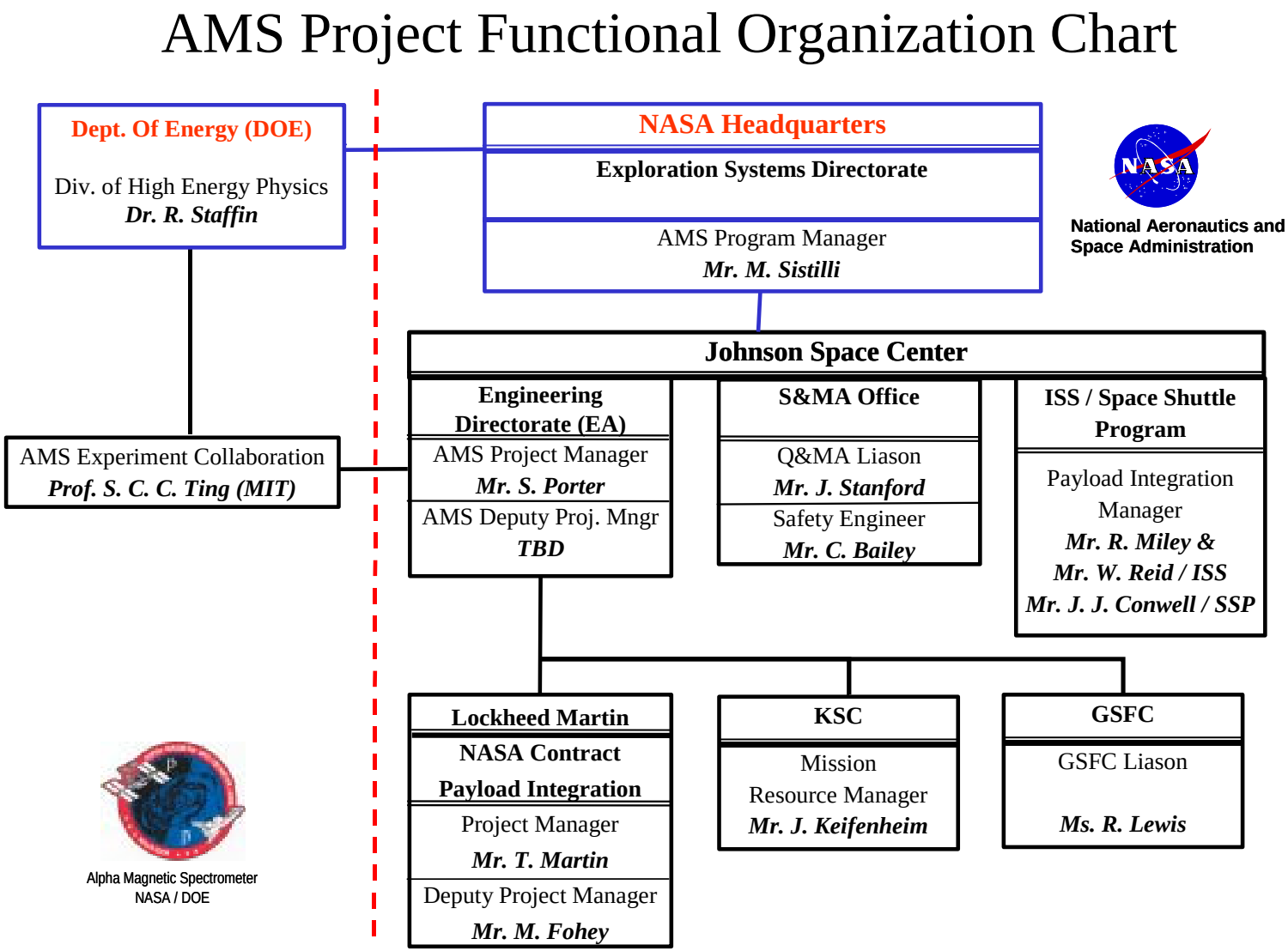

TABLE 2-1 AMS RESPONSIBILITY SUMMARY

PROGRAM ACTIVITY	RESPONSIBILITY	SUPPORT	SECTION
AMS CMP (JSC27542)	APO, LMSO	AMS Collaboration, EB, EC, EP, ES, EV, DA, CB, NC, NT, MO, OB, OC, OD, OZ, SA, XA, MSFC, KSC, GSFC	2.2.1
AMS Payload Interface Control Document (ICD) ICD-C (JSC29095)			
Project Plan for AMS (JSC27296)			
PTRS (JSC29789)			
Government Certification Approval Request (GCAR) & CoFR			
Master Verification Plan			
Safety Data Packages			
AMS Integration Electrical & Software Development	APO, LMSO	AMS Collaboration, NA, EV, EP	2.2.2
AMS Integration GSE and STE Development	APO, LMSO	AMS Collaboration, NA, ES, KSC	
AMS Integration Hardware Development	APO, LMSO	AMS Collaboration, NA, ES, EC, EP, EV	
AMS Experiment Flight & Ground Hardware	AMS Collaboration	APO, LMSO, KSC	2.2.3
ACOP Development	AMS Collaboration	OZ	
AMS Payload Drawings, Stress, Fracture, Thermal and Materials Analysis	AMS Collaboration, APO, LMSO	NA, ES, EC, EV, EP	2.2.4
IDRDs & Annexes	OC	APO, LMSO, AMS Collaboration, OZ	2.2.5
Payload Integration Agreement (PIA) (SSP-57113)	OZ	APO, LMSO, AMS Collaboration, OB, OC, OD, KSC, MSFC, DA, XA, CB, MO	2.2.6
ISS/AMS Hardware ICD (SSP-57213)		APO, LMSO, NA	
ISS/AMS Software ICD (SSP-57313)		APO, LMSO, NA	
HOSC	MSFC	APO, LMSO, AMS Collaboration, OZ	2.2.7
PDL	MSFC/LMSO	APO, AMS, OZ	2.2.8
Mission Planning, Training & MCC	DA, OZ	APO, LMSO, AMS Collaboration	2.2.9
Mission Integration Plan (MIP) (Including Annexes)	MO	APO, LMSO, OC, OZ	2.2.10
NSTS/AMS ICD-A-TBD		APO, LMSO, OZ, NA	

Additional detail on support responsibilities can be found in Section 2.2.

TABLE 2-2 AMS SUPPORT FACILITIES REQUIREMENTS (JSC)

• J13 – SML (Structures and Mechanics Laboratory) (for component Static Testing)
• J14 – EMI (Electromagnetic Interference) Chamber
• J16 – SAIL (Shuttle Avionics Integration Laboratory) & OIU (Orbiter Interface Unit) Laboratory
• J32/J33 – Thermal Vacuum Chambers (Thermal Vacuum & Thermal Cycle)
• J44 – ESTL (Electronic Systems Test Laboratory)
• J49 – VATF (Vibration and Acoustic Test Facility)
• J8 – Photolab Facility
• J9/J10 – Manufacturing and Materials Processing
• J9 – SVMF (Space Vehicle Mockup Facility)
• NBL (Neutral Buoyancy Laboratory)
• HITF (Hypervelocity Impact Technology Facility)
• J16 – High Bay Controlled Storage Facility
• J50 – High Bay Controlled Storage Facility

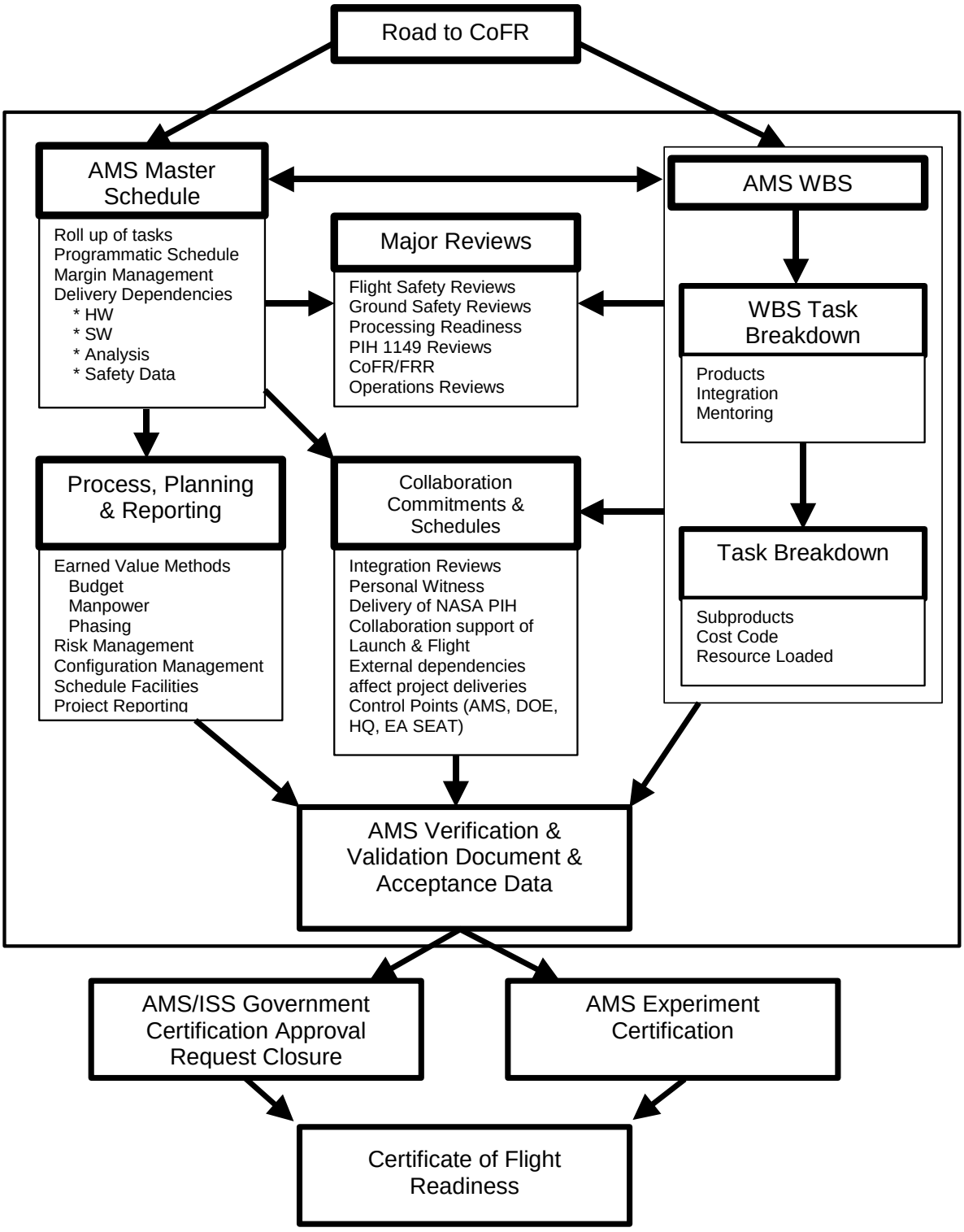

Figure 2-2 AMS ROAD TO CoFR

3.0 APPLICABLE AND REFERENCE DOCUMENTS

The reference documents that form part of this Project Plan are shown in Table 3-1 and are applicable to AMS as specified herein or in the AMS PTRS. The current document issue in effect on the date of approval of this Project Plan shall apply unless otherwise noted. A notation of "Current issue" after date of approval indicates all future changes and revisions are applicable to the AMS project as stated above. Updates to the AMS Applicable and Reference Document list and their corresponding call-out in this and other AMS documents must be carefully considered as they may have significant impact to the hardware requirements, engineering, design, development, test, verification and operations. The documents have been broken out into ISS/STS Program Requirement Documentation and Miscellaneous (Misc.) Documentation for readability. AMS deliverable documentation can be found in Section 4.0.

TABLE 3-1 APPLICABLE AND REFERENCE DOCUMENTS

STS/ISS DOCUMENT NUMBER	REVISION / RELEASE DATE	DOCUMENT TITLE
NSTS 21000-IDD-ISS	A CPN 27 2/18/98 12/07/01	International Space Station Interface Definition Document
NSTS 1700.7	B 05/11/01	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 1700.7 ISS Addendum	Basic 02/01/02	Safety Policy and Requirements for Payloads Using the International Space Station
SSP 30233	F 07/16/99	Space Station Requirements for Materials and Processes
SSP 30243	G 7/32/02	Space Station Requirements for Electromagnetic Compatibility
SSP 30312	H 11/22/99	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP 52054	B 05/01	ISS Program Payloads Certificate of Flight Readiness Implementation Plan, Generic

STS/ISS DOCUMENT NUMBER	REVISION / RELEASE DATE	DOCUMENT TITLE
SSP 57003	Basic IRN-0001 11/18/99 06/21/01	Attached Payload Interface Requirements Document
SSP 57004	Basic IRN-0001 9/22/99 05/16/01	Attached Payload Interface Control Document Template

MISC. DOCUMENT NUMBER	REVISION / RELEASE DATE	DOCUMENT TITLE
EA-WI-023	D Feb-04	Project Management of GFE Flight Projects
EA-WI-025	A Nov-01	GFE Flight Project Software and Firmware Development
IPC 2221	Basic Amendment-1 02/01/98 Jan 2000	Generic Standard on Printed Board Design
IPC 6011	Basic 02/01/98	Generic Performance Specification for Printed Boards
IPC 6012	A Amendment-1 10/99 Jul 2000	Qualification and Performance for Rigid Printed Boards
JPD 5335.1	C 1/16/01	JSC Quality Manual
JPG 8500.4	H 03/12/04	JSC Engineering Drawing Practices
JSC 27301	D 02/14/02	Materials Control Plan for JSC Flight Hardware
JSC 61360	A 07/98	Engineering Directorate Certified Parts Approval Process
JSC-SPEC-M1	B Nov 1985	Specification Marking, Identification, and Inspection

MISC. DOCUMENT NUMBER	REVISION / RELEASE DATE	DOCUMENT TITLE
MSFC-HDBK-527/JSC-09604	F 9/30/88	Materials Selection List for Space Hardware Systems
NASA-STD-8739.1	Basic 8/6/99	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
NASA-STD-8739.2	Basic 08/31/1999	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Basic Chg 2 12/15/97 01/18/01	Soldered Electrical Connections
NASA-STD-8739.4	Basic 2/9/98	Crimping, Interconnecting Cables, Harnesses, and Wiring
NASA-STD-8739.5	Basic 02/09/98	Fiber Optic Terminations, Cable Assemblies, and Installation
NPR 6000.1	F 04/26/99	Requirements for Packaging, Handling and Transportation for Aeronautical and Space System Equipment and Associated Components
SE-M-0096	A 06/28/82	General Specification For Materials and Processes Requirements for JSC Controlled Payloads,
SN-C-0005	D Chg 7 07/20/98 06/27/01	Space Shuttle Contamination Control Requirements
DODR-4500.32R	Vol. 1, Vol. 2 3/15/87 2/15/87	Military Standard Transportation and Movement Procedures
MIL-STD-129	N 5/15/97	Standard Practice for Military Marking
MIL-STD-130	K 1/15/00	Identification Marking of U.S. Military Property
MIL-STD-2073-1	D Notice 1 12/15/99 05/10/02	Standard Practice for Military Packaging
ANSI/ESD S20.20-1999	1999	Standard for the Development of an ESD Control Program

ORDER OF PRECEDENCE

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence. All specifications, standards, exhibits, drawings or other documents that are invoked as “applicable” in this specification are incorporated as cited. All documents that are referred to by an applicable document are considered to be for guidance and information only, with the exception of ICDs, which shall have their applicable documents considered to be incorporated as cited.

4.0 REQUIREMENTS

4.1 PROGRAM REQUIREMENTS

The primary goal of the AMS Project is to successfully build, certify and fly the AMS payload on the Shuttle and ISS. The NASA AMS Project Office (APO) resides in the JSC Engineering Directorate. The APO is responsible for the development, certification, and mission success of the Payload Integration Hardware (PIH) and its associated Ground Support Equipment (GSE) and Special Test Equipment (STE). Note that all STE is one time use hardware that is developed in support of a specific test. In addition, the APO is responsible for certifying the entire payload for flight safety and integration of the entire payload into the ISS and STS programs. The U.S. Department of Energy and the AMS collaboration are responsible for development, certification, and mission success of the experiment components. The ISS program is responsible for physical and analytical integration as well as installation and on-orbit operations of the AMS payload on the ISS. This includes all necessary ICDs, Payload Integration Agreements, and increment-specific documentation. The STS program is responsible for the physical and analytical integration into the Space Shuttle, launch, operations on the STS, and transfer to ISS. This includes all necessary ICDs, MIPs, and other STS integration documentation.

The ISS and STS requirements for the AMS payload are listed in Table 3-1. Table 4-1 details all of the deliverable documentation that will be produced by the APO in cooperation with other NASA AMS team members. The developer of these documents is also listed as well as the control authorities. Figure 4-1, AMS Documentation Tree, shows the relationship of these documents and includes informational documents.

The APO is responsible for delivering all of the Payload Integration Hardware listed in Tables 4-2 and 4-3. The STS and ISS program are responsible for delivery of all of the hardware listed in Table 4-4. The APO will integrate the STS and ISS program provided hardware onto the other PIH; however, all certification of the STS and ISS program provided hardware will be done by STS or ISS.

The AMS is an unpressurized payload; however, the onboard command and control and backup data recording hardware will require a location in the pressurized volume of the Station so that onboard crew can operate that hardware for those functions. This equipment is referred to as the AMS Crew Operations Post (ACOP). That hardware has to meet the requirements for pressurized payloads that have requirements that are not applicable to truss site-attached

payloads. Although the ACOP will be addressed in all of the AMS documentation, the ACOP (which is provided by the AMS collaboration and not by NASA/JSC) will have its own set of requirements and verification documentation. Vehicle software to support the AMS payload is to be developed by and integrated by STS or ISS and will have requirements that will be documented in SSP 57313, "Alpha Magnetic Spectrometer (AMS) Software Interface Control Document." The closure of the software interface verifications will be part of the MVP. AMS Experiment internal software is the sole responsibility of the AMS Experiment team.

TABLE 4-1 AMS PROJECT DELIVERABLE DOCUMENTATION LIST

Document #	Document Name	Delivery Date	Responsibility	Control Authority
N/A	AMS Master Schedule	Update As Required	LM/APO/AMS	AMS CCB
JSC 27296 Appendix A	AMS WBS	Update As Required	LM/APO	AMS CCB
JSC 27296	Project Plan	PDR – CDR - Rebaselining	LM/APO	AMS CCB
JSC 27542	Configuration Management Plan	PDR – CDR - Rebaselining	LM/APO	AMS CCB
JSC 29789	Project Technical Requirements Specification	PDR – CDR - Rebaselining	LM/APO	AMS CCB
JSC TBD	Master Verification Plan	L-36	LM/APO	AMS CCB
JSC 29095	AMS to PIH ICD	PDR – CDR - Rebaselining	LM/APO	AMS CCB
JSC 29202	AMS to VC ICD	PDR – CDR - Rebaselining	LM/APO	AMS CCB
SSP 57113	AMS Payload Integration Agreement	CDR - Rebaselining	OZ	ISS PCB
SSP 57213	AMS to ISS H/W ICD	CDR - Rebaselining	OZ	ISS PCB
SSP 57313	AMS to ISS S/W ICD	L-12 – Preliminary L-3 - Final	OZ	ISS PCB
NSTS TBD	AMS to STS MIP	L-36	MO	SSP/ISS JIPT
NSTS TBD	AMS to STS ICD	L-30	MO	SSP/ISS JIPT

Document #	Document Name	Delivery Date	Responsibility	Control Authority
JSC 29075	Phase O/I Flight Safety Review Data Package	FSR Phase O/I	LM/APO	AMS CCB
JSC TBD	Phase II Flight Safety Review Data Package	FSR Phase II	LM/APO	AMS CCB
JSC TBD	Phase III Flight Safety Review Data Package	FSR Phase III	LM/APO	AMS CCB
JSC 29076	Phase O/I Ground Safety Review Data Package	GSR Phase O/I	LM/APO	AMS CCB
JSC TBD	Phase II Ground Safety Review Data Package	GSR Phase II	LM/APO	AMS CCB
JSC TBD	Phase III Ground Safety Review Data Package	GSR Phase III	LM/APO	AMS CCB
JSC TBD	AMS Verification Data and Acceptance Data Package	L-6	LM/EAPO	AMS CCB
JSC TBD	GCAR	L-4	LM/APO/NA	AMS CCB

TABLE 4-2 APO/LMSO PROVIDED FLIGHT HARDWARE

ITEM	UNITS
Cryomagnet Vacuum Case (VC) (Flight Article)	1
Safety Critical Meteoroid and Orbital Debris (M/OD) shields	at least 2
Payload Attach System (PAS) (Passive Half)	1
EVA Interface Panel (Interface to UMA)	1
Interface Panel A (Interface to ROEU/PDA)	1
Cabling from interface panels to J-Crate and PDB	1
Digital Data Recording System (DDRS–02) and associated cabling/interface cards/software	1
Thermal Blankets	6
Unique Support Structure-02 (USS-02)	1
Brackets to interface the EBCS, FRGF, PVGF, ROEU/PDA, and UMA to the USS-02	1 Each

TABLE 4-3 APO/LMSO PROVIDED GSE

ITEM	UNITS
VC Structural Test Article (STA) (NOTE: VC STA also serves as Flight Spare VC)	1
Primary Support Stand (PSS)	1
Lower USS Support Fixture	1
Primary Lifting Fixture	1
Multi-purpose Lifting Fixture	2
Intermediate Support Fixtures	4
USS-02 Assembly Fixture	1
Vacuum Case Test Fixture (VCTF)	1
Special Test Equipment (STE) for Structural Testing	Multiple
Neutral Buoyancy Laboratory (NBL) Mockup	1
VC/Magnet Shipping Fixture	2

TABLE 4-4 NASA STS/ISS PROVIDED FLIGHT HARDWARE

ITEM	UNITS
Electronic Berthing Camera System (EBCS) w/cables	1
EVA (Extravehicular Activity) Handrails	10 or less
Flight Releasable Grapple Fixture (FRGF)	1
Portable Foot Restraints (PFR) Worksite Interface Fixture (WIF)	1
Power Video Grapple Fixture (PVGF) w/cables	1
Remotely Operated Electrical Umbilical/Payload Disconnect Assembly (ROEU/PDA) w/cables	1
Umbilical Mechanism Assembly (UMA) (Passive Half) w/cables	1

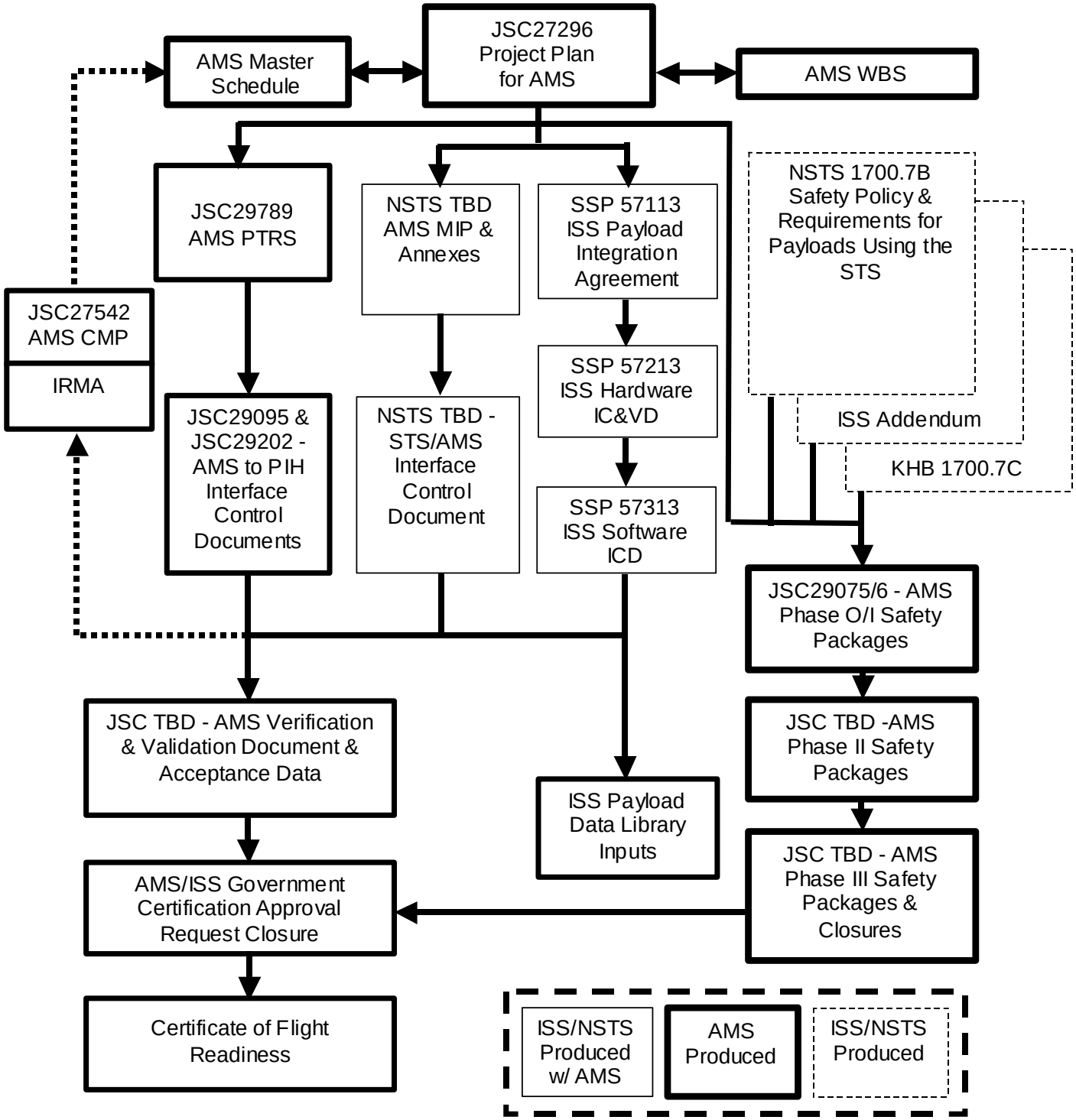

Figure 4-1 AMS DOCUMENTATION PROCESS FLOW

4.1.1 CONFIGURATION MANAGEMENT FOR MAJOR INTEGRATION STEPS

4.1.1.1 Purpose

The configuration management requirements, responsibilities and procedures are contained in JSC-27542, "AMS Configuration Management Plan (CMP)." All changes to this Project Plan shall be controlled by the AMS Configuration Control Board as delegated by the Director, Engineering Directorate. Documents jointly controlled (if applicable) by the CMP and the Shuttle Program are also in accordance with NSTS 07700, Volume IV, "Space Shuttle Configuration Management Requirements." Documents jointly controlled by the CMP and the International Space Station Program are also in accordance with SSP 50123-01, "Configuration Management Handbook, Volume 1." The purpose of this plan is to establish and implement an AMS configuration management system (CMS) to manage and control the following:

- AMS Payload Integration Hardware design requirements
- Interfaces (structural/mechanical, cable, display and control, command, telemetry and data) to Orbiter, ISS and to the AMS Experiment resource requirements consisting of power, weight, volume, and crew time
- AMS PIH software requirements
- Mission requirements

This process will ensure that all proposed changes to the baseline are evaluated and dispositioned in an orderly and coordinated manner and will maintain compatibility of the AMS Payload with the Orbiter and with the International Space Station.

4.1.1.2 Design Reviews

Configuration of the integration hardware equipment will be established through appropriate design reviews. The AMS Preliminary and Critical Design Reviews (PDR/CDR) were supported by a design review committee appointed from various JSC and AMS organizations and chaired by the NASA/JSC AMS Project Manager. The reviews were conducted in accordance with the guidelines as described in EA-WI-023.

4.1.1.3 Baseline Design Configuration

A baseline configuration for payload integration hardware will be released via drawings and documentation in accordance with JPG 8500.4, Rev H, "JSC Engineering Drawing Practices." These drawings shall define the configuration sufficiently to allow end item identification, end

item modification, and end item fabrication/assembly, and safety assessment, as appropriate. Note that the AMS-02 PIH PDR and CDR were both completed prior to the project handover from SM to EA.

4.1.1.4 Fabrication and Assembly

Fabrication and assembly of flight integration hardware will follow the baseline design configuration and will be inspected to the requirements specified therein. Task Performance Sheets (TPSs) will be used to ensure conformance to the baseline design requirements. Data Package Requirements shall be satisfied by use of JSC Form 911 (JSC Projects Parts Tag) and/or JSC Form 772 (Functional Equipment Historical Record) will be used to track all hardware. Fabrication and assembly of experiment hardware will be performed by various AMS collaboration members. These members will utilize a quality system of their choosing to build and certify their hardware.

4.1.1.5 Testing and Verification

PIH and safety critical experiment verification testing shall be accomplished with approved test procedures or TPSs. Verification shall be accomplished in accordance with JSC TBD AMS MVP. Verification tests shall be performed using flight items with the exception of some of the structural testing.

4.1.1.6 AMS Payload Training

Payload training of the ISS crew, AMS trainees and operations personnel will be accomplished using AMS ground hardware, AMS training hardware and AMS flight hardware. This training will be implemented by the JSC-36307, "NASA Training Implementation Plan (TIP)."

4.1.1.7 AMS Payload Operations

The AMS payload will be operated from an AMS Payload Operations Control Center which will have communications, video and data interfaces with the Payload Operations Control Center at MSFC. The payload operations will be in accordance with SSP 58311, Volume 1, "Payload Operations Integration Center Payload Operations Handbook" and SSP 58312, Volume 2, "Payload Operations Integration Center Payload Operations Handbook – Increment Operations." AMS payload operations include prelaunch activities to confirm Launch Commit Criteria, operations during ascent to open a vent valve for the dewar system, STS on-orbit check out of the experiment, transfer operations from the STS to the ISS, check out on the ISS, and nominal

operations on the ISS. During shuttle operations the AMS POC at JSC will interface with Mission Control Center in Houston.

4.1.2 PROGRAM DOCUMENTATION REQUIREMENTS

Table 4-1 shows the documentation required for AMS on the International Space Station including the requirements on the payloads that are needed to meet the Space Shuttle requirements. Figure 4-1 shows the documentation process that will be followed by AMS.

The AMS requirement documents can be found in Section 3.0.

4.1.3 SAFETY AND MISSION ASSURANCE REQUIREMENTS

The requirements for STS and ISS Flight Payload Safety and KSC Ground Processing Safety are per documents listed in Table 4-1, ISS/STS/AMS Documentation List. The methods of implementation, verification and closure are also per the documents listed. The overall AMS payload safety is the ultimate responsibility of the NASA Project Manager; however, all other organizations will be actively involved in the safety process. The major organizations and/or functions are: AMS Payload Project Manager, JSC STS Mission Management, ISS Management, LMSO and the AMS Experiment Collaboration.

Per the Implementing Arrangement Between the Department of Energy and NASA (Signed September 20, 1995), the requirements for reliability and performance of the AMS Experiment are the responsibility of the sponsoring organization (Department of Energy) and the AMS Experiment Collaboration.

The responsibility for the AMS integration function is with NASA Project Manager. The reliability and performance of the overall AMS payload will be considered continuously by all parties of the integrated AMS team in the process of design, development, engineering and test of the AMS payload. NASA has no responsibility for mission success for the experiment; however, when necessary, NASA will make recommendations for improvement in the experiment design that will potentially enhance mission success probabilities.

The requirements of NSTS 1700.7B, “Safety Policy and Requirements for Payloads Using the Space Transportation System;” NSTS 1700.7B ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space Station”; 45 SW HB S-100/KHB 1700.7, “Space Shuttle Payload Ground Safety Handbook;” and LMSMSS 31039, “Safety and Health Plan

Science, Engineering, Analysis, and Test Contract" shall apply. Flight hazards shall be reviewed and approved by the JSC Payload Safety Review Panel (PSRP) and ground hazards by the KSC Ground Safety Panel in accordance with NSTS/ISS 13830, "Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle and the International Space Station."

4.2 DESIGN REQUIREMENTS

The design requirements for the PIH are fully defined in JSC 29789, Project Technical Requirements Specification.

5.0 FACILITY REQUIREMENTS

JSC manufacturing, storage and test facilities will be required to conduct some of the tasks listed below. The AMS Project Manager will coordinate schedules with each facility as required. Funding for the tests/facilities will be provided by the Engineering Directorate as required, and the appropriate test request forms will be submitted.

5.1 SPACE ENVIRONMENTAL SIMULATION LABORATORY

Thermal vacuum chamber(s) in the Space Environmental Simulation Laboratory (SESL), JSC Building 32 or 33 may be used, as required, for engineering and verification testing of the AMS payload hardware in a space thermal vacuum environment.

5.2 VIBRATION AND ACOUSTIC TEST FACILITY

Test facilities in the Vibration and Acoustic Test (VATF), JSC building 49, may be used for shock and vibration testing of AMS payload hardware for verification testing as specified in JSC 28792, AMS Structural Verification Plan.

5.3 EMI/EMC TEST FACILITY

The EMI/EMC test facility in JSC Building 14 may be used as required for testing the AMS payload hardware and selected components to ensure compatibility with the EMI requirements specified in SSP 57003, Attached Payload Interface Requirements Document.

5.4 ORBITER INTERFACE UNIT LABORATORY

The Orbiter Interface Unit (OIU) Laboratory will be used for testing the OIU/AMS MIL-STD-1553 data bus system.

5.5 ELECTRONIC SYSTEM TEST LABORATORY

The Electronic Systems Test Laboratory (ESTL) located in JSC Building 44 will used as required for testing the AMS Ku-Band interface.

5.6 STRUCTURES AND MECHANICS LABORATORY

The Structures and Mechanics Laboratory (SML) in JSC Building 13 may be used for the AMS static test and modal test. The Vacuum Case STA, several AMS-02 component STAs and the

flight USS-02 may be used in the tests. The test results will be used to correlate the AMS-02 finite element model (FEM).

5.7 INTEGRATION AND STORAGE FACILITIES

JSC Building 10, 16, and 50 shall be used as the integration and storage facilities for the AMS payload integration hardware prior to shipping to the AMS Experiment in Europe or to KSC.

5.8 HYPERVELOCITY IMPACT TECHNOLOGY FACILITY

This Hypervelocity Impact Technology Facility (HITF) at White Sands will be used for assessing the damage to various AMS materials that will be exposed on orbit. The AMS team will use the data to estimate failure probability of the AMS experiment operation during its residence on the ISS.

5.9 SPACE VEHICLE MOCKUP FACILITY

The Space Vehicle Mockup Facility (SVMF) will be used for assessing fit and function of the AMS payload on the ISS truss and the fit, function and operation of the ACOP items stowed and operated in the ISS pressurized volume. The facility will also be used for some integrated training, training for removal, translation and deployment of the AMS on the truss, and training for the removal from the truss, translation and placement/attachment in the STS payload bay.

5.10 MANIPULATOR DEVELOPMENT FACILITY

The Manipulator Development Facility (MDF) may be used with an AMS mockup to assess manipulator requirements for operations stated in section 5.9.

5.11 NEUTRAL BUOYANCY LABORATORY

A mockup of the AMS payload will be used in the Neutral Buoyancy Laboratory (NBL) to evaluate payload movement as described in sections 5.9 and 5.10 and to evaluate EVA requirements. The NBL will be used for crew training for possible EVAs in the AMS vicinity and to evaluate access to various locations on the AMS.

5.12 KENNEDY SPACE CENTER FACILITIES

Facilities will be required at KSC for pre-flight testing and payload integration. Two electrical and data interface tests will occur at KSC. They include the Functional Interface Test (FIT) and the KSC Interface Test (KIT).

The following engineering tests will be performed at KSC during the processing of the payload for launch. At times when engineering processing or test are not being performed at the locations listed below, the AMS instrument should be available for science verification testing, baseline data collection and/or calibration.

5.12.1 OFF-LINE PAYLOAD PROCESSING FACILITY

Functional checkout of the AMS payload shall be performed during the off-line testing in the Multi-Purpose Payload Processing Facility (MPPF) or other payload processing facility as designated by KSC. This processing will include cryogenic servicing of the superfluid helium dewar on the AMS.

5.12.2 SPACE STATION PROCESSING FACILITY

Both the FIT and the KIT shall be performed at the Space Station Processing Facility (SSPF) using the Payload Test and Checkout System (PTCS) and the Cargo Integration Test Equipment (CITE). In addition, a CITE end-to-end test will be performed utilizing the Orbiter Ku-Band system while the Orbiter is in the Orbiter Processing Facility (OPF). KSC may designate facilities other than the SSPF for this testing listed above with the exception of the CITE testing. This processing will include cryogenic servicing of the superfluid helium dewar on the AMS.

5.12.3 ORBITER PROCESSING FACILITY

An Interface Verification Test (IVT) (i.e., AMS payload to Ku-Band interface) shall be performed at the KSC OPF utilizing an AMS payload simulator and the Space Shuttle flight Ku-Band antenna.

5.12.4 LAUNCH PAD & MOBILE LAUNCH PLATFORM

Launch pad procedures will include removal of any protective covers from the AMS payload, closeout photos, etc. IVT of the AMS payload with the Orbiter will be performed as well as an S-Band end-to-end test from the AMS Payload in the Orbiter to the Payload Operations Integration Center (POIC) and on to the AMS Payload Operations Center. This processing will include cryogenic servicing of the superfluid helium dewar on the AMS.

AMS flight support equipment will be located inside the Mobile Launch Platform (MLP) during integration prior to launch and during the launch itself. This hardware will be used to communicate with the AMS payload through the T0 connector and through the ROEU. The data

received from the payload will include adequate information to provide a go/no-go call on all of our launch commit criteria.

6.0 RISK MANAGEMENT

The AMS project shall assess the current and planned activity to identify specific risks to meeting project objectives. The AMS Risk Management System is derived from the ISS Program Office Integrated Risk Management Application. The AMS Risk Management Score Card (Table 6-1) has been modified to better reflect the AMS program. These risks will be updated every month and reported to the AMS Configuration Control Board. The AMS IRMA tool can be found at:

http://irma.jsc.nasa.gov/ams/

This tool will provide a tracking number, description, open date, estimated closure date, actual closure (or accepted status) date, mitigation plan, likelihood and consequence ranking (5x5 red/yellow/green matrix), criteria for ranking based on AMS project requirements and objectives, risk owner and various tracking reports.

For AMS purposes, a Risk is any circumstance or situation that poses a threat to: crew or vehicle safety, program controlled costs, program controlled schedule, or major mission objectives and for which an acceptable resolution is deemed unlikely without a focused management effort. Detailed risk mitigation plans must be developed, documented, tracked, implemented, and followed through for successful risk mitigation. A Concern is a low-level item that lacks maturity or definition and is 'too far over the horizon', but nonetheless should be monitored and tracked for early mitigation or is an issue that has not yet been reviewed by the corresponding functional group or team to determine validity. All potential risks that are related to AMS experiment mission success will be marked as a Concern unless the AMS representative to the CCB approves its elevation to a Risk.

When determining the likelihood of a risk, the criteria have been established and will be used by the AMS project to properly score the risk item. If the risk is a safety risk, then a fault tolerance approach or a design for minimum risk approach can be used. For the fault tolerance approach, a likelihood of '1' indicates that the risk requires more than two faults to occur. A likelihood of '2' indicates that the risk requires two faults to occur. A likelihood of '5' indicates that the risk requires a single fault to occur. When using a design for minimum risk approach, a likelihood of '1' indicates that the risk will occur no more than once in 4 mission life cycles. A likelihood of '2' indicates the risk will occur in 1-4 mission life cycles. A likelihood of '3' indicates the risk will occur 1-2 times in the mission life cycle. A likelihood of '4' indicates the risk will occur 2-

8 times in the mission life cycle. A likelihood of '5' indicates the risk will occur 8 or more times in the mission life cycle. If the risk is not safety related, and the general categories defined in Table 6-1 can not be used, a probability of occurrence can be used. A likelihood of '1' indicates a probability of <0.1%, '2' indicates 0.1%-1%, '3' indicates 1%-10%, '4' indicates 10%-99%, and '5' indicates 99% or greater. This is based on each likelihood level increasing by an order of magnitude.

TABLE 6-1 AMS RISK MANAGEMENT SCORECARD

Level	Likelihood	Consequence			
		Cost	**Schedule**	**Safety**	**Mission Success**
1	Remote	No NASA Cost Impact	10% or greater Management Reserve	No hazardous impact to safety of vehicle, crew or other payload exists	No science impact
2	Less Remote	Within Current Budget	5%-10% Management Reserve	Hazard has been mitigated to the full and complete compliance of safety requirements with standard controls	Workaround required in one or more experiments, or Helium supply depleted in 18-36 months.
3	Unlikely	Requires Project Contingency Funds	0.1%-5% Management Reserve	Hazard has been mitigated and is compliant with safety requirements with use of non-standard controls	Impact to science in one or more detectors, or Helium supply depleted 6-18 months, or loss of some scientific data
4	Likely	Requires HQ Contingency Funds	Launch Ready Jan ‘08	Hazard required a non-compliance report/waiver to achieve safety compliance	Loss of one or more detectors, or Helium supply depleted <6 month
5	Very Likely	Requires new allocation from HQ	Launch Ready after Jan ‘08	Hazard is not mitigated in conjunction with the applicable safety requirements	Complete loss of science

APPENDIX A: AMS Project Work Breakdown Structure

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
X	**1.0**	**Management & Control**	LM/EA	Overall project management reports & schedules
	1.1	**Requirements Definition**	LM/EA	Planning for requirements definition
	1.1.1	**General Administrative**	LM/EA	
	1.1.2	**Pricing**	LM/EA	
	1.1.3	**Scheduling**	LM/EA	
	1.1.4	**Estimating & Variance Analysis**	LM/EA	
	1.2	**Design**	LM/EA	Planning for design definition
	1.2.1	**General Administrative**	LM/EA	
	1.2.2	**Pricing**	LM/EA	
	1.2.3	**Scheduling**	LM/EA	
	1.2.4	**Estimating & Variance Analysis**	LM/EA	
	1.3	**Flight Production & Certification**	LM/EA	Planning for production & certification including logistics/transportation costs
	1.3.1	**General Administrative**	LM/EA	
	1.3.2	**Pricing**	LM/EA	
	1.3.3	**Scheduling**	LM/EA	
	1.3.4	**Estimating & Variance Analysis**	LM/EA	
	1.3.5	**Logistics & Transportation**	LM provides logistics support - Transportation provided by NASA/JB7	Planning for deployment including logistics/transportation costs
	1.4	**Deployment**	LM/EA	
	1.4.1	**General Administrative**	LM/EA	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	1.4.2	**Pricing**	LM/EA	
	1.4.3	**Scheduling**	LM/EA	
	1.4.4	**Estimating & Variance Analysis**	LM/EA	
	1.4.5	**Logistics & Transportation**	LM provides logistics support - Transportation provided by NASA/JB7	Planning for operations including logistics/transportation costs
	1.5	**Operations**	LM/EA	
	1.5.1	**General Administrative**	LM/EA	
	1.5.2	**Pricing**	LM/EA	
	1.5.3	**Scheduling**	LM/EA	
	1.5.4	**Estimating & Variance Analysis**	LM/EA	
	1.5.5	**Logistics & Transportation**	LM provides logistics support - Transportation provided by NASA/JB7	
	2.0	**Systems Engineering & Integration**	LM/EA	Systems Engineering & Integration Documentation & Drawings
X	**2.1**	**Requirements Definition**	LM/EA	Payload documentation & integration
	2.1.1	**Payload Specific Documentation**	LM/EA	
	2.1.1.1	Structural Verification Plan	LM Responsibility	SVP
	2.1.1.2	Project Technical Requirements Specification	LM Responsibility	PTRS
	2.1.1.3	Payload Integration Agreement	OZ Responsibility - LM provides input data	PIA
	2.1.1.4	Mission Integration Plan	MA Responsibility - LM provides input data	MIP
	2.1.1.5	Project Plan for AMS-02	LM - Document Complete - will need update for new system (formerly PRD/PMP)	Project Plan
	2.1.1.6	Configuration Management Plan	LM - Document Complete - will need update for new system	CMP
	2.1.1.7	ISS ICD (Includes ISS Verification Plan)	OZ Responsibility - LM provides input data	ISS ICD

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	2.1.1.8	STS ICD	MA Responsibility - LM provides input data	STS ICD
	2.1.1.9	AMS ICD	LM Responsibility	
	2.1.1.9.1	PIH ICD	Excludes VC Interfaces - Document signed, but needs updates	AMS to PIH ICD
	2.1.1.9.2	VC ICD	Document complete - VC designed to meet	VC ICD
	2.1.1.10	ISS Software ICD	OZ Responsibility - LM provides input data	ISS Software ICD
	2.1.1.11	AMS-02 Master Verification Plan	LM Responsibility – NA/NT provides input data	AMS-02 Master Verification Plan
	2.1.2	**ISS Coordination**	LM	
	2.1.3	**STS Coordination**	LM	
X	**2.2**	**Design**	LM/AMS	
	2.2.1	**Preliminary Design Review**	LM - Complete	PDR Data Package - Presentations - RID tracking
	2.2.2	**Critical Design Review**	LM - Complete	CDR Data Package - Presentations - RID tracking
X	**2.3**	**Flight Production & Certification**	LM/EA/AMS	
	2.3.1	**SR&QA**		
	2.3.1.1	**Flight Safety Reviews**	LM/EA/NC	FSR Data Package - Presentations - Issue Tracking
	2.3.1.2	**Ground Safety Reviews**	LM/EA/NC	GSR Data Package - Presentations - Issue Tracking
	2.3.1.3	**Quality Assurance for Payload Integration Hardware**	LM/EA/NT	QA support for all PIH
	2.3.1.4	**Reliability for Payload Integration Hardware**	LM/EA/NT	Reliability support for all PIH
	2.3.1.5	**COFR AMS Payload**	LM/EA/NT/AMS	COFR documentation development
	2.3.1.6	**Configuration Management**	LM/EA/AMS	CM support for entire project
	2.3.1.7	**Risk Management**	LM/EA/AMS	Risk Identification and Mitigation Planning
	2.3.1.8	**Quality Assurance for Experiment Hardware/software**	AMS - Not NASA Responsibility	QA support for experiment hardware/software - Not NASA responsibility

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	2.3.1.9	**Reliability for Experiment Hardware/software**	AMS - Not NASA Responsibility	Reliability support for experiment hardware/software - not NASA responsibility
	2.3.2	**Overall Certification Testing**	LM	
	2.3.2.1	**Full-up Static Test**	LM	Test Report
	2.3.2.1.1	Pre-test analysis and planning	LM	Test Plan
	2.3.2.1.2	Test	LM - Using IABG Facility in Munich - Facility costs may be paid by DLR	Test Data
	2.3.2.1.3	Post-test analysis and reporting	LM	Test Report & Analysis
	2.3.2.2	**Full-up Modal Test**	LM	Test Report
	2.3.2.2.1	Pre-test analysis and planning	LM	Test Plan
	2.3.2.2.2	Test	LM - Using IABG Facility in Munich - Facility costs may be paid by DLR	Test Data
	2.3.2.2.3	Post-test analysis and reporting	LM	Test Report & Analysis
	2.3.3	**Systems Acceptance Review**	LM/EA	SAR documentation
X	**2.4**	**Deployment**	LM/AMS	Deployed AMS Payload
	2.4.1	**STS & ISS Integrated Analyses**	LM	
	2.4.1.1	**Structural Analyses**	LM	Integrated structural analysis reports
	2.4.1.1.1	Finite Element Model Correlation	LM	FEM Correlation Reports
	2.4.1.1.2	STS Coupled Loads Analyses	LM/MA	CLA Report
	2.4.1.1.3	ISS Loads Analyses	LM/OB	FEM & ISS Integrated Report
	2.4.1.2	**Thermal Analyses**	LM	Integrated thermal analysis reports
	2.4.1.2.1	Thermal Model Review & Integration	LM	Final Thermal Model
	2.4.1.2.2	STS Analyses	LM/MA	STS Thermal analysis report
	2.4.1.2.3	ISS Analyses	LM/OB	ISS Thermal analysis report

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	2.4.2	**Integration in Culham, England**	LM/CGS - LM responsible for all PIH	Integrated STA magnet & Flight magnet
	2.4.3	**Integration in Geneva, Switzerland**	LM/AMS - LM responsible for all PIH	Integrated AMS Payload
	2.4.4	**Flight Readiness Review**	LM/EA	FRR Report & Presentation
	2.4.5	**Off-line Integration at KSC**	LM/AMS	Integrated AMS Payload
	2.4.6	**On-line Integration at KSC**	LM/AMS/OZ/MA	AMS Payload in Shuttle ready for launch
X	**2.5**	**Operations**	LM/AMS	
	2.5.1	**NBL Testing**	LM/XA/MOD - Test Complete	NBL test report
	2.5.1.1	Pre-test analysis and planning	LM	Test Plan
	2.5.1.2	Test	LM/XA	Test Data
	2.5.1.3	Post-test analysis and reporting	LM	Test Report & Analysis
	2.5.1	**Training**	LM/MOD	Training Data, Manual, Reports
	2.5.2	**MCC Support**	LM/MOD	MCC support before and during mission
	2.5.3	**KSC Support**	LM/KSC/OZ	KSC support before, during, & after launch
	2.5.4	**Post Launch Support**	LM/KSC	All remaining PIH dispositioned to storage location
	3.0	**AMS Experiment Mentoring & Integration**	LM/EA	All experiment components integrated into PIH
X	3.1	**Cryomagnet Subsystem**	AMS - ETH Zurich Developing Cryomagnet Subsystem	Integrated & certified Cryomagnet System
X	3.1.1	**SFHe Tank**	AMS - Hardware in Manufacturing at HBE - 2 in production	Integrated & certified SFHe Tank System
	3.1.1.1	Mentoring	LM	Safety and Integration Reports
	3.1.1.1.1	Welding Oversight	LM/ES	Safety and Integration Reports
	3.1.1.1.2	Pressure System Oversight	LM/EP	Safety and Integration Reports
	3.1.1.2	Integration	LM - Integration into LM VC (STA and Flight)	Integration Drawings

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	3.1.2	**Magnet System**	AMS - Hardware in Manufacturing at SCL	Integrated & certified magnet
	3.1.2.1	Mentoring	LM - help from LM Palo Alto	Safety and Integration Reports
	3.1.2.2	Integration	LM - Integration into LM VC (STA and Flight)	Integration Drawings
	3.1.3	**Cryogenic System**	AMS - Hardware in Manufacturing/Design at SCL	Integrated & certified cryogenic system
	3.1.3.1	Mentoring	LM - help from LM Palo Alto	Safety and Integration Reports
	3.1.3.1.1	Welding Oversight	LM/ES	Safety and Integration Reports
	3.1.3.1.2	Pressure System Oversight	LM/EP	Safety and Integration Reports
	3.1.3.2	Integration	LM - Integration with LM VC (STA and Flight)	Integration Drawings
X	3.1.4	**Non-linear Support Strap System**	AMS - Hardware in Manufacturing/Certification at SCL	Integrated & certified support strap system
	3.1.4.1	Mentoring	LM - help from LM Palo Alto	Safety and Integration Reports
	3.1.4.2	Integration	LM - help from LM Palo Alto and Denver - Includes strap tests	Integration Drawings
	3.1.4.2.1	Non-linear Dynamic Strap Test	LM/SCL	Dynamic strap test report
	3.1.4.2.1.1	Pre-test analysis and planning	LM	Test Plan
	3.1.4.2.1.2	Test	LM	Test Data
	3.1.4.2.1.3	Post-test analysis and reporting	LM	Test Report & Analysis
	3.1.4.2.2	Non-linear Static Strap Test	LM	Static strap test report
	3.1.4.2.2.1	Pre-test analysis and planning	LM	Test Plan
	3.1.4.2.2.2	Test	LM	Test Data
	3.1.4.2.2.3	Post-test analysis and reporting	LM	Test Report & Analysis
X	3.1.5	**STA Cryomagnet Acoustic Test**	LM/SCL	Acoustic Test Report
	3.1.5.1	Pre-test analysis and planning	LM	Test Plan

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	3.1.5.2	Test	LM - Using ESTEC Facility in Noordwijk, The Netherlands	Test Data
	3.1.5.3	Post-test analysis and reporting	LM	Test Report & Analysis
X	3.1.6	**STA Cryomagnet Sine Sweep Test**	LM/INFN/SCL	Sine Sweep Test Report
	3.1.6.1	Pre-test analysis and planning	LM	Test Plan
	3.1.6.2	Test	LM - Using INFN Facility in Terni, Italy	Test Data
	3.1.6.3	Post-test analysis and reporting	LM	Test Report & Analysis
X	3.2	**Transition Radiation Detector**	AMS - RWTH Aachen Developing TRD Subsystem	Integrated & Certified TRD System
	3.2.1	**TRD Detector**	AMS - RWTH Aachen Developing TRD Detector Subsystem	Integrated & Certified TRD Detector
	3.2.1.1	Mentoring	LM	Safety and Integration Reports
	3.2.1.1.1	Pressure System Oversight	LM/EP	Safety and Integration Reports
	3.2.1.2	Integration	LM - Integrate onto USS-02	Integration Drawings
	3.2.2	**TRD Gas Supply System**	AMS - MIT Developing TRD Gas Supply System	Integrated & Certified TRD Gas Supply System
	3.2.2.1	Mentoring	LM	Safety and Integration Reports
	3.2.2.1.1	Welding Oversight	LM/ES	Safety and Integration Reports
	3.2.2.1.2	Pressure System Oversight	LM/EP	Safety and Integration Reports
	3.2.2.1.3	Radiation Source Oversight	LM/NC	Safety and Integration Reports
	3.2.2.2	Integration	LM - Integrate onto USS-02	Integration Drawings
X	3.3	**Time of Flight Detectors**	AMS - INFN Bologna Developing TOF Detector Subsystem	Integrated & Certified TOF System
	3.3.1	**Upper TOF**	AMS - INFN Bologna Developing TOF Detector Subsystem	Integrated & Certified UTOF
	3.3.1.1	Mentoring	LM	Safety and Integration Reports

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	3.3.1.2	Integration	LM - Integrate onto USS-02	Integration Drawings
	3.3.2	**Lower TOF**	AMS - INFN Bologna Developing TOF Detector Subsystem	Integrated & Certified LTOF
	3.3.2.1	Mentoring	LM	Safety and Integration Reports
	3.3.2.2	Integration	LM - Integrate onto USS-02	Integration Drawings
X	3.4	**Tracker**	AMS - INFN Perugia/Geneva/Aachen Developing Tracker Detector Subsystem	Integrated & Certified Tracker
	3.4.1	**Mentoring**	LM	Safety and Integration Reports
	3.4.2	**Integration**	LM - Integrate onto USS-02 and VC	Integration Drawings
X	3.5	**Anti-Coincidence Counter**	AMS - RWTH Aachen Developing ACC	Integrated & Certified ACC
	3.5.1	**Mentoring**	LM	Safety and Integration Reports
	3.5.2	**Integration**	LM - Integrate on VC	Integration Drawings
X	3.6	**Ring Imaging Cherenkov Counter**	AMS - INFN Bologna Developing RICH Detector Subsystem	Integrated & Certified RICH
	3.6.1	**Mentoring**	LM	Safety and Integration Reports
	3.6.2	**Integration**	LM - Integrate on USS-02	Integration Drawings
X	3.7	**Electromagnetic Calorimeter**	AMS - INFN Pisa/LAPP Annecy/IHEP Beijing	Integrated & Certified ECAL
	3.7.1	**Mentoring**	LM	Safety and Integration Reports
	3.7.2	**Integration**	LM - Integrate on USS-02	Integration Drawings
X	3.8	**Electronics**	AMS - MIT/CSIST/CGS Developing Electronics	Integrated & Certified Electronics System
	3.8.1	**Mentoring**	LM	Safety and Integration Reports
	3.8.2	**Integration**	LM - Integrate on USS-02 - Majority of crates are mounted to radiators	Integration Drawings
	3.8.3	**STEP Avionics Interface Test**	LM/AMS - Test Complete	STEP Test Report

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	3.8.3.1	Pre-test analysis and planning	LM/AMS	Test Plan
	3.8.3.2	Test	LM/AMS	Test Data
	3.8.3.3	Post-test analysis and reporting	LM/AMS	Test Report & Analysis
	3.8.4	**Avionics Preliminary Integration Test**	LM/AMS - Test Complete	PIT Report
	3.8.4.1	Pre-test analysis and planning	LM/AMS	Test Plan
	3.8.4.2	Test	LM/AMS	Test Data
	3.8.4.3	Post-test analysis and reporting	LM/AMS	Test Report & Analysis
	3.8.5	**Avionics Functional Integration Test**	LM/AMS/OZ/MA/KSC	FIT Report
	3.8.5.1	Pre-test analysis and planning	LM/AMS	Test Plan
	3.8.5.2	Test	LM/AMS/OZ/MA/KSC	Test Data
	3.8.5.3	Post-test analysis and reporting	LM/AMS	Test Report & Analysis
	3.8.6	**Avionics KSC Integration Test**	LM/AMS/OZ/MA/KSC	KIT Report
	3.8.6.1	Pre-test analysis and planning	LM/AMS	Test Plan
	3.8.6.2	Test	LM/AMS/OZ/MA/KSC	Test Data
	3.8.6.3	Post-test analysis and reporting	LM/AMS	Test Report & Analysis
	3.8.7	**ESTL RS-422 Test**	LM/AMS/MA	RS-422 Test Report
	3.8.7.1	Pre-test analysis and planning	LM/AMS	Test Plan
	3.8.7.2	Test	LM/AMS/MA	Test Data
	3.8.7.3	Post-test analysis and reporting	LM/AMS	Test Report & Analysis
X	3.9	**Thermal Control System**	AMS - ETH/CGS/OHB/NLR/Geneva Developing TCS	Integrated & certified TCS
	3.9.1	**Radiators**	AMS - OHB/CGS	Integrated & certified Radiators

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	3.9.1.1	Mentoring	LM	
	3.9.1.1.1	Pressure System Oversight	LM/EP	
	3.9.1.2	Integration	LM - Integrate on USS-02	Integration Drawings
	3.9.2	**Tracker Thermal Control System**	AMS - NLR/Geneva Developing TTCS	Integrated & certified TTCS
	3.9.2.1	Mentoring	LM	
	3.9.2.1.1	Welding Oversight	LM/ES	
	3.9.2.1.2	Pressure System Oversight	LM/EP	
	3.9.2.2	Integration	LM - Integrate on USS-02 and VC	Integration Drawings
	3.9.3	**Overall Thermal Vacuum Test**	AMS/ESA	Thermal Vacuum Test Report
	3.8.7.1	Pre-test analysis and planning	AMS/ESA	Test Plan
	3.8.7.2	Test	AMS/ESA	Test Data
	3.8.7.3	Post-test analysis and reporting	AMS/ESA	Test Report & Analysis
	3.10	**AMS Crew Operations Post**	AMS - Not NASA Responsibility	Integrated ACOP System
	4.0	**Payload Integration Hardware Development, Integration & Certification**	LM/EA	All H/W & S/W
	4.1	**Flight Hardware**	LM/EA	All Flight H/W & S/W
X	4.1.1	**USS-02**	LM	USS-02
	4.1.1.1	Management & Control	LM	
	4.1.1.2	Requirements Definition	LM	
	4.1.1.3	Design	LM	
	4.1.1.4	Flight Production & Certification	LM - Overall Testing covered in Section 2.0 - Component tests covered here	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.1.1.5	Deployment	LM	
X	4.1.2	**Flight & STA VC**	LM	Flight and STA VC
	4.1.2.1	Management & Control	LM	
	4.1.2.2	Requirements Definition	LM	
	4.1.2.3	Design	LM	
	4.1.2.4	Flight Production & Certification	LM/STADCO - Overall Testing covered in Section 2.0 & 3.0 - Component test covered here	
	4.1.2.5	Deployment	LM	
X	4.1.3	**STS & ISS Integration Hardware**	LM	All STS & ISS Integration H/W
	4.1.3.1	Management & Control	LM	
	4.1.3.2	Payload Attach System	LM	Integrated PAS System
	4.1.3.2.1	Requirements Definition	LM/OZ	
	4.1.3.2.2	Design	LM	
	4.1.3.2.3	Flight Production & Certification	LM	
	4.1.3.2.3.1	PAS Static Test	LM - Test Complete	PAS Static Test Report
	4.1.3.2.3.1.1	Pre-test analysis and planning	LM	Test Plan
	4.1.3.2.3.1.2	Test	LM	Test Results
	4.1.3.2.3.1.3	Post-test analysis and reporting	LM	Test Report & Analysis
	4.1.3.2.3.2	PAS IVT at KSC	LM/OB - Test Complete	PAS IVT Report
	4.1.3.2.3.2.1	Pre-test analysis and planning	LM/OB	Test Plan
	4.1.3.2.3.2.2	Test	LM/OB	Test Results
	4.1.3.2.3.2.3	Post-test analysis and reporting	LM/OB	Test Report & Analysis

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.1.3.2.3.3	PAS Thermal Test	LM/EC	PAS Thermal Test Report
	4.1.3.2.3.3.1	Pre-test analysis and planning	LM	Test Plan
	4.1.3.2.3.3.2	Test	LM/EC - Test in Building 33	Test Results
	4.1.3.2.3.3.3	Post-test analysis and reporting	LM	Test Report & Analysis
	4.1.3.2.4	Deployment	LM - Integrate on USS-02	
	4.1.3.3	Electronic Berthing Cues System	LM - GFE request in PIA - worked through PIM	Integrated EBCS
	4.1.3.3.1	Requirements Definition	OM	Full requirements definition delivered to LM
	4.1.3.3.2	Design	OM	
	4.1.3.3.3	Flight Production & Certification	OM	Certified EBCS delivered to LM
	4.1.3.3.4	Integration	LM with requirement definition from OM - Includes Bracket	EBCS Bracket
	4.1.3.3.5	Deployment	LM - Integrate on PAS	
	4.1.3.4	Power Video Grapple Fixture	LM - GFE request in PIA - worked through PIM	Integrated PVGF
	4.1.3.4.1	Requirements Definition	OM	Full requirements definition delivered to LM
	4.1.3.4.2	Design	OM	
	4.1.3.4.3	Flight Production & Certification	OM	Certified PVGF delivered to LM
	4.1.3.4.4	Integration	LM with requirement definition from OM - Includes Bracket	PVGF Bracket
	4.1.3.4.5	Deployment	LM - Integrate on USS-02	
	4.1.3.5	Flight Releasable Grapple Fixture	LM - GFE request in PIA - worked through PIM	Integrated FRGF
	4.1.3.5.1	Requirements Definition	MA	Full requirements definition delivered to LM
	4.1.3.5.2	Design	MA	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.1.3.5.3	Flight Production & Certification	MA	Certified FRGF delivered to LM
	4.1.3.5.4	Integration	LM with requirement definition from MA - Includes Bracket	FRGF Bracket
	4.1.3.5.5	Deployment	LM - Integrate on USS-02	
	4.1.3.6	Handrails	LM - GFE request in PIA - worked through PIM	Integrated Handrails
	4.1.3.6.1	Requirements Definition	MA	Full requirements definition delivered to LM
	4.1.3.6.2	Design	MA	
	4.1.3.6.3	Flight Production & Certification	MA	Certified Handrails delivered to LM
	4.1.3.6.4	Integration	LM with requirement definition from MA	
	4.1.3.6.5	Deployment	LM - Integrate on USS-02	
	4.1.3.7	Worksite Interface (WIF)	LM - GFE request in PIA - worked through PIM	Integrated WIF
	4.1.3.7.1	Requirements Definition	MA	Full requirements definition delivered to LM
	4.1.3.7.2	Design	MA	
	4.1.3.7.3	Flight Production & Certification	MA	Certified WIF delivered to LM
	4.1.3.7.4	Integration	LM with requirement definition from MA	
	4.1.3.7.5	Deployment	LM - Integrate on USS-02	
	4.1.3.8	Umbilical Mechanism Assembly	LM - GFE request in PIA - worked through PIM	Integrated UMA
	4.1.3.8.1	Requirements Definition	OM	Full requirements definition delivered to LM
	4.1.3.8.2	Design	OM	
	4.1.3.8.3	Flight Production & Certification	OM	Certified UMA delivered to LM
	4.1.3.8.4	Integration	LM with requirement definition from OM - Includes Bracket	UMA Bracket
	4.1.3.8.5	Deployment	LM - Integrate on USS-02	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.1.3.9	Remotely Operated Electrical Umbilical	LM - GFE request in PIA - worked through PIM	Integrated ROEU
	4.1.3.9.1	Requirements Definition	MA	Full requirements definition delivered to LM
	4.1.3.9.2	Design	MA	
	4.1.3.9.3	Flight Production & Certification	MA	Certified ROEU delivered to LM
	4.1.3.9.4	Integration	LM with requirement definition from MA - Includes Bracket	ROEU Bracket
	4.1.3.9.5	Deployment	LM - Integrate on USS-02	
	4.1.3.10	Digital Data Recording System-02	LM	Integrated DDRS-02 System
	4.1.3.10.1	Requirements Definition	LM	
	4.1.3.10.2	Design	LM	
	4.1.3.10.3	Flight Production & Certification	LM	
	4.1.3.10.4	Integration	LM	
	4.1.3.10.5	Deployment	LM	
X	4.1.4	**Micro Meteoroid & Orbital Debris Shields**	LM	MMOD Shields and Analysis
	4.1.4.1	TRD Gas Supply System Shield	LM - Safety concern for pressure vessel	TRD Gas Supply Shield
	4.1.4.1.1	Requirements Definition	LM/MIT	
	4.1.4.1.2	Design	LM	
	4.1.4.1.3	Flight Production & Certification	LM	
	4.1.4.1.4	Integration	LM	
	4.1.4.1.5	Deployment	LM	
	4.1.4.2	SFHe Tank Shield	LM - Safety concern for pressure vessel	Test Report & Analysis
	4.1.4.2.1	Requirements Definition	LM/SCL - Is the design for VC, VCS, SFHe Tank - No additional hardware	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.1.4.2.2	Integration	LM/SCL - Includes MMOD Analysis and Test	
	4.1.4.3	Warm Helium Tank Shield	LM - Safety concern for pressure vessel	Warm Helium Tank Shield
	4.1.4.3.1	Requirements Definition	LM/ETH	
	4.1.4.3.2	Design	LM	
	4.1.4.3.3	Flight Production & Certification	LM	
	4.1.4.3.4	Integration	LM	
	4.1.4.3.5	Deployment	LM	
X	4.2	**Ground Support Equipment & Special Test Equipment**	LM/EA	All GSE and STE
	4.2.1	**Primary Support Stand**	LM - Drawings ready for production	PSS
	4.2.1.1	Management & Control	LM	
	4.2.1.2	Requirements Definition	LM/AMS	
	4.2.1.3	Design	LM	
	4.2.1.4	Production & Certification	LM	
	4.2.1.5	Deployment	LM	
	4.2.2	**Vacuum Case Test Fixture**	LM - Drawings in work	VCTF
	4.2.2.1	Management & Control	LM	
	4.2.2.2	Requirements Definition	LM/AMS	
	4.2.2.3	Design	LM	
	4.2.2.4	Production & Certification	LM	
	4.2.2.5	Deployment	LM	
	4.2.3	**O-ring Test Fixture**	LM - Hardware complete	OTF
	4.2.3.1	Management & Control	LM	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.2.3.2	Requirements Definition	LM/SCL	
	4.2.3.3	Design	LM	
	4.2.3.4	Production & Certification	LM	
	4.2.3.5	Deployment	LM	
	4.2.4	**Multi-Purpose Lift Fixtures**	LM - Hardware complete	MPLF (x2)
	4.2.4.1	Management & Control	LM	
	4.2.4.2	Requirements Definition	LM	
	4.2.4.3	Design	LM	
	4.2.4.4	Production & Certification	LM	
	4.2.4.5	Deployment	LM	
	4.2.5	**Primary Lift Fixture**	LM - Hardware complete	PLF
	4.2.5.1	Management & Control	LM	
	4.2.5.2	Requirements Definition	LM	
	4.2.5.3	Design	LM	
	4.2.5.4	Production & Certification	LM	
	4.2.5.5	Deployment	LM	
	4.2.6	**Intermediate Support Fixtures**	LM - Hardware complete	ISF (x4)
	4.2.6.1	Management & Control	LM	
	4.2.6.2	Requirements Definition	LM	
	4.2.6.3	Design	LM	
	4.2.6.4	Production & Certification	LM	
	4.2.6.5	Deployment	LM	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.2.7	**Assembly Fixture**	LM - Drawings ready for production	Assembly Fixture
	4.2.7.1	Management & Control	LM	
	4.2.7.2	Requirements Definition	LM	
	4.2.7.3	Design	LM	
	4.2.7.4	Production & Certification	LM	
	4.2.7.5	Deployment	LM	
	4.2.8	**Lower USS Shipping Fixture**	LM - Hardware complete	LUSS Shipping Fixture
	4.2.8.1	Management & Control	LM	
	4.2.8.2	Requirements Definition	LM	
	4.2.8.3	Design	LM	
	4.2.8.4	Production & Certification	LM	
	4.2.8.5	Deployment	LM	
	4.2.9	**VC Shipping Fixture**	LM/Stadco - Hardware in production	VC Shipping Fixtures (x2)
	4.2.9.1	Management & Control	LM	
	4.2.9.2	Requirements Definition	LM	
	4.2.9.3	Design	Stadco	
	4.2.9.4	Production & Certification	Stadco	
	4.2.9.5	Deployment	LM	
	4.2.10	**PAS Test Fixture**	LM - Hardware complete	PAS Test Fixture
	4.2.10.1	Management & Control	LM	
	4.2.10.2	Requirements Definition	LM	
	4.2.10.3	Design	LM	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.2.10.4	Production & Certification	LM	
	4.2.10.5	Deployment	LM	
	4.2.11	**Static Test Fixtures**	LM	Static Test Fixtures for full up static test
	4.2.11.1	Management & Control	LM	
	4.2.11.2	Requirements Definition	LM	
	4.2.11.3	Design	LM	
	4.2.11.4	Production & Certification	LM	
	4.2.11.5	Deployment	LM	
	4.2.12	**Modal Test Fixtures**	LM	Modal Test Fixtures for full up modal test
	4.2.12.1	Management & Control	LM	
	4.2.12.2	Requirements Definition	LM	
	4.2.12.3	Design	LM	
	4.2.12.4	Production & Certification	LM	
	4.2.12.5	Deployment	LM	
	4.2.13	**Acoustic Test Fixtures**	LM	Acoustic Test Fixture
	4.2.13.1	Management & Control	LM	
	4.2.13.2	Requirements Definition	LM	
	4.2.13.3	Design	LM	
	4.2.13.4	Production & Certification	LM	
	4.2.13.5	Deployment	LM	
	4.2.14	**Misc. Test Fixtures**	LM	Misc. Test Fixtures
	4.2.14.1	Management & Control	LM	

Charge Number Level	WBS Code	AMS WBS Title	Comments	Product
	4.2.14.2	Requirements Definition	LM	
	4.2.14.3	Design	LM	
	4.2.14.4	Production & Certification	LM	
	4.2.14.5	Deployment	LM	
	4.2.15	**NBL Mockups**	LM - Hardware complete	NBL Mockup
	4.2.15.1	Management & Control	LM	
	4.2.15.2	Requirements Definition	LM	
	4.2.15.3	Design	LM	
	4.2.15.4	Production & Certification	LM	
	4.2.15.5	Deployment	LM	