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POWER EXTENSION PACKAGE (PEP)
SYSTEM DEFINITION EXTENSION

Orbital Service Module Systems Analysis Study

VOLUME 7
PEP Logistics and Training Plan Requirements

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PREFACE

The extension phase of the Orbital Service Module (OSM) Systems Analysis Study was conducted to further identify Power Extension Package (PEP) system concepts which would increase the electrical power and mission duration capabilities of the Shuttle Orbiter. Use of solar array power to supplement the Orbiter's fuel cell/cryogenic system will double the power available to payloads and more than triple the allowable mission duration, thus greatly improving the Orbiter's capability to support the payload needs of sortie missions (those in which the payload remains in the Orbiter).

To establish the technical and programmatic basis for initiating hardware development, the PEP concept definition has been refined, and the performance capability and the mission utility of a reference design baseline have been examined in depth. Design requirements and support criteria specifications have been documented, and essential implementation plans have been prepared. Supporting trade studies and analyses have been completed.

The study report consists of 12 documents:

Volume	1	Executive Summary
Volume	2	PEP Preliminary Design Definition
Volume	3	PEP Analysis and Tradeoffs
Volume	4	PEP Functional Specification
Volume	5	PEP Environmental Specification
Volume	6	PEP Product Assurance
Volume	7	PEP Logistics and Training Plan Requirements
Volume	8	PEP Operations Support
Volume	9	PEP Design, Development, and Test Plans
Volume	10	PEP Project Plan
Volume	11	PEP Cost, Schedules, and Work Breakdown Structure Dictionary
Volume	12	PEP Data Item Descriptions

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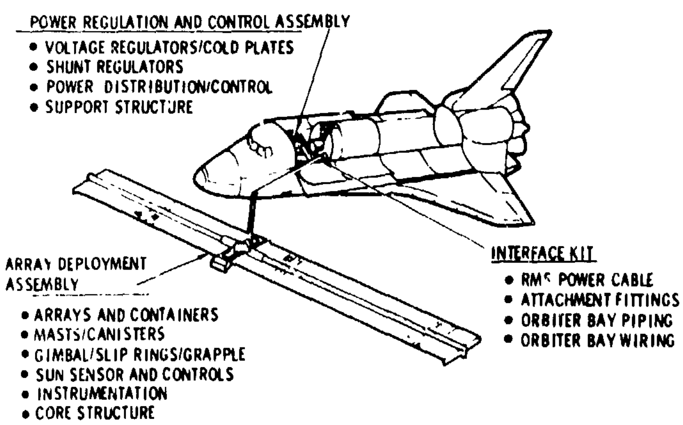
FOREWORD

The Power Extension Package (PEP) is a solar electrical power generating system to be used on the Shuttle Orbiter to augment its power capability and to conserve fuel cell cryogenic supplies, thereby increasing power available for payloads and allowing increased mission duration. The Orbiter, supplemented by PEP, can provide up to 15 kW continuous power to the payloads for missions of up to 48 days duration.

When required for a sortie mission, PEP is easily installed within the Orbiter cargo bay as a mission-dependent kit. When the operating orbit is reached, the PEP solar array package is deployed from the Orbiter by the remote manipulator system (RMS). The solar array is then extended and oriented toward the sun, which it tracks using an integral sun sensor/gimbal system. The power generated by the array is carried by cables on the RMS back into the cargo bay, where it is processed and distributed by PEP to the Orbiter load buses. After the mission is completed, the array is retracted and restowed within the Orbiter for earth return.

The figure below shows the PEP system, which consists of two major assemblies -- the Array Deployment Assembly (ADA) and the Power Regulation and Control Assembly (PRCA) -- plus the necessary interface kit. It is nominally installed at the forward end of the Orbiter bay above the Spacelab tunnel, but can be located anywhere within the cargo bay if necessary. The ADA, which is deployed, consists of two lightweight, foldable solar array wings with their containment boxes and deployment masts, two diode assembly interconnect boxes, a sun tracker/control/instrumentation assembly, a two-axis gimbal/slip ring assembly, and the RMS grapple fixture. All these items are mounted to a support structure that interfaces with the Orbiter. The PRCA, which remains in the Orbiter cargo bay, consists of six pulse-width-modulated voltage regulators mounted to three cold plates, three shunt regulators to protect the Orbiter buses from overvoltage, and a power distribution and control box, all mounted to a support beam that interfaces with the Orbiter.

PEP is compatible with all currently defined missions and payloads and imposes minimal weight and volume penalties on these missions. It can be installed and removed as needed at the launch site within the normal Orbiter turnaround cycle.



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Section 1
INTRODUCTION

The Power Extension Package (PEP) will offer a major increase in power level and mission duration for the benefit of Orbiter payloads. Mission analyses indicate that the need for these resources will begin with the earliest planned Spacelab missions and will continue through the next decade. As a permanent addition to the STS program, PEP will require a comprehensive logistical support program. This program will ensure the ready availability of PEP with dependable performance and reliability.

This segment of the PEP study, performed by the McDonnell Douglas Astronautics Company, has addressed the requirements for PEP logistics support to be implemented in Phase C/D. Although the logistics study has been based on a specific PEP design concept, as illustrated in the Foreword, the resulting logistics requirements have been expressed in a general form compatible with any design concept developed in accordance with the PEP System Specification (MDAC document 1D23472). Critical logistics requirements (particularly maintainability) have been incorporated in the System Specification.

Initial planning for PEP was based on an ETR launch. Recent payload mission studies have exposed the long duration mission advantages of a WTR launch. Current planning assumes PEP will be available for both launch sites. The detailed plans that will later be prepared in response to the requirements derived in this study will address the unique logistics tasks at each of the two sites. The requirements of this study report are compatible with the operational concepts given in Volume 8, Operations Support.

Section 2
LOGISTICS

This section of the report provides recommendations for logistics activities and logistics planning based on the following major program assumptions.

A. A system prime contractor will perform logistics functions to support all program hardware (engineering models, flight equipment, simulators, mockups, trainers, GSE, etc.) to be provided by that contractor or by NASA. This effort will include support at all locations where the equipment will be used to implement the PEP operations requirements.

B. The system prime contractor will plan and implement a logistics system at both KSC and VAFB to support PEP operations. The system will include the planning and providing of products and services to assure cost effective coverage of the following logistics functional elements: maintainability; maintenance; spares and supply support; fuels, pressurants and fluids; operations and maintenance documentation; training; preservation, packaging and packing; transportation and handling; storage; and logistics management information reporting.

C. The system prime contractor will prepare and implement a Power Extension Package Operations Logistics Plan, PEPOLP, (see Volume 12,DR LS-01). This plan will describe how each logistics functional element will be implemented to assure cost effective support to PEP ground and flight operations. All PEP logistics functions to be performed at launch and landing sites (including alternate and contingency sites) will be compatible with and responsive to the KSC Space Transportation System Integrated Logistics Plan (K-SM-12 series documents). The Space Shuttle Logistics Requirements, JSC-07700, Volume XII, will be used as a guideline document to optimize compatibility with the Space Shuttle logistics system.

2.1 ANALYSIS AND PLANNING

To establish a sound basis for planning, analysis should be conducted in sufficient detail to identify and quantify the logistics resources required on all contractor-furnished hardware to support PEP operations. An independent assessment should be made of all the logistics support requirements necessary to implement the operational logistics program and these should be incorporated in a plan for the allocation of resources to provide that support.

2.1.1 Support Requirements Analysis (SRA)

SRA should be conducted on PEP hardware, that is, flight systems, subsystems, support equipment, maintenance ground equipment, and trainers, for the systematic identification of logistics support requirements. Analytical outputs would be used to influence design as applicable; to provide data for maintainability predictions, allocations, assessment; and to provide a basis for maintenance planning. Analysis would be performed to the depth required to ensure that all logistics resources required to operate and maintain each PEP system are defined (reference Volume 12, DR LS-07).

2.1.2 Optimum Repair Level Analyses (ORLA)

ORLA should be conducted in order to recommend repair levels which will accrue minimum total support cost within operational and technical constraints over the PEP life cycle. The ORLA would provide repair versus discard-at-failure decisions; recommend level of repair; repair parts provisioning data; source, maintenance and recoverability (SMR) codes; and maintenance planning data.

2.2 MAINTAINABILITY

A maintenance concept will be required to refurbish and repair PEP hardware between missions. The concept should include a plan establishing design criteria and defining the methods to be employed during maintenance and the procedures for verifying that the equipment meets specification and is ready for use.

2.2.1 Maintainability (M) Assurance Plan Preparation

An M assurance plan should be prepared for implementing a PEP M concept, consistent with performance and mission objectives, which will reduce maintenance and maintenance costs and serve as a planning and control document for the PEP M program. The M Assurance Plan would contain the M goals for PEP in the form of mean-time-to-repair (MTTR) goals and the approach for planning and arrangement of the PEP M effort. This should include descriptions of the major M tasks necessary to ensure an effective M program for PEP with approaches to implement the following:

- Development of M design criteria
- Establishment of effective management of the M effort
- Development of design evaluation and trade study methods

- Development of M predictions
- Development of M demonstration and verification requirements

The M assurance plan would ensure that PEP maintenance life cycle costs are reduced, creating the best mix of repair and maintenance characteristics in the design through a program of analysis, evaluation, test, and corrective action (reference Volume 12, DR LS-02).

2.2.2 Maintainability Design Criteria Specification

Design criteria should be developed in order to define the basic M principles and requirements to be implemented by the designers during the design evaluation process. The M design criteria normally contain the unique guidelines necessary to design M into the PEP systems. They also provide information for improving the design through tradeoff studies. The design criteria would serve the following functions.

- Limit the complexity of the maintenance procedures
- Provide accessibility
- Facilitate checkout
- Reduce the need for and frequency of design-dictated maintenance
- Reduce downtime and support costs
- Obtain maximum utilization of personnel and equipment capabilities
- Reduce potential for maintenance costs

Use of the design criteria will ensure that the PEP system can be economically maintained within the confines of the planned checkout and launch concept. The criteria will also establish the inherent M of the PEP as the design develops.

2.2.3 Maintainability Design Evaluation

An M design evaluation should be made to (1) ensure that M requirements are considered and incorporated; and (2) verify that the design conforms to M criteria. M design analysis consists of quantitative and qualitative evaluations during formal and informal design reviews and mockup evaluations. The evaluation would consist of comparing the design to M predictions and M design checklists. Trade studies would be conducted to select the most desirable and cost effective design alternative when M provisions are insufficient. The results of the evaluation would be provided to the appropriate design element for a determination of the impact on hardware design.

2.2.4 Maintainability Task Analysis/Tradeoffs

Total preventive and corrective maintenance downtimes shou d be ascertained for each maintenance action identified. The distribution of task times and total time for maintenance functions would also be determined. Tradeoffs would be performed if maintenance times were not adequate. The maintainability task analysis will serve to determine that the maintainability design of the equipment is adequate.

2.2.5 Maintainability Prediction

M predictions for quantitative Mean Time to Repair (MTTR) estimates are needed for each PEP hardware element. They will permit verification that the proposed design meets M requirements and identify design features requiring corrective action.

The M predictions would be quantitative estimates of the time required to accomplish maintenance actions.

2.2.6 Maintainability Problem Reporting and Corrective Action System

A formal Maintainability Problem Reporting and Corrective Action system is required to ensure that PEP will evolve into a basically maintainable system during the design cycle (reference Paragraph 4.3.2.11, JSC 07700, Volume XII).

2.2.7 Maintainability Demonstrations/Verifications

M demonstrations and verifications will verify the achievement of M design requirements. An M demonstration and verification program generally consists of three phases:

- Analytical--which starts with the design evaluation and continues until the operational phase of system where design changes are evaluated.
- In-Process Verification--which is integrated with mockup activities and other testing requirements.
- Formal Demonstration--where specific maintenance tasks are performed to verify critical design areas or activities.

The M demonstrations and verifications are used to verify the achievement of M characteristics and identify M problems.

2.2.8 Maintainability Analysis of Engineering Changes

M analysis of engineering changes and field modifications are required to identify the impact of hardware changes on M characteristics.

2.3 MAINTENANCE

A maintenance concept is needed within the maintenance plan to establish a baseline for maintenance analysis and planning. It should outline objectives and policies and establish the level and scope of maintenance permitted in each tier of the PEP operations and support organizations. The maintenance concept would be applied during all stages of the program and influence design through maintainability planning, logistics planning, and resources acquisition.

2.3.1 Concept Definition

Implementing the maintenance concept requires studies and trades to ensure establishment of a maintenance system that is cost-effective but entirely responsive to operational time constraints, prevents deterioration of inherent design levels and operating safety. An example of a maintenance concept is: removal and replacement to the functional line replaceable unit level by the using organization, limiting repair-in-place to only those tasks justified by maintenance analysis. Levels of maintenance are established to support this concept such as organizational level (remove and replace) and intermediate and depot levels where the removed items are repaired off-line at on-site facilities, government depots and vendor or manufacturer facilities.

The maintenance concept would be utilized to develop a maintainability program which influences design, drives maintenance analysis and provides the basis for maintenance planning which requires assignment of responsibilities and acquisition of maintenance resources.

2.3.2 Repair Policy

A repair policy is established to guide repair actions for organization, intermediate and depot levels of maintenance. It is normally incorporated in the maintenance plan and includes such items as the percentage of a spare part acquisition cost that is considered to be the maximum economical repair cost for the part.

2.3.3 Maintenance Plan

A PEP Program Maintenance Plan should be prepared and periodically updated. This plan (reference DR LS-01, Paragraph D) would:

- Define contractor versus NASA responsibilities.
- Establish the program level maintenance management system.
- Ensure acquisition of maintenance resources.
- Ensure maximum utilization of existing or planned maintenance resources

at the launch site.

2.4 SPARES PROVISIONING

Spares provisioning data is required which includes but is not limited to: contract identification, part number, specification, noun/nomenclature, source code, National Stock Number, name and address of manufacturer, quantity per assembly, quantity per end item quantity recommended, unit price, weight, code, indenture, next higher assembly production lead time, shelf life, service life, MTTR, depot overhaul turnaround, environmental control, interchangeability, modifications, and related packaging code consistent with transportation, handling, and storage requirements (reference Volume 12, DR LS-05).

2.5 FUELS, PRESSURANTS AND FLUIDS

A Forecast of Requirements is needed for fuels, pressurants and fluids.

2.5.1 Forecast of Requirements

Forecasting of requirements should be in accordance with NHB 5100.2, Paragraph 52.500. They are provided to NASA so that PEP requirements can be consolidated with overall NASA requirements. Forecasts should be based on official contract schedules (reference Volume 12, DR LS-09).

2.5.2 Storage, Handling, and Safety Criteria Identification

Unique storage, handling and safety requirements for fuels, pressurants and fluids should be identified for PEP.

2.6 OPERATIONS AND MAINTENANCE DOCUMENTATION (O&MD)

Documents to Support Organization and Intermediate Maintenance require preparation and maintenance (reference Volume 12, DR LS-[illegible]).

A system should be established to ensure that engineering changes and field modifications are incorporated into Operations and Maintenance manuals and technical support documentation.

2.7 PRESERVATION, PACKAGING AND PACKING (P/P/P)

P/P/P instructions for each deliverable item and spare part in accordance with NHB 6000.1C should be provided.

2.7.1 Instruction, Preparation, and Update

Preparation and update, as required, of detailed packaging instructions for each PEP item which is shipped as an entity should be made. The data sheets are used for definition of packaging to ensure protection during transportation, handling and storage, and are input data to the Packaging Data File which will be maint ined by the contractor. Preparation of the data sheet requires:

- Determination of physical dimensions, physical constraints, and environmental limitations for each end item and spare part.
- Specification of the best method of packaging based on factors mentioned above. This includes packaging material and container type.
- Identification of one time usable versus reusable containers for each end item and spare part.

2.7.2 P/P/P Performance

Packaging instructions prepared under Paragraph 2.7.1 above are used when performing the required P/P/P for each contract end item shipped by the contractor.

2.7.3 Handling Procedures for Flight-Critical and High-Value Items

High cost and flight-critical items should be identified and handling procedures prepared in accordance with NHB 6000.1C (reference Volume 12, DR LS-08).

2.8 TRANSPORTATION

Provisions for the transport of PEP equipment should be made.

2.8.1 Transportation Requirements Definition

Transportation requirements should be defined that will form the basis for planning transportation services required for movement/delivery of PEP equipment and spares, in accordance with NHB 6000.1C.

2.8.2 Transportation Plan Preparation

A transportation plan should be prepared to describe the transportation effort which will support the movement of PEP items. The transportation plan establishes the goals for transportation analysis including the criteria necessary to determine cost effective transportation modes. The information in this plan will provide a baseline to conduct transportation analysis, develop schedules and implementation of transportation requirements (reference Volume 12, DR LS-03).

2.9 STORAGE CRITERIA

PEP equipment requiring short- and long-term storage should be accommodated.

2.9.1 Short-Term Storage Criteria Specification

Short-term storage criteria is needed to help in the determination of the requirements and resources in terms of environment, area of space stacking and space for efficient mobility of handling equipment. Criteria should identify type of storage, average amount to be stacked or packed per day, type of binning or shelving, etc., type of packaging material for the containers and appropriate environment for the short-term storage items.

2.9.2 Long-Term Storage Criteria Specification

Long-term storage criteria needs developing to establish the environmental tolerances required to prolong or maintain shelf life. This, along with storage constraints dictated by design specifications or packaging materials, will help provide the required environment to the items placed in long-term storage. The optimum shelf life for the items will then be provided.

2.10 LOGISTICS MANAGEMENT INFORMATION SYSTEM

A PEP Logistics Management System should be developed and implemented that is compatible with the KSC and VAFB SIMS. It will provide management visibility and the status of the logistics program. The system would delineate contractor performance against program milestones, funding and contractual requirements.

Logistics reports from the above system would be provided at scheduled intervals.

Section 3
TRAINING

Assistance should be provided to KSC for development and implementation of a training program to ensure that personnel employed in the inspection, handling, installing, testing, integration, maintenance, and launch activities of all PEP-related hardware and software have been adequately trained and are qualified to perform their tasks competently.

Standard personnel manual skills training (soldering, welding, wire crimping, etc.) as well as general safety and hazard training would be provided as required by the government. Requirements for this type training should be identified and requirements and schedules would be provided to the government.

3.1 TRAINING REQUIREMENTS ANALYSIS

A training requirements analysis should be performed to identify the training courses, manpower, materials and training aids required (reference Volume 12, DR TS-03). The results of the training requirements analysis would provide the basis for the training plan.

3.2 TRAINING PLAN

A Training Plan must be prepared, implemented and maintained that describes the administration, documentation and activities required to implement the PEP training program (reference Volume 12, DR TS-01). The plan should conform to the Space Shuttle Ground Operations Training Plan, K-S12.5 and Paragraph 1D500.7 of NHB 5300.4 (1D-1). It should also provide for the requirements described below:

A. Preparation of training and certification standards and definition of specific areas/tasks requiring certification.

1. Skill tasks employed during assembly, test, checkout and other physical activities (e.g., welding, soldering, wire wrapping, etc.) which may be unique to PEP hardware or procedures.

2. Operational tasks involving knowledge and decision-making as typified by console operators during test, checkout and launch operations.

B. Preparation of training materials (courses, training aids, and student handouts).

C. Development of training and certification requirements and conduct of training in a manner to assure trained and certified personnel are available in the numbers and times required.

D. Preparation of fiscal requirements and schedules.

E. Identification of operational maintenance-critical tasks which are to be performed only by trained and certified personnel and implementation of the procedures required to ensure that only properly trained and certified personnel perform these tasks (including handshop skills, i.e., soldering).

F. Maintenance of files and records of training certification/recertification. Formats for required training courses including certification forms are contained in KSC Handbook KHB 3410.1A.

G. Certification of personnel to perform tasks.

H. Provisions and classroom space should be made available for the training of NASA and other government agency personnel on a "space available" basis, or as negotiated by the government.

The training plan should address as a minimum the following items:

- ATE Console Operators Certification Training.
- PEP/Orbiter Support Software Modification, Familiarization/Utilization Training.
- GSE Operators Certification.
- Flight Systems Training.
- Training and Certification for Quality Assurance Designers.
- Training for Critical Processes (i.e., adhesive and resin applications, welding, brazing, soldering, and contamination control operations).
- Performance of organizational and intermediate maintenance functions.

3.3 TRAINING SCHEDULE

A schedule of the PEP training activities to be conducted must be developed (reference Volume 12, DR TS-02).

Section 4
LOGISTICS IMPLEMENTATION

This element deals with the logistical activities associated with the PEP at KSC and VAFB, namely implementing the PEPOLP. Logistics functions should be supported at the launch and landing sites (including alternate and contingency sites) in accordance with the requirements, the approved PEPOLP, and KSC SM 12.0 Series Documents.

4.1 SUPPLY SUPPORT

A. Establishes inventory requirements for PEP flight hardware, GSE and support equipment spares and coordinates these requirements with the KSC STS ILS Provisioning Organization to ensure that equipment is available to meet operational requirements.

B. Consists of expediting and retrieval of PEP and GSE support equipment/spares from supply to the operation sites.

C. Defines to KSC Central Supply those tools and items peculiar to the PEP checkout at KSC and VAFB that, upon government approval, will be provisioned in a KSC Central Supply tool crib.

D. Provides material requirements projections per DR LS-09, Volume 12.

E. Provides interface and defines requirements for transportation support by KSC.

F. A list of "missing essential" LRUs are developed for NASA approval which will be required at the launch pads to provide quick response to failures which may occur during launch operations.

All other logistics functions, including warehousing, receiving, packaging and unpackaging of routine spare parts, shipping, maintenance of equipment and records and accountability will be the responsibility of the government.

4.2 INTERMEDIATE (OFF-LINE) MAINTENANCE

The system prime contractor should be responsible for any intermediate level (off-line) maintenance of PEP LRUs which have been determined to be beyond the capability of the intermediate shops and labs planned at KSC and/or VAFB as defined in GP 1037 and in accordance with the PEPOLP.

4.3 TRAINING

The system prime contractor should be prepared to implement the training plan developed under the direction of KSC, to ensure that personnel employed in the inspection, handling, installing, testing, integration, maintenance and launch activities of all PEP-related hardware and software at KSC, VAFB and alternate/contingency landing sites have been adequately trained and are qualified to perform their tasks competently.

The training implementation provides for the following:

A. Preparation of training and certification standards and definition of specific areas/tasks requiring certification.

1. Skill tasks employed during assembly, test, checkout and other physical activities (e.g., welding, soldering, wire wrapping, etc.) which may be unique to PEP hardware or procedures.

2. Operational tasks involving knowledge and decision-making as typified by console operators during test, checkout and launch operations.

B. Preparation of training materials (courses, training aids, and student handouts).

C. Development of training and certification requirements and conduct training in a manner to assure trained and certified personnel are available in the numbers and times required.

D. Preparation of fiscal requirements and schedules.

E. Identification of operational and maintenance-critical tasks which are to be performed only by trained and certified personnel and implementation of the procedures required to ensure that only properly trained and certified personnel perform these tasks (including handshop skills, i.e., soldering).

F. Maintenance of files and records of training certification/recertification. Formats for required training courses including certification forms are contained in KSC Handbook KHB 3410.1A.

G. Certification of personnel to perform tasks.

H. Provisions and classroom space should be made available for the training of NASA and other government agency personnel on a "space available" basis, or as negotiated by the government.

The training implementation addresses as a minimum, the following types of training:

- ATE Console Operators Certification Training.

- Support Software Modifications for PEP Familiarization/Utilization Training (i.e., Data Reduction Diagnostics).
- GSE Operators Certification.
- Facility Operators Certification.
- Flight Systems Training.
- Training and Certification for Quality Assurance Designers.
- Training for Critical Processes (i.e., adhesive and resin applications, welding, brazing, soldering, contamination control operations, and NDE).
- Performance of organizational, intermediate and depot maintenance functions.