SPACE STATION
SIMULATION COMPUTER SYSTEM (SCS) STUDY
for
NASA/MSFC

OPERATIONS CONCEPT REPORT

TRW-SCS-90-XT4

21 December, 1990

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George C. Marshall Space Flight Center
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Attn: Mr. M. Watson/E035

Subject: Contract No. NAS8-37745
SCS Operations Concept Report
Simulation Computer System for Space
Station Program

In accordance with the requirements of the subject contract, the technical report titled SCS Operations Concept Report is herewith submitted and distributed as shown.

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SPACE STATION SIMULATION COMPUTER SYSTEM (SCS) STUDY

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SCS SCS

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CDRL: TRW-SCS-90-XT4

21 December, 1990

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1.0 INTRODUCTION

The Payload Training Complex (PTC) will be a facility at the Marshall Space Flight Center (MSFC) that is used to provide training for the Space Station Freedom (SSF). Training will be provided for the onboard crew, payload scientists, station scientists, ground control personnel, and support personnel on the operations of the wide variety of experiments that will be on-board the SSF. The Simulation Computer System (SCS) is the computer hardware, software, and workstations that will support training at the PTC.

This PTC/SCS Operations Concept Document identifies the various training functions that the PTC will be required to support during a typical experiment development/training cycle. Operations concepts are provided which illustrate the conceptual utilization of the PTC/SCS to support payload training requirements.

1.1 IDENTIFICATION

This PTC/SCS Operations Concept Document represents the results of the SCS Study Extension task 4 to investigate SCS operational issues and develop an operational concept for the PTC/SCS.

1.2 SCOPE

This document contains operational concepts relating to payload operations training in the MSFC SSF Payload Training Complex. It is intended to cover, at a very top level, all payload training functions that will be conducted in the PTC. Operational scenarios relating to all aspects of the training function are incorporated in this document, including simulator development and verification functions as well as specific training activities.

1.3 PURPOSE AND OBJECTIVES

The purpose and objective of this document is to identify operational issues/interfaces relating to the PTC and the SCS and to provide recommendations throughout the document for the concepts of operation for conducting payload training in the PTC. Also identified are interface procedures within the operational elements of the PTC as well as interfaces to external users.

1.4 ORGANIZATION

This document is organized into four major sections.

- Section 1.0, Introduction, identifies the PTC/SCS Operations Concept Document and defines its scope, purpose, objective, and organization.

- Section 2.0, Definition of the PTC/SCS, identifies the basic purpose and scope of the PTC/SCS and defines the operational characteristics of the facility.

- Section 3.0, User/Function Definitions, describes the operational elements and users of the PTC/SCS that will be involved in the operations of the PTC to support training related activities. These users/functions include development activities relating to training functions as well as the actual conduction of training sessions.

- Section 4.0, PTC/SCS Operational Concepts, contains recommendations about the operations that will occur during the training process for a given SSF payload increment. These recommendations are intended to show the operational utilization of the PTC and its SCS to support various training related functions for each SSF payload increment, from the initial training assessment to the conduct of the final integrated training.

2.0 DEFINITION OF THE PTC/SCS

The current recommended baseline for the Payload Training Complex (PTC) Simulation Computer System (SCS) will be a distributed network system utilizing SSF Data Management System (DMS) kits with local host computers to accomplish the payload training program objectives. The system will support training for two US Lab modules and Part Task Trainers as well as provide capabilities for simulator development and Integrated Test and Verification activities. For the purposes of this operations concept document a 6 DMS kit reference configuration as shown in Figure 2-1 is assumed. This configuration provides seven dedicated host computers networked together to support the training functions. One host will serve as the Training Session Manager, one host with a DMS kit will be dedicated to development, one host with DMS kit will be dedicated to the IT&VE functions, two hosts with DMS kits will support the part task trainers, one host with DMS kit will support training in the US Lab module 1 and another host with DMS kit will support the US Lab module 2 training functions. The seventh host computer will be dedicated to the ESA and JEM part task trainers. Instructor stations on the network can access any of the dedicated host computers to conduct the training activities. A detailed description of the architecture of the SCS is provided in the Baseline Architecture Report of the SCS Study, TRW-SCS-90-XT2. This document outlines the functions of the SCS and capabilities it will provide to support the payload training program.

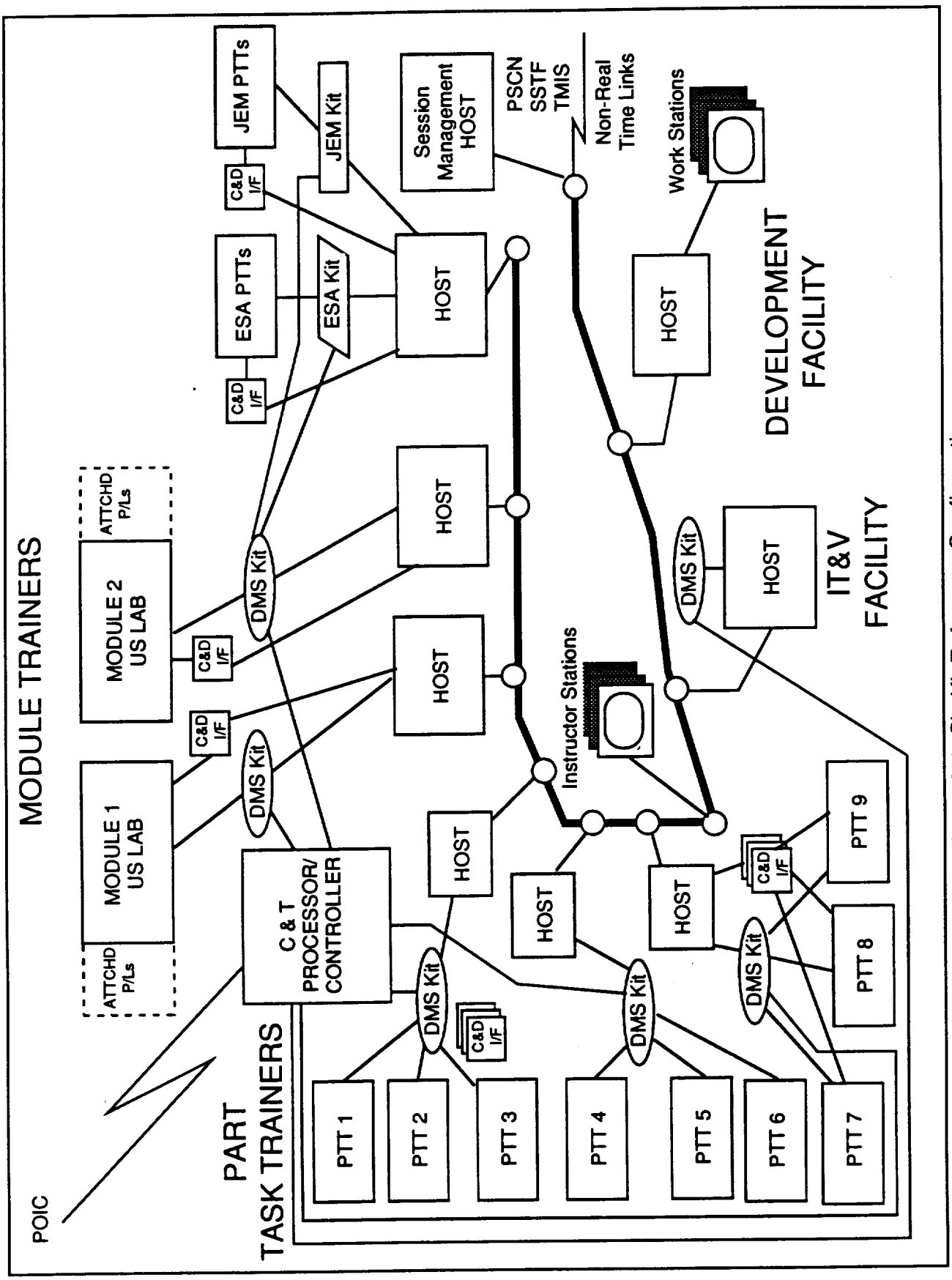

Figure 2-1. Six Kit Reference Configuration

3.0 USER/FUNCTION DEFINITIONS

The operations of the PTC and associated SCS will involve three primary groups or areas of responsibility:

- Payload Training Organization
- PTC/SCS Operations Organization
- Payload Element Developers/Principal Investigators (PED/PI)

The fourth group associated with PTC operations is the trainees, the end users of the PTC. This group consists of the Onboard Crew Members, Ground Support Personnel, Ground Processing Personnel, and Payload Support Team Members. While this group will be the ultimate beneficiaries of the PTC/SCS services and will thus be a large part of PTC operations, they will not be responsible for any of the operations.

In addition to the above groups which are directly involved in the PTC operations there are other external organizations that will provide major inputs to the PTC/SCS operations. The most significant of these is the Mission Planning Organization. The responsibilities of each of these organizations relating to PTC operations is discussed in the following sections.

3.1 PAYLOAD TRAINING ORGANIZATION

The MSFC Payload Training Organization is the primary organization responsible for payload operations training. This group will work with the PED/PI to identify the payload operations requiring training, derive training objectives for the tasks to be trained, develop training plans to satisfy identified training objectives, and establish evaluation criteria for the satisfactory accomplishment of the training objectives. The Payload Training Organization will insure that individual experiment training plans are compatible with the overall PTC and Space Station Training Facility (SSTF) guidelines. The primary responsibility of this group will be to insure that integrated operations and associated training objectives are identified and properly implemented. This organization will be responsible for all training activities conducted in the PTC and will also serve as the interface between the PED/PI organization and the SSTF organization responsible for full integrated SSF increment training.

3.2 PTC/SCS OPERATIONS ORGANIZATION

The PTC/SCS Operations Organization's primary responsibility will be the day to day operations of the facility and systems. These operations will support the Payload Training Organization to insure that the facility and computer systems are properly configured to support the training objectives identified by the training organization. The operations organization will be responsible for development

activities in response to the training organization's requirements, IT&V, and facility operations, including communications and data handling with external facilities. The PTC/SCS Operations Organization will also be responsible for all configuration management of all the software and equipment utilized in the PTC.

3.3 PAYLOAD ELEMENT DEVELOPERS/PRINCIPAL INVESTIGATORS

The Payload Element Developers/Principal Investigators (PED/PI) are the subject matter experts on the individual payloads and are responsible for the overall training on their operations. During the Training Assessment function they will identify the experiment operations functions requiring training and establish the skills criteria necessary for each of these operations. They will develop the individual payload training plan and work with the Payload Training Organization to integrate the individual payload training plan into the overall SSF Payload Increment Training Plan. The PED/PI organization will be responsible for providing the detailed information that the training organization will input into the SCS to comprise the Training Database. In many cases they will also be responsible for the development of the payload simulators that will be utilized to accomplish the training objectives. They will participate in the training program and will certify the elements of the training program.

4.0 PTC/SCS OPERATIONAL CONCEPTS

During the payload development cycle an experiment will progress through various activities relating to training at the PTC, as illustrated in Figure 4-1. These training activities will begin with the Training Assessment function soon after experiment selection, will proceed through the completion of Joint Integrated Training prior to an SSF payload increment launch, and will extend to onboard training using materials developed at the PTC. The following sections present top level concepts of the PTC and SCS operations for each training related function.

In developing the operations concepts for this document, several assumptions were made, as listed below:

1. Capabilities of the PTC/SCS discussed in this document reflect the operational requirements encountered during the preparation of this document and may not be included in any PTC/SCS baseline configuration.

2. At least some of the Payload Simulator Development will be performed at the PTC under the direction of the Payload Training Organization. It is unreasonable to assume that all simulators will be developed by the PED/PIs.

3. The PTC/SCS Operations Organization will develop a PTC Users Capability Document to distribute to the PED/PIs and other PTC users. This document should contain a PTC/SCS system description, hardware interface specifications, software interface specifications, functional interface specifications, and system standards.

4.1 TRAINING ASSESSMENT

The payload development cycle begins when PED/PI teams are selected to develop an experiment to be included in an SSF payload increment. The PED/PI then expands the experiment proposal information into an initial Experiment Definition Document which provides a functional overview of the operations and interfaces of the experiment. The Simulation Developers User's Guide, provided by the Payload Training Organization, will contain the information defining the operational guidelines and hardware/software interfaces to which the training systems must conform. These documents will provide the structure under which the training development cycle is accomplished.

The initial step in the training cycle is the Training Assessment function, in which an analysis is performed to determine the training requirements for a specific experiment and an approach is developed to satisfy those training requirements. The Training Assessment function is illustrated in Figure 4-2. The purpose of this phase is to derive training requirements for both academic and hands-on media training.

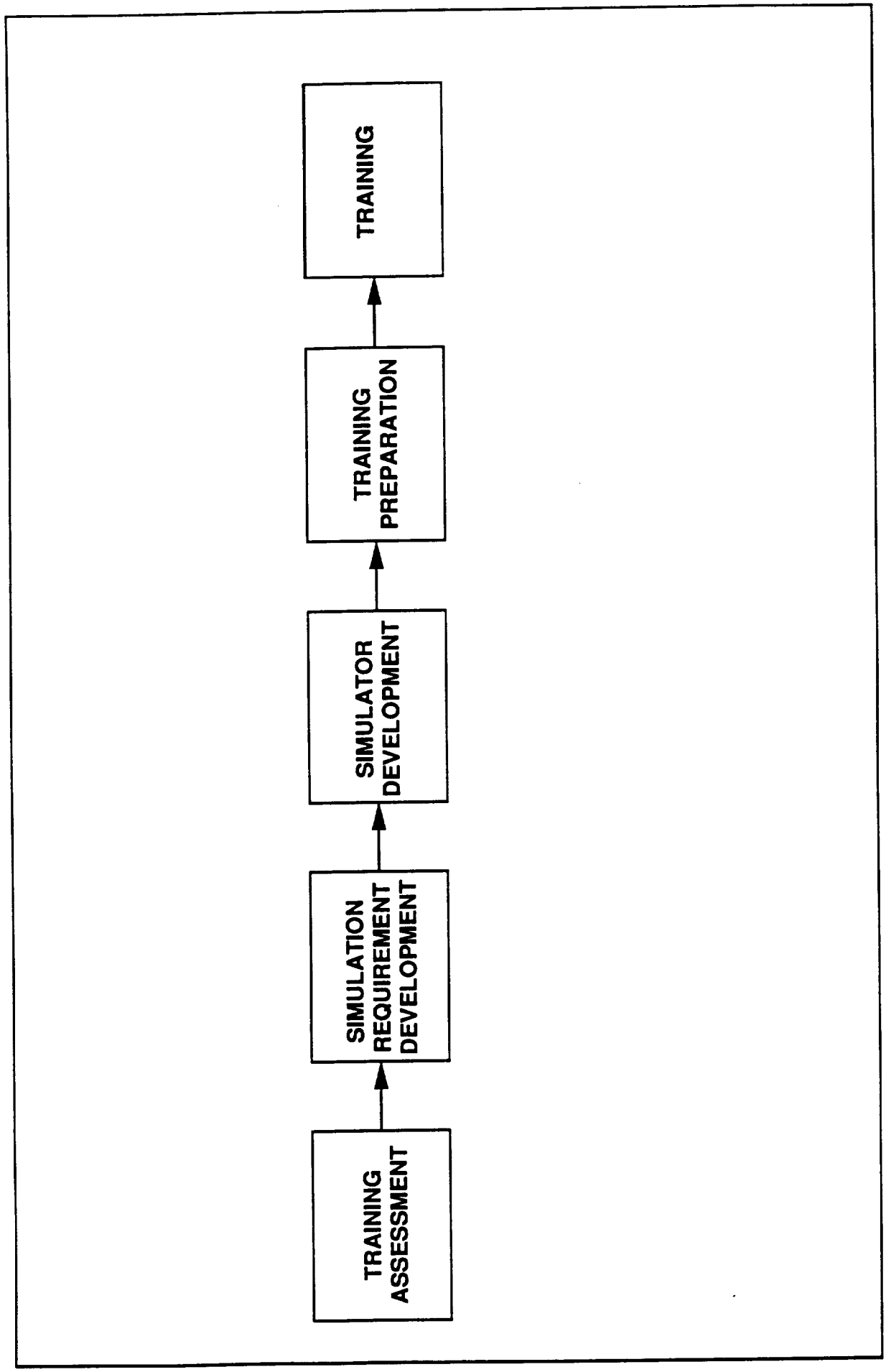

Figure 4-1. TRAINING OPERATIONS FLOW

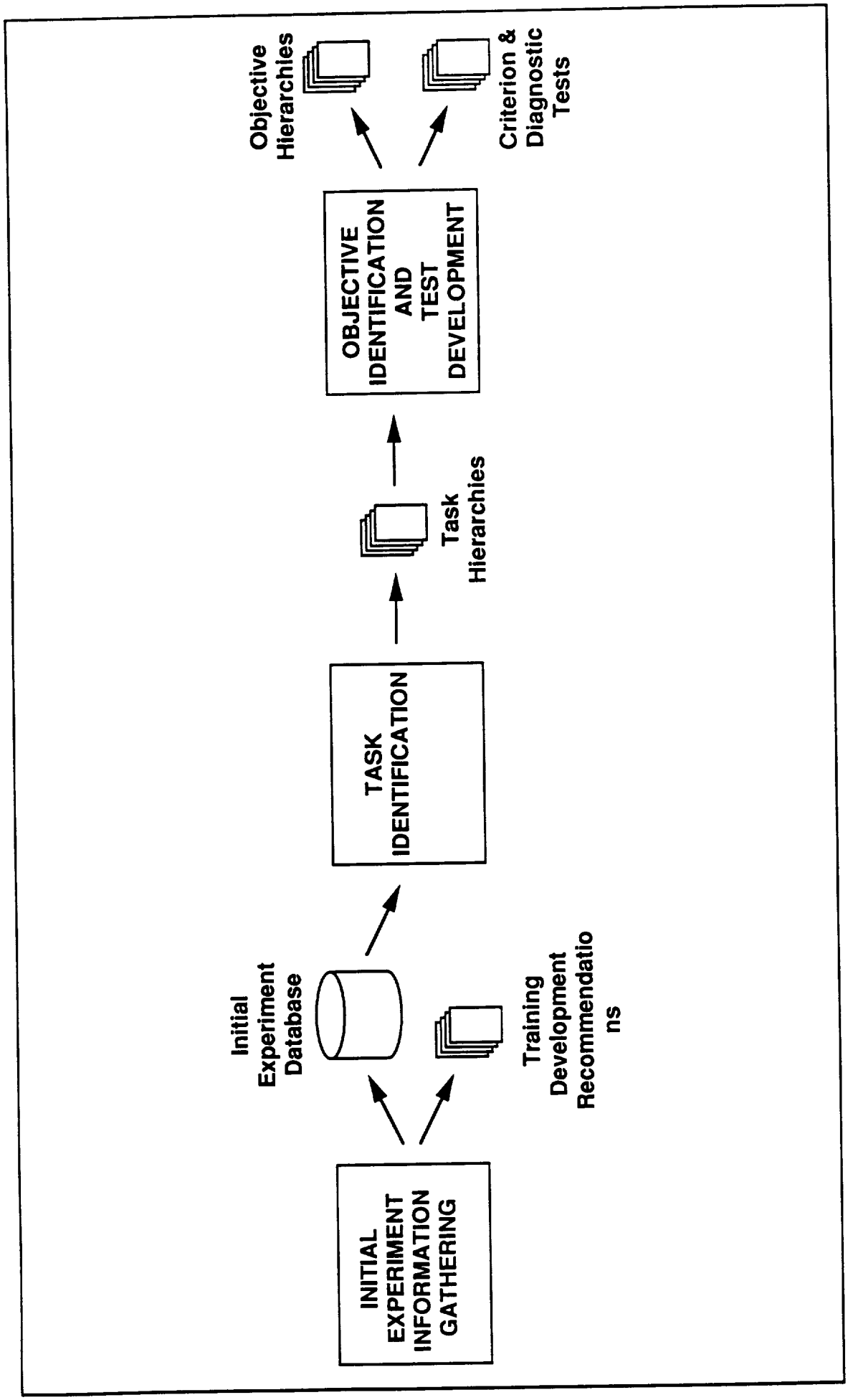

Figure 4-2. TRAINING ASSESSMENT FLOW

These training requirements will be derived from specific information about the experiment to be trained, and the policies and constraints imposed by the MSFC Payload Training Program. In many ways, this is the most critical phase, since all subsequent development steps will draw upon the results reached here. Traditionally, in the Spacelab program, the process of determining training objectives and simulation needs has been a joint effort between the PED/PI and the MSFC Payload Mission Management Organization. The PED/PI identifies specific training objectives for his experiment operations for both the flight crew and PED/PI ground operations personnel. The Payload Mission Management Organization then determines any additional training objectives that are required for the ground operations cadre and the simulation needs required to satisfy these integrated training objectives. This is a very important element of the training program because these training objectives and their associated training performance measurement criteria are the primary drivers for the subsequent stages of the training program.

The Training Assessment process is essentially the training program front-end analysis. Training requirements are derived in the form of the tasks necessary to operate and maintain a particular experiment. These tasks are characterized and classified for training in a way which will provide source data for all other steps in the training program. Training Objectives and test criteria for the accomplishment of each objective are then developed from the tasks to be trained.

From the PTC/SCS standpoint the principal participants in the Training Assessment function will be the PED/PI and the MSFC Training Coordination team, consisting of the Training Manager, Training Analysts, and Simulation Engineers who will be responsible for defining the PTC simulator functions and conducting the experiment training in the PTC. During the Training Assessment function an analysis will be accomplished to identify the data that will serve as the foundation for systematic development of a training program for each experiment. This information will include such experiment training related data as:

- Description of task
- Type of task
- Type of activity being performed
- Task conditions
- Initiating cues
- Terminating cues
- Output
- Standards
- Consequences of inadequate performance
- References
- Tools and equipment
- Personnel requirements
- Payload safety considerations

The SCS will serve as the repository for this information. A three-phase approach to training analysis will be conducted during the training assessment function. These three phases consist of:

1. Phase I - A needs analysis to define potential requirements of training;

2. Phase II - A functional objective analysis to identify the tasks required for functional objective performance; and

3. Phase III - A task analysis to define the elements, skills, and knowledge needed by the individual for task performance.

The SCS will provide an automated means of identifying training objectives and relating them back to experiment operations functional objectives. This will provide an audit trail from training/simulation needs back to specific experiment functional objectives and also provide the data necessary to go forward to the simulation analysis and simulator validation functions.

4.1.1 Define Potential Requirements of Training

The first stage of the Training Assessment function involves obtaining sufficient information about the experiment to be trained to allow top-level simulation and training system requirements to be developed. The Training Analyst will develop an in-depth understanding of experiment functions and interfaces by gathering experiment requirements into an Training Database. They will be maintained as the source for traceability from experiment information, through intermediate products, to detailed academic and hands-on media requirements. The data items in the Training Database will include:

- Experiment Description
- Experiment Purpose
- Drawings, Schematics and Associated Lists
- Experiment Training Requirements
- Experiment Operational Requirements
- Experiment Development Schedule
- Experiment Review Materials
- NASA and PTC Training Policies
- Simulator Development Schedule
- Trainee Information

Once the first phase data is determined, Training Development Recommendations (TDR) forms will be completed by the Training Analyst and the Simulation Engineer and provided for later reference and training correlation.

4.1.2 Function Objective Performance Task Requirements

The second phase of the Training Assessment function entails review and selection of tasks for training. This task analysis will identify the elements, skills, and knowledges needed to perform the tasks under specified conditions and in accordance with established standards. Common skill and knowledge elements will

be grouped to eliminate redundancy and provide a more efficient approach to subsequent program development.

Once a body of knowledge has been assembled about the operation of an experiment, this knowledge may be analyzed to derive the tasks necessary to operate and support the experiment during a Space Station increment. These tasks may be organized into a Task Hierarchy consisting of Activities, Phases, Tasks, and Sub-Tasks. This hierarchical arrangement demonstrates proper task sequencing and the dependent relationships between tasks and levels of tasks.

After a Task Hierarchy has been established, the tasks are characterized and classified in various ways. Task attributes such as Conditions and Standards of Performance are added to them, as well as a number of other properties such as Criticality and Difficulty. When each task has been sufficiently detailed, performance criterion and training effectiveness evaluation techniques can be derived, as described in the next paragraph.

4.1.3 Training Objectives and Test Development

The third phase of the Training Assessment function consists of developing testing criteria to determine if the objectives of a particular training program have been met. After the Task Hierarchies for an experiment are defined, they can be used to establish task performance criterion tests that define the desired proficiency levels that each trainee is expected to obtain in the performance of the specified task objectives. In contrast to the Task Hierarchy which states what must be done to operate the experiment, the Objective Hierarchy describes what must be learned in order to perform experiment tasks. The training objectives will be used as the framework for all instruction, both academic and hands-on. Lessons will be designed around accomplishment of the objectives and simulators will be designed with the functionality and fidelity necessary to train the specified objective behaviors. Objectives will be used to determine lesson sequence and aid in training media selection.

For the proficiency level criterion associated with each task requirement, measurement techniques will be identified to evaluate the student's accomplishment of the objectives. This evaluation of the students obtained proficiency level in the accomplishment of each task objective will be used as a final validation of the total training system to demonstrate that the Training Program/System meets the training objectives defined during the training assessment phase. The result of Training Objective and Test Development is a hierarchy of objectives with related test items. These objectives and tests identify what is to be taught, and how the results of this teaching will be demonstrated.

4.2 SIMULATION REQUIREMENTS

The development of Simulator Requirements will primarily be the responsibility of the Payload Training Organization. However, the PED/PI organization will make

major inputs into this process and in some cases will be responsible for the detailed requirements specifications. This process should result in Simulator Requirements which detail the development requirements for simulator hardware and software which reflect Mission and Science, as well as individual and integrated experiment training objectives. The Training Database that was developed as part of the Training Assessment function will form the basis for the requirements development process. The requirements development must also take into account overall SSF training plans, PTC resources, experiment development schedules, and the planned training curricula for each experiment. These requirements will in turn, be used as the basis for simulator design and development.

The Simulator Requirements will be developed in a series of steps leading to progressively more detailed requirements, as illustrated in Figure 4-3. The initial analysis will result in an Experiment Overview Report (EOR) which defines the general complexity of the experiment operations and associated training requirements. This information will provide the information necessary to understand the scope of the training objectives and the resources that will be required to accomplish those objectives. From this a Simulation Approach Document (SAD) for each experiment simulator will then be developed. This document will be basically equivalent to the Part 1 Experiment Simulator Requirements Document (ESRD) that are currently being developed for Spacelab payloads. This document will provide a description of training scope for each experiment, outline the approach for satisfying the training objectives that were identified during the Training Assessment function, and will establish the organization responsibilities for the simulator development to satisfy the training objectives. The Payload Training Organization will be responsible for the development of these initial reports. Once the Simulator Approach has been baselined and agreed to by the PED/PI, the Training Organization, and the Development Organization, simulator requirements development will proceed to the development of a detailed math model and requirements document for each simulator (Experiment Software Requirements Document [ESRD]). Simulator Requirements derivation, though discussed as a sequential process, will actually be iterative in nature; gradually producing mature simulator requirements as the understanding of particular experiments grows and experiment data becomes available.

4.2.1 Experiment Overview Report

The Experiment Overview Report (EOR) represents an initial effort to evaluate an experiment in terms of the simulation and training problems which it represents. Its building blocks are comprised of data items developed as part of the data acquisition phase of the Training Assessment function. The Payload Training Organization will be responsible for deriving this report from the experiment information stored in the Training Database during the Training Assessment function. In addition, if the experiment data has changed or been augmented since the time that the data base was developed, it may be necessary to update them before proceeding with further analysis. Any further data items developed as part of Simulator Requirements Derivation should also be included as part of the database so that all analysis efforts will have access to the same inputs.

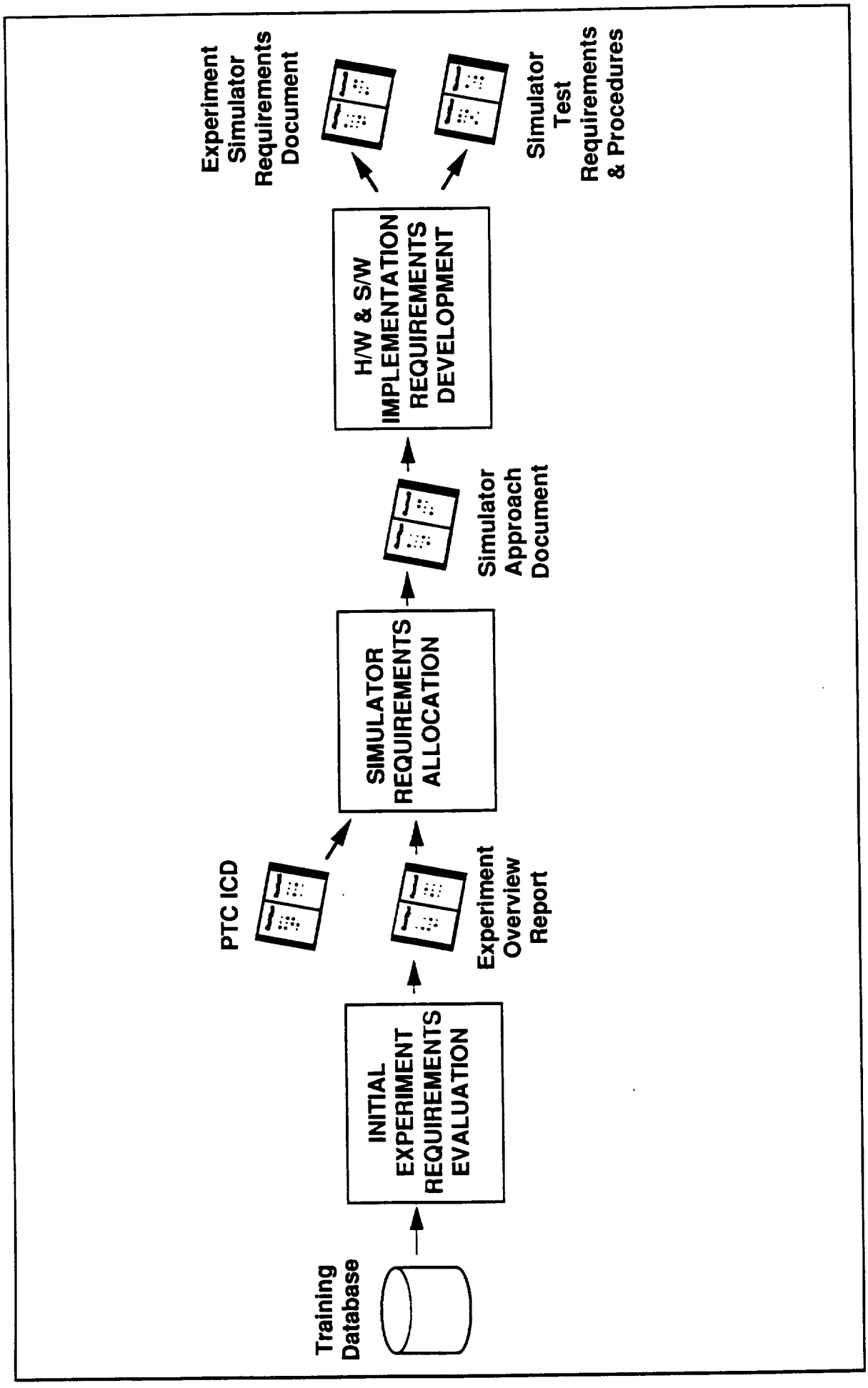

Figure 4-3. SIMULATION REQUIREMENTS DEVELOPMENT FLOW

The PED/PI organization must review and concur with the overview report and the PTC/SCS Operations organization should review this information to become cognizant of the scope of training required for each experiment and the potential utilization of PTC resources.

4.2.2 Simulator Approach Document

To develop the Simulator Approach the Payload Training Organization, working in conjunction with the PED/PI, will examine the training requirements derived from the front-end training analysis for each experiment, and integrate them with each other and with real-world constraints such as PTC capabilities (as defined in the PTC Users Capabilities Document), status of experiment development, cost-effectiveness strategies, and other external factors to develop a preliminary approach for each simulator that will be used to train an experiment in a mission increment. This approach will be the basis for the development of top-level simulator requirements and will serve as a generalized plan for all requirements definition and related activities. The SAD will define the simulator skeleton, its major components and the strategy for their development. It will also unify all the training objectives for an experiment simulator into an integrated concept which can be coordinated with the overall Space Station Training plan. This information will be used to determine the required inputs and outputs for the various simulator functions. The major responsibility in developing this document is to translate the requirements from the training objectives to the appropriate simulator components and to identify the responsible development organizations.

The Experiment Overview and Simulator Approach documents will serve to coordinate simulator development efforts between the PTC and the PED/PIs. The EOR will flag significant training scope and design details of PED/PI-developed simulators to PTC developers. The PED/PI in turn will receive guidance to ensure that:

1. The simulators will be supportable by standard PTC facilities.

2. The simulator will satisfy integrated simulator requirements.

3. All experiment training objectives are satisfied either by the simulator or other elements of the training program.

For each training objective top level simulator functional requirements necessary to satisfy the training objectives will be specified. PTC interface requirements will be specified by an ICD.

The Payload Training Organization will be the lead organization responsible for the development of the Simulator/Training Approach Document. However, both the PED/PI organization and the PTC/SCS Operations Organization will have major inputs into its development. The PTC/SCS Operations Organization must provide the inputs regarding the PTC resource availability and scheduling constraints, and the PED/PI will provide the detailed experiment information and concur in the allocation of the development responsibilities.

4.2.3 Experiment Simulator Requirements Document

Once the various elements of the simulator and training program have been defined the the basic simulator approach has been baselined, the final step is to use this information to develop hardware and software implementation requirements in sufficient detail to allow simulator design and development efforts to proceed. Based on the development responsibilities that were agreed to in the simulator approach document the Payload Training Organization or the PED/PI organization will proceed with the development of detailed Experiment Simulator Requirements Documents (ESRD).

The ESRD organizes these requirements under the same simulator elements and sub-functions defined in the Simulator Approach Document. Since the general simulation method for each sub-function of each element has been previously determined, all that is needed are descriptions of the specific requirements to accomplish each function. For software models, this consists of whatever is necessary to define its inputs, outputs, and behavior. For hardware components, this will mean system schematics, mechanical drawings, parts lists, and any other information about the actual experiment needed by the responsible development organization to create simulator hardware specifications.

4.2.4 Simulator Test Requirements and Procedures

In order to assure that the requirements specified in the ESRD are met by the simulator, the Payload Training Organization will develop Simulator Test Requirements and Procedures. Requirements specify what simulator capabilities need to be tested to assure compliance with the ESRD. Procedures provide the step by step instructions on how to perform the testing. Note that the testing described in the Simulator Test Requirements and Procedures will be performed by the Payload Training Organization on the completed simulator after the PTC/SCS Operations Organization or the simulator developers have completed their IT&V functions.

4.3 SIMULATOR DEVELOPMENT

The Simulator Development function begins following the generation of the simulator requirements which are documented in the Experiment Simulator Requirements Document (ESRD). These requirements are the basis for all Simulator Development function activities which consist of the design, implementation, and testing of the simulator hardware and software. Simulator development can be performed either locally (at the PTC) or at the PED/PI site. The operations for the PED/PI site development can not be defined and mandated to the same extent as local operations. Therefore, PED/PI site development will be discussed separately in each of the following paragraphs. Figure 4-4 shows the sequential processes of the Simulation Development function which will be discussed in their respective order.

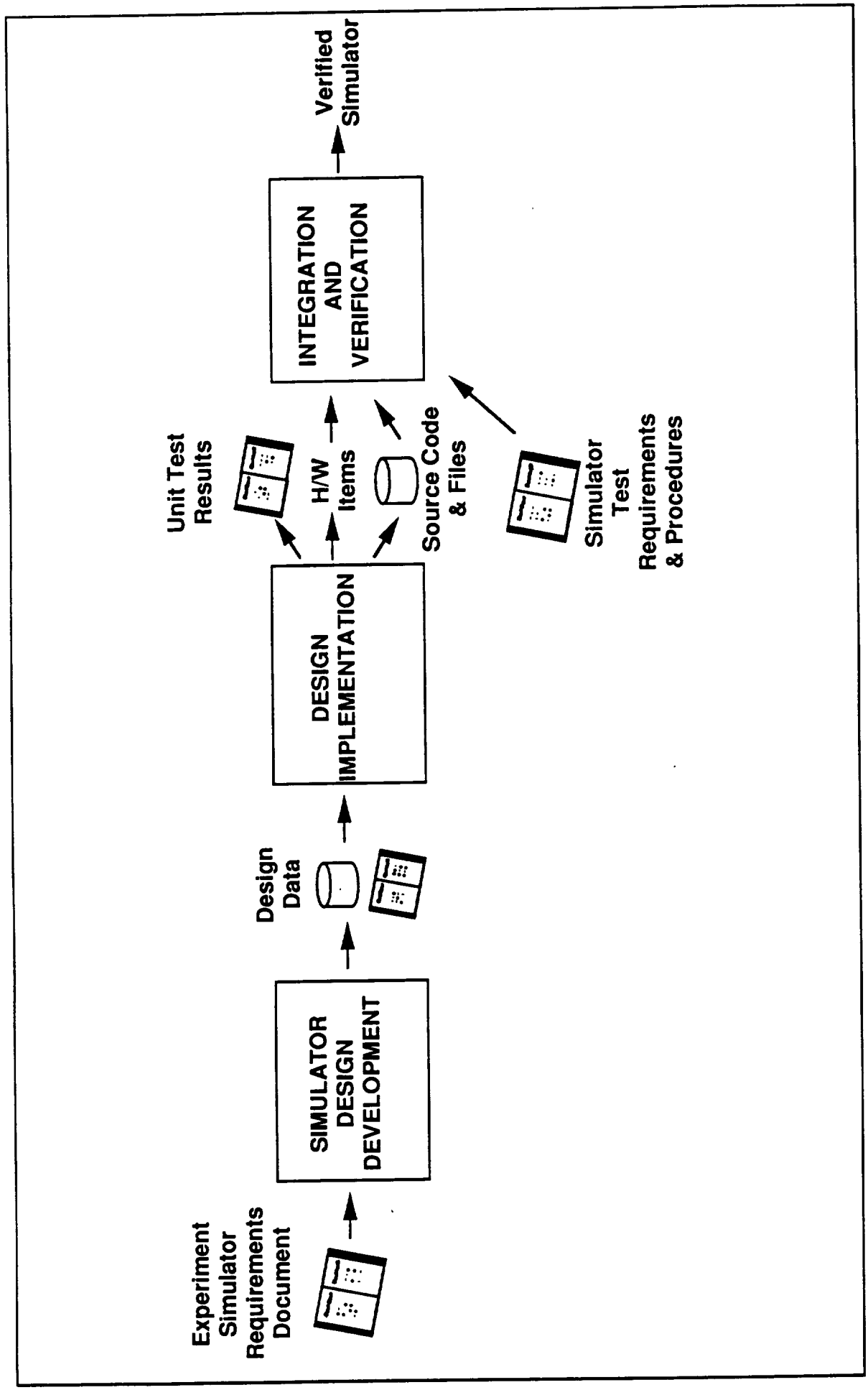

Figure 4-4. SIMULATOR DEVELOPMENT FLOW

4.3.1 Simulator Design

Locally developed simulators can consist of hardware and software components or a software only model. Hardware design will be accomplished using CAD/CAM equipment available in the PTC development facility. The design will include the traceability to the requirements (ESRD) which will be captured in a Teamwork requirements model. All hardware design will meet the SCS interfaces as specified in the PTC Users Capability Document. The output of this activity will be the drawings, schematics, and specifications for the hardware components which include C&D panels, mockups, and functionally equivalent payload data systems/interface equipment and simulators.

The software requirements will also be contained in a Teamwork model and transfered to the development host (Rational) via SSE tools. The Rational provides tools which will support the translation of these requirements into design constructs and automates the traceability process. The software design will meet the SCS software interfaces as specified in the PTC Users Capability Document for the simulation executive, simulation services, and the user interface. Unit Development Folders (UDFs) will be established in the early stages of the design phase and serve as vehicles for capturing all requirements, design, and test results associated with specific software units. These notebooks provide a central repository for the collection and documentation of all information relative to the development and maintenance of a software unit. The outputs of the design phase will consist of design overview data and Ada package specifications and bodies with Program Design Language (PDL) since the software will be implemented in the Ada language. If the target environment is a specialized simulator processor, then another language may be used by the developers. In this case, the developer must provide his own software development environment since the SCS only supports Ada development. The design data will identify all procedures and define program logic with PDL.

All PED/PI site development will be performed on PED/PI-provided equipment rather than via remote access to the SCS resources. The SSE/ITVE simulation software development methodology incorporates the design and coding of software on the Rational, software builds performed on another development host (VAX/VMS system in the SCS), and integrated testing performed on the target host (VAX/ELN in the SCS). This distribution of development functions would force the availability of remote access to multiple systems in the SCS configuration. The only cost effective access mechanism would provide remote access to the SCS LAN which severely impacts the SCS security requirements. Due to common restrictions in remote bandwidth, full access to the SCS LAN can not be supported in an efficient manner (e.g. distributed graphical user interfaces such as X-Windows). The combination of these problems make simulator development via remote access to the SCS impractical.

Simulator development at PED/PI sites is not constrained to the same operational concept as local developments, but the simulator design will be traceable to the requirements in the ESRD. The software design will meet the SCS software interfaces as specified in the PTC Users Capability Document for the simulation

executive, simulation services, and the user interface. The design data will be consistent with the requirements for local simulation development which designates the identification of all procedures and definition of program logic with PDL. All hardware design will meet the specified interfaces for the SCS. The design output will be drawings, schematics, and specifications for the hardware components which include C&D panels, mockups, and functionally equivalent payload data systems/interface equipment and simulators.

The culmination of the design process is the Simulator Design Review (SDR). This review is critical to the development process and must involve all affected organizations to ensure adherence to training, simulation, and interface requirements. The Payload Training Organization will ensure the simulation requirements are properly interpreted in the design to provide adequate training. The PTC/SCS Operations Organization will ensure that the design is compatible with all SCS hardware and software interfaces. The PED/PI will verify that the design provides an accurate representation of the current experiment design. The design approved at this review provides the baseline for subsequent simulator implementation.

4.3.2 Simulator Implementation

Simulator hardware components will be identified for procurement or fabrication by the developers. Those components identified for fabrication will be built to the design drawing and specifications. Functional and interface testing/inspections of individual fabricated components will be performed and the results documented to ensure compliance with the design specifications. Acceptance tests will be performed on all procured items to verify compliance with procurement specifications.

Locally developed software will be implemented with the Ada language from the design PDL available on the Rational development host. In the case of software targeted for non-SCS processors, the appropriate native Ada compiler or cross compiler must be procured by the developing organization for execution on SCS resources. Typically the unit testing will be performed on the Rational or one of the other compilation hosts. Source code and unit test results will be incorporated into the UDF. Following the completion of unit testing, an initial integration will be performed which consists of integrating the software units and executing informal tests. These tests are performed by the software developers and are not as exhaustive as the formal verification tests.

Likewise, software developed at the PED/PI sites will be implemented from the design PDL generated using their selected development environment. Unit testing will be performed on all software modules produced. Prior to delivery of the simulator to the PTC, an informal integration will be performed to the extent possible for the simulator configuration. If the simulator consists of flight equivalent hardware and specialized simulation equipment, then a relatively complete initial integration can be performed at the PED/PI site. However, the initial integration for software simulators targeted for the SCS simulation hosts is expected to be limited to simple functional tests using stubs and drivers. Therefore, these simulators to be delivered to the PTC in a preliminary state of integration.

4.3.3 Simulator Integration, Verification, and Validation

Simulator integration is the incorporation of simulator hardware and software into an operational PTC training configuration in the SCS Integration, Test, and Verification (IT&V) facility. The PTC Operations Organization is responsible for the integration and checkout process which demonstrates that the simulator functions properly in the SCS environment . Limited remote access will be available to support the electronic transfer of files (source code, executables, etc.) from PED/PI sites to the PTC. This mechanism supports a quick turnaround for incorporation of software modifications developed at the PED/PI sites for problem resolution during all testing activities. The integration and checkout for PED/PI site developed software targeted for SCS simulation hosts will include additional effort and schedule due to the limitation of the initial integration at the PED/PI site. The integration and checkout process confirms that the simulator meets all SCS hardware and software interfaces prior to release for verification and validation testing.

The simulator verification and validation process includes the necessary testing and inspection to ensure that the simulator implementation meets all training and simulation requirements. The Payload Training Organization is responsible for all verification and validation functions. The simulator test requirements and procedures will be developed concurrently with the simulator requirements. These test procedures will be executed in the IT&V facility and results of the tests will be recorded in test reports. The simulator developers and the PTC/SCS Operations Organization will support test activities in the investigation and resolution of reported problems.

Once the simulator has been validated in the IT&V facility, it must be integrated into the training environment. Interface testing will be performed to ensure that the simulator was integrated properly. A limited subset of the verification and validation tests will be executed to confirm that no anomalies have been introduced during the trainer reconfiguration.

4.3.4 Payload Simulator Transportability

Payload simulators will be transported to the Space Station Training Facility (SSTF) located at JSC to support crew training during the last six months prior to launch. The SSTF will contain a complete duplicate of the SCS hardware and software required for a PTC U.S. Lab trainer. This concept provides payload simulator interfaces (both hardware and software) at the SSTF that are identical to those provided by the PTC. Therefore, payload simulators will be directly transportable to SSTF.

4.4 TRAINING PREPARATION

Preparing for training will be the responsibility of the Payload Training Organization, with each Space Station increment being assigned to a different Training Manager (with the support of one or more Simulation Engineers). In performing the Training Preparation function, the Training Manager is responsible for developing or acquiring the necessary training materials, and for scheduling the necessary personnel (students, instructors, operations support) in order to support the required training activities. Training Preparation will be undertaken after the Training Assessment and the Simulation Development functions have been completed, and uses the results from these functions as inputs. Training Preparation will be conducted concurrently with the Mission Planning System (MPS) activities, which are to provide mission planning products (Onboard Short Term Plan, Crew Procedures, and Ephemeris and Environment Data) via an interface from the Payload Operations Integration Center (POIC) to the PTC.

Training Preparation is the process in which the Training Database's training activities are prepared for implementation, as illustrated in Figure 4-5. The actual process followed depends on the type of training which is required: Classroom Sessions, Self-Study Materials, Computer Based Trainers, or Simulator Training. The process listed for each of these training methods will depend almost totally on PED/PI involvement for the development efforts, with the Payload Training Organization providing the organization and integration efforts. The PED/PI is expected to perform almost all of the preparation work, provide the required printed or audio-video training materials, and provide the training scenario information (if not the actual development work) for the training sessions. The Students which will participate in the training include Onboard Crew Members, Ground Support Personnel, Ground Processing Personnel, and Payload Support Team Members.

4.4.1 Inputs to Training Preparation

The Training Preparation function receives the Training Database from the Training Assessment function, consisting of the Training Objectives and Test Items which specify the training requirements, training methods, and training recipients. The simulators and other tools which are to be used to accomplish the training are provided by the Simulation Development function, which also provides the information for configuring and operating the Simulation Computer System (SCS). When the Training Preparation is performed, an interface will be required to access the Short Term Plan, Crew Procedures, and Environmental Data which are maintained by the MPS in the POIC. The payload-specific data discussed in this section is assumed to be provided by the PED/PIs, with the Payload Training Organization personnel taking the data and integrating it into the Training Database.

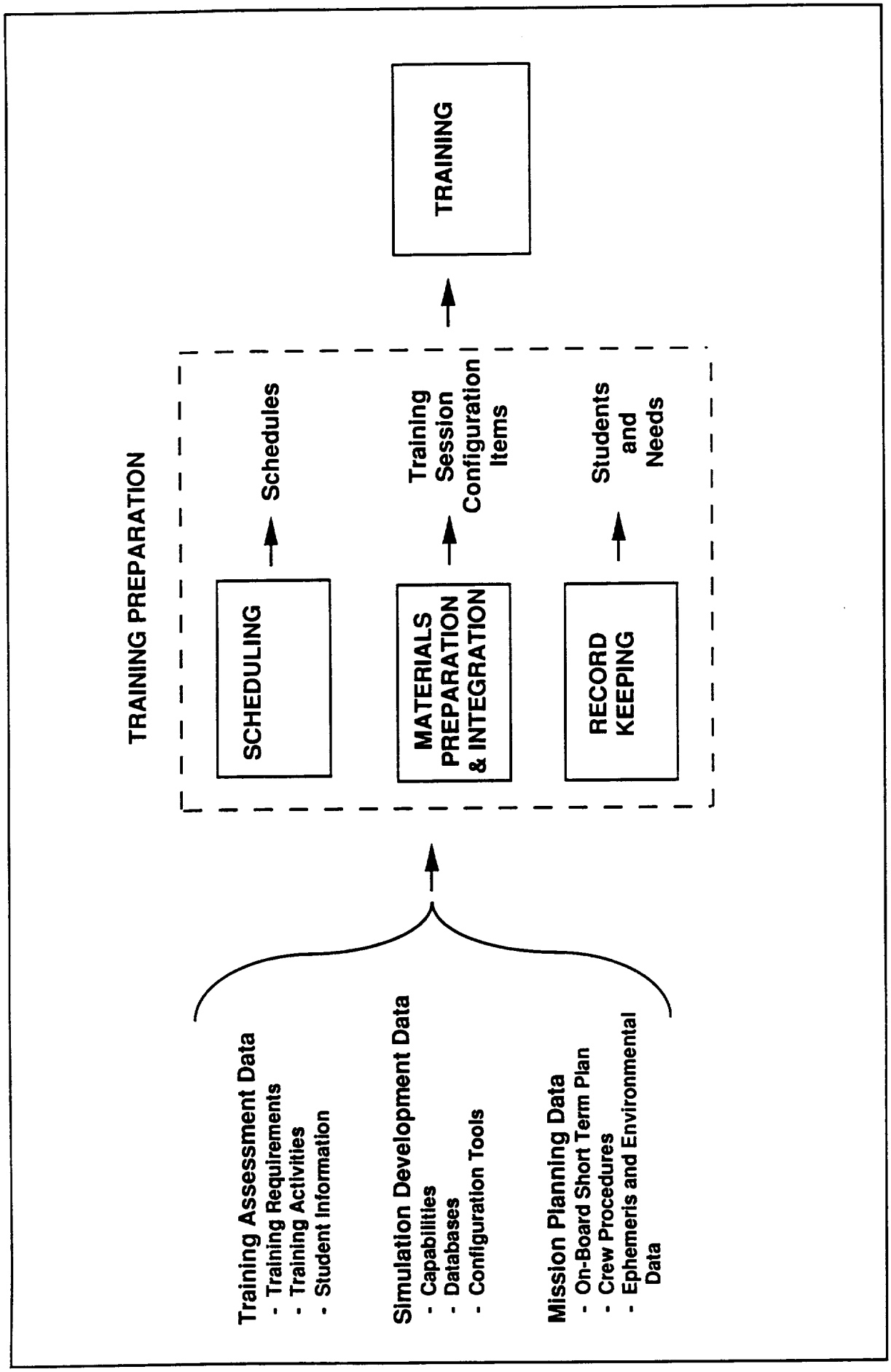

Figure 4-5. TRAINING PREPARATION FLOW

4.4.1.1 Training Assessment Function

The Training Assessment function provides the details of the Training Objectives and Tests, the suggested Training Activities for meeting those objectives, and information about the Students which are to be trained, as listed below.

1. Training Objectives and Tests
   - List of experiment tasks for which training is required.
   - List of skills and behaviors required to perform each task.
   - List of the Test Items required - these identify how the results of the training will be demonstrated.

2. Training Activities
   - Matrix of Training Media which bests supports each Training Objective - media can include classroom sessions, self study materials, computer based training, and simulator training.
   - Flow of training activities from the introductory sessions to the integrated simulation sessions.

3. Student Information
   - List of the student types which require training (i.e., Crew, Ground Support, Ground Processing, etc.) - all personnel that require training may not receive it at the PTC, although some of the training can be made available (via video tapes, etc.) to those personnel.
   - Matrix of what training objectives apply to each student type.

4.4.1.2 Simulation Development Function

Training Preparation depends on the Simulator Development function to provide the necessary Simulation Tools for a given Space Station increment or Space Station subsystem. This includes information about the capabilities of the simulators, and procedures for configuring and operating the simulators in the Simulation Computer System (SCS). Documentation provided by the developers will define the capability of the simulators, the level of fidelity they support, and the maintenance/ troubleshooting procedures for the simulator hardware. Developer provided documentation will also identify the contents of databases, including listings of database information with formats, range of values, units, descriptions, and default values of the data. The PTC/SCS Operations Organization will provide configuration and operations manuals which include specific instructions for setting up and operating the simulator, special requirements such as operating environment or limitations, and a description of all simulator control interfaces.

4.4.1.3 Mission Planning System

The POIC contains the Mission Planning System which provides the tools to develop, integrate, and maintain the information needed to define and schedule the activities which are to be performed by the crew. Also generated and maintained by the MPS is the environment database for the Station. The MPS data will be required

to perform the Training Preparation tasks, and it is assumed that a network interface shall be available between the POIC and the PTC in order to access this data. The three elements of the MPS which are required at the PTC are listed below.

1. The Onboard Short Term Plan provides the time-referenced progression of SSF subsystem and payload tasks. These are used to define the sequence of events which are simulated during training sessions.

2. The Crew Procedures provides the detailed step-by-step instructions for operating the SSF subsystems and the payload equipment. These are used to define the steps which the students are expected to perform on the simulators and the response to malfunction conditions which the students will face.

3. The Ephemeris and Environment Data provides the environment in which the SSF subsystems and payloads operate. The time-referenced data includes the orbital parameters of the SSF, the position of celestial objects (Earth, Moon, Sun, etc.), the attitude profile of the SSF, and thermal and power profiles for the SSF's subsystems.

4.4.2 The Training Preparation Process

The following paragraphs define the process involved in the Training Preparation function for the different types of training. Note that there is much commonality in the activities required for the different types, and that these activities will be discussed in detail in the next section.

4.4.2.1 Classroom Sessions

Classroom training may consist of lectures, viewgraph presentations, computer based demonstrations, hardware demonstrations, and question and answer sessions. Classroom sessions are usually performed by the PED/PI representative who is most familiar with the equipment or topic of discussion. Classroom sessions can be video taped for later viewing by other students, or even viewed at various locations (through video teleconferencing, if available) in order to allow one session to serve the needs of many students. The operations involved in preparing for classroom sessions include:

1. Acquisition and generation of training materials - includes generating and copying handouts, developing presentations, and planning and developing demonstrations.

2. Scheduling facilities and training equipment - includes locating and scheduling classrooms with the required capacity and capabilities and locating training equipment such as audio/video equipment or computer equipment.

3. Scheduling instructors - includes locating the appropriate instructor to teach each session and scheduling that instructor's time.

4. Scheduling students - includes determining which students require each particular session, and scheduling the students' time to attend the session.

5. Updating training records - includes processing test scores or other evaluation criteria and entering the data into the Training Database to indicate completion of training requirements.

4.4.2.2 Self Study Materials

Self study materials consist of documentation, workbooks, video tapes, computer software, or any other media which can be studied by the students at their own leisure and at their own facilities. The portability of these materials allows students to conduct this portion of the training at their normal locations, negating the need for travel to the PTC. These materials are usually provided by the PED/PI, or based on PED/PI or project generated materials. Self study materials are useful for providing background information to the students prior to other training sessions, as well as for providing reference information for students during the training program. The operations involved in preparing self study materials include:

1. Acquisition and generation of training materials - includes generating, copying, and distributing workbooks, video tapes, computer disks, or other self-study media.

2. Scheduling students - includes determining which students require each set of materials, and scheduling the students' time to study the materials.

3. Updating training records - includes processing test scores or other evaluation criteria and entering data into the Training Database to indicate completion of training requirements.

4.4.2.3 Computer Based Training

This training consists of independent computer based trainers which provide students with training that serves to familiarize them with experiment functions, interfaces, and procedures. These trainers can be operated by the student without an instructor being present and contain the necessary training knowledge to guide the student through the lesson. These trainers are not considered part of the SCS, but will interface to the SCS for uploading or downloading information. Once the training software is developed it can be distributed to students at remote locations, providing the students have access to the necessary hardware. The operations involved in preparing for computer based training include:

1. Preparing and verifying training scenarios - includes building the appropriate databases for the specific training scenarios (sequence of events, malfunctions, expected student responses).

2. Scheduling training equipment or distributing training scenarios - includes locating, scheduling, and configuring the appropriate computer training tools for local training; or distributing the completed training scenarios and appropriate documentation for remote site training.

3. Scheduling students - includes determining which students require each particular scenario and making arrangements with the students to perform the training.

4. Updating training records - includes processing the evaluation criteria, and entering data into the Training Database to indicate completion of training requirements.

4.4.2.4 Simulator Training

Simulator training consists of all training activities conducted using the PTC/SCS. The student normally begins on Stand Alone Trainers which simulate the interfaces and operations for individual experiments. Module Training follows, wherein the individual simulators are integrated into a module and the student acquires experience in the integrated operations of the entire complement of experiments in one SSF lab (either the US, ESA, or JEM Labs). Consolidated Increment Training are extensions of Module Training wherein the training activities in the ESA Lab and/or the JEM Lab are added to those in the US Lab. Integrated Training and Joint Integrated Training advance this process by introducing first the POIC and then the ROCs or DOCs into the training environment, thus allowing the student to interface with the ground control personnel in a complete simulation of the flight configuration. The operations involved in preparing for simulator training include:

1. Preparing and verifying training sessions - includes building the appropriate databases for the specific training sessions (sequence of events, malfunctions, expected student responses, simulator control information, environmental data).

2. Scheduling training equipment - includes locating, scheduling, and configuring the appropriate training simulators; scheduling supporting host system operators, facilities, and other equipment; and scheduling any other facilities which may be participating.

3. Scheduling students - includes determining which students require each particular session, and scheduling the students' time to attend the session.

4. Updating training records - includes processing the evaluation criteria, and entering data into the Training Database to indicate completion of training requirements.

4.4.3 Details of Training Preparation Operations

From the discussion of the Training Preparation process in the previous paragraphs, it can be seen that the activities required can be broken down into 3 specific areas: Scheduling, Materials Preparation/Integration, and Record Keeping. Detailed operational concepts for these activities are provided in the following paragraphs.

4.4.3.1 Scheduling

When a Training Requirement is to be satisfied, the Training Manager must determine what personnel are involved and what facilities and resources are required, and must schedule these to accomplish the training. The Training Requirements provide a syllabus of the required training and a matrix specifying which type of students are required to complete each segment of the syllabus (this information will be part of the Training Database). It is the function of the Training Manager to schedule the training sessions in the required order, making arrangements for the appropriate students to attend, making arrangements for the required training personnel to be prepared and available to provide the training, and making arrangements for the necessary facilities and equipment to be available. The Training Manager must juggle all of the time commitments of the students and integrate those with the availability of the training resources and personnel (where applicable) in order to accomplish the required training. In performing the scheduling job, the Training Manager interacts with the PTC/SCS Operations Organization, which maintains and schedules the PTC resources to meet all user's needs. The following tools are used by the Training Manager to perform the scheduling job:

1. PTC Scheduling Form which shall identify all resource requirements to the PTC/SCS Operations Organization, and ideally should be incorporated into the PTC Scheduling Software. The PTC Scheduling Form is made up of the following information:
   - General requirements - identification of the requestor and mission, needed dates and times, type of training planned, special personnel required.
   - Facility requirements - mockups (panels, terminals, hand-controllers, experiment hardware), control stations, computer hardware, audio communications, video channels, interfaces with external facilities (POIC, ROC, DOC, remote operator sites).
   - Simulator requirements - simulators (versions), support software, system software.
   - Session requirements - time (GMT or MET) of session, starting configuration of simulators (checkpoint), databases.

2. Training Management Software which supports the management of students as they proceed through the various training phases. This software would access the Training Database to provide record keeping on individual students and support the scheduling of each student's training activities. The transfer of training records from the Training Database to TMIS would also be supported.

4.4.3.2 Materials Preparation/Integration

As part of the Training Database, the Training Assessment function determines what training method is most appropriate for fulfilling the training requirements. As each training session is scheduled, the Training Manager prepares or integrates the materials which are used in that session. As noted in the overview section, this can include course work for classroom or self study lessons as well as simulation databases for computerized trainers or simulators. The Training Manager acquires most of the course work from the PED/PIs or other appropriate domain experts, and assumes the task of integrating and distributing the data. In generating the databases, the Training Manager relies on inputs from the Mission Planning System to define the scenario's activities/environment, and inputs from the PED/PI or other experts to define the scenario's procedural functions. Once the scenario database is generated, the Training Manager integrates all the software and database information required to accomplish the training session into a specific checkpoint, then verifies the session by performing a dry run from this checkpoint.

In support of this operation, the Training Manager would make use of scenario development software, which supports an instructor in generating scenario databases for particular training sessions. This software would provide an interface for easy definition of the configuration of the session, the planned training steps, the expected crew responses, and the required simulation controller or instructor inputs.

4.4.3.3 Record Keeping

The Training Database contains a matrix specifying which type of students are required to complete each segment of the training syllabus, and also contains the evaluation criteria to be used to certify satisfactory completion. This matrix will be also used to keep track of the progress each student has made in completing their requirements. After a student completes a lesson or session, the Training Manager refers to the evaluation criteria and makes a determination of the student's progress. This data will be entered into the Training Database, allowing a student's progress and remaining requirements to be monitored and assessed.

In support of this operation, the Training Manager would make use of the Training Management Software which supports the management of students as they proceed through the various training phases. This software would access the Training Database to provide record keeping on individual students to support the recording of each student's training progress. The transfer of training records from the Training Database to TMIS would also be supported.

4.5 TRAINING

The Training function is the culmination of the overall SSF training development and implementation process which will occur in support of the Payload Training Complex (PTC) payload training activities. The purpose of the Training function will be to perform the different types of training necessary to provide the students with the skills and behaviors that they require to perform their duties. The Training function will be undertaken after the Training Preparation function and the Simulator Development function have been completed, and uses the results from these functions as inputs. The Payload Training Organization has the ultimate responsibility for providing training, with each Space Station increment being assigned to a different Training Manager (with the support of one or more Simulation Engineers). The operations of the PTC in support of training are the responsibility of the PTC/SCS Operations Organization, which is also responsible for providing a verified and configured simulation system.

The Training function is the process during which the Training Manager's plans and schedules are implemented by the PTC/SCS Operations Organization and the Training Conductor (who will be a member of the Training Manager's group), as illustrated in Figure 4-5. The actual process followed depends on the type of training which is required: Classroom Sessions, Self-Study Materials, Computer Based Training, or Simulator Training. The process listed for each of these training methods will depend on some PED/PI involvement, with the Training Conductor providing the organization and integration efforts. The students which will participate in the training include Onboard Crew Members, Ground Support Personnel, Ground Processing Personnel, and Payload Support Team Members.

4.5.1 Inputs to Training

The Training function will receive the training schedules from the Training Preparation function, including information on what specific training sessions are to be scheduled, what students are to be trained, who is to perform the training, and what training resources (facilities and simulators) are to be used. The training materials and databases which are to be used will also be provided by the Training Preparation function, either prepared by the Training Manager or the PED/PIs. When the PTC is supporting Joint Integrated Training or Integrated Training, it may require interfaces to the Payload Operations Integration Center (POIC) or to remote training sites.

The simulators and other tools which are to be used to accomplish the training will be provided by the Simulation Development function, which will also provide the instructions for configuring and operating the Simulation Computer System (SCS). The simulators will consist of software, hardware, and database elements, and will be accompanied by information about their capabilities and by procedures for configuring and operating them in the Simulation Computer System (SCS), as detailed below:

1. Payload and Subsystem Simulators
   - Mockups and interface panels - the training environment will contain the appropriate operational hardware elements housed in a realistic module.
   - Software simulators - include math models or other types of functional and procedural simulators
   - Supporting databases - contain parameter values, operating sequence data, and other data which can be reconfigured by the instructor as required.

2. Documentation
   - Capabilities of simulators - what nominal and malfunction procedures are supported, and to what level of fidelity.
   - Contents of databases - listings of database information with formats, range of values, units, descriptions, and default values of the data.
   - Configuration and operations manuals - including specific instructions for setting up and operating the simulator, special requirements such as operating environment or limitations, and a description of all simulator control interfaces.
   - Maintenance and troubleshooting manuals - defining procedures to locate and correct problems with simulator hardware.

4.5.2 The Training Process

The following paragraphs define the process involved in the Training function for the different types of training and also define the interfaces which are to be exercised. Note that there is some commonality in the activities required for the different types, and that these activities will be discussed in detail in the next section.

4.5.2.1 Classroom Sessions

Conducting classroom sessions will involve distributing the handouts, lecturing on the materials, and conducting the demonstrations developed during the Training Preparation function. It is expected that the instructor for all experiment training will be a member of the PED/PI team. It is also expected that the instructor for all SSF subsystem training will be a systems engineer or other specially designated and trained person. Tools required include the classroom facilities, audio/video equipment, and computer equipment necessary to perform the training.

In order for classroom sessions to be most productive, they will be captured on video tape and/or distributed via teleconferencing. This allows one session (usually the one presented for the crew members) to serve the training requirements of many more students than could attend a single session. It also allows for non-resident students, such as PED/PI personnel and ground support personnel, to receive the training at their home sites and on their own schedules. Capturing the lessons also serves to capture the knowledge of the instructor for later use.

4.5.2.2 Self Study Materials

The only activities required for training using the self study materials are distributing the materials and tracking the results of the training. These activities will be handled by the Training Manager and will require no PTC resources.

4.5.2.3 Computer Based Training

This training will consist of independent computer based trainers (expert systems) which provide students with training that will familiarize them with experiment functions, interfaces, and procedures. These trainers will be operated by the student without an instructor being present and will contain the necessary training knowledge to guide the student through the lesson. Several computer based trainers may be provided as part of the PTC so that resident and visiting students can use them. These trainers are not considered part of the SCS and will be provided by the Payload Training Organization. Once the training software is developed, it will be distributed to students at remote locations, providing the students have access to the necessary hardware.

The computer based trainers at the PTC will be managed similarly to any other PTC system by the PTC/SCS Operations Organization. This organization is responsible for maintaining and scheduling the equipment, as detailed below:

1. Configuring the equipment - includes integrating the required operating system software, training software, and scenario databases on the appropriate computer trainers.

2. Maintaining the equipment - includes repairing any malfunctioning hardware, investigating and correcting any software errors, and upgrading the hardware as necessary to keep it up to date and compatible with the software.

3. Scheduling the equipment - includes scheduling the use of the computer trainers by any student.

Regardless of where the computer based trainers are located, the Training Conductor has the responsibility of verifying the trainers, assisting the students in conducting the training (should such assistance be required), and gathering training results, as detailed below:

1. Performing an acceptance review - includes going through the same operations which the student is expected to execute to assure that the trainer will operate as expected and that all the required training materials are available and accurate.

2. Assisting the student - includes providing answers to student's questions regarding the training environment or any aspects of the training lesson.

3. Gathering evaluation data - includes retrieving the data files which compare the actual responses of the student with the expected responses and provide an evaluation of the student's performance.

4.5.2.4 Simulator Training

Simulator training will consist of all training activities conducted using the SCS. The student will begin on Stand Alone Trainers which simulate the interfaces and operations for individual experiments. Module Training follows, wherein the individual simulators are integrated into a module and the student acquires experience in the integrated operations of the entire complement of experiments in one SSF lab (either the US, ESA, or JEM Labs). Consolidated Increment Training are extensions of Module Training wherein the training activities in the ESA Lab and/or the JEM Lab are added to those in the US Lab. Integrated Training and Joint Integrated Training advance this process by introducing first the POIC and then the ROCs or DOCs into the training environment, thus allowing the student to interface with the ground control personnel in a complete simulation of the flight configuration.

The PTC/SCS Operations Organization will be responsible for maintaining the SCS and its software in a state of readiness for the users as well as for scheduling the SCS to meet the needs requested by the Training Managers on the PTC Scheduling Forms. These operations are detailed below:

1. Configuring the equipment - includes integrating the required operating system software, training software, support software, and scenario databases on the SCS; integrating the SCS computers to the mockups and other hardware elements of the SCS; and configuring the interfaces between the SCS and other facilities (POIC, ROCs, DOCs, remote sites).

2. Maintaining the equipment - includes repairing any malfunctioning hardware, investigating and correcting any software errors, planning and supervising upgrades to the SCS system software and hardware, and investigating any malfunctioning interfaces between the SCS and other facilities.

3. Scheduling the equipment - includes scheduling the use of the SCS in response to the PTC Scheduling Forms.

The Training Conductor will be responsible for verifying that the SCS is ready to provide the necessary training, conducting the training session, and gathering training results, as detailed below:

1. Performing a training readiness test - includes going through the same operations which the student is expected to execute to assure that the trainer will operate as expected and that all the required training materials are available and accurate; and verifying that all hardware, software, and interfaces (including those to other facilities) are ready to support training.

2. Conducting the training session - includes initializing the trainer from the previously generated checkpoint, following the progress of the student and injecting malfunction conditions where appropriate, communicating with the student as a surrogate for other crew members or ground personnel, and performing the actions of other crew members or ground controllers where those actions have an effect on the training.

3. Gathering evaluation data and participating in debriefs - includes accessing the trainer after the student has finished to retrieve the data files which compare the actual responses of the student with the expected responses; and discussing the training session with the student to review the progress of the session, the student's responses to the malfunction conditions, and any problems encountered with the training equipment or crew procedures.

4.5.3 Details of Training Operations

From the discussion of the Training process in the previous paragraphs, it can be seen that the activities required can be broken down into 5 areas: Configuration and Maintenance, Verification, Scheduling, Training, and Record Keeping. Detailed operational concepts for these activities are provided in the following paragraphs.

4.5.3.1 Configuration and Maintenance

The PTC/SCS Operations Organization will be responsible for configuring and maintaining all PTC equipment, including the SCS and the separate computer based trainers. The PTC/SCS Operations Organization will be responsible for the maintaining any remote training stations (MPACs or equivalent hardware located at other sites) that are supported by the SCS. Setting up the necessary equipment at the remote site and establishing the necessary interfaces will be the responsibility of the Remote Site Operators. Note that the PTC/SCS Configuration and Maintenance function is discussed in detail in the next section.

4.5.3.2 Training Readiness Testing

Once a particular training session is planned, the Training Conductor will be responsible for performing a readiness test of the training system (either the SCS for simulator training or the separate trainers for computer based training). This test includes going through the same operations which the student is expected to execute and using the same equipment and materials that the student is expected to use. The purpose of the test is to assure that the training system will operate as expected and that all the required training materials are available and accurate. This includes verifying that all hardware, software, and interfaces (including those to other facilities) are ready to support training.

4.5.3.3 Scheduling

The PTC/SCS Operations Organization will be responsible for accepting all the PTC Scheduling Forms for a given training period and allocating the SCS resources to meet the Training Managers' needs. This will often involve resolving conflicts between requests for the same resources by two or more Training Managers, which will usually be resolved based on payload priority. Non-training requirements for SCS resources will also have to be scheduled, including preventive maintenance, system upgrades, and software installations. Resource scheduling software (if available) will be used by the PTC/SCS Operations Organization to schedule PTC resources to support the user requests made on the PTC Schedule Forms. This software would integrate the requirements for concurrent training schedules, maintenance schedules, upgrade schedules, etc. This software would also support the incorporation of the scheduling constraints of those resources required to support sessions involving external facilities. A weekly schedule would be produced to inform the users of their allocation of SCS resources.

4.5.3.4 Training

The actual training operations will be performed by the Training Conductor with assistance from other members of the Payload Training Organization. For computer based training the Training Conductor will not be directly involved, but rather will serve as a consultant to the student should the student have questions regarding the training environment or the any aspects of the training lesson. During simulator training the Training Conductor will serve as the Simulation Director at the Simulation Control Station, acting as the coordinator for all activities which are required to support the student during the training session. These activities will include initializing the trainer from the previously generated checkpoint, configuring the crew interface hardware to the correct initial configuration, and establishing the interfaces to any external facilities involved. As the session progresses, the Training Conductor will follow the progress of the student and will inject malfunction conditions into the system at the appropriate times. The Training Conductor will also communicate with the student as a surrogate for other crew members or ground personnel, and will perform the actions of non-participating crew members or ground controllers where those actions have an effect on the training session.

4.5.3.5 Record Keeping

The Training Database will contain a matrix specifying which type of students are required to complete each segment of the training syllabus, and will also contain the evaluation criteria to be used to certify satisfactory completion. This matrix will also be used to keep track of the progress each student has made in completing their requirements. After a student completes a Training Objective, the Training Manager will refer to the Test Items for that Training Objective and make a determination of the student's progress. This data will be entered into the Training Database, allowing a student's progress and remaining requirements to be monitored and assessed.

In support of this operation, the Training Manager will use training management software which supports the management of students as they proceed through the various training phases. This software will access the Training Database to provide record keeping on individual students, and will support the recording of each student's training progress. The transfer of training records from the Training Database to TMIS will also be supported.

4.6 CONFIGURATION MANAGEMENT AND MAINTENANCE

The maintenance and configuration management activities apply to the PTC hardware, SCS operational software, SSF system simulation software, and the payload simulators. The following sections discuss the concepts and issues related to both maintenance and configuration management.

4.6.1 Configuration Management

The Configuration Management (CM) function allows latitude for design and development, provides a clear and logical method of making necessary changes, and ensures confidence in the integrity of the released products. The PTC/SCS Operations Organization is responsible for the CM function. The following paragraphs discuss the CM function in terms of configuration identification, configuration control, and status accounting.

4.6.1.1 Configuration Identification

Configuration identification provides the means by which the configuration of hardware and software products are specified and controlled. Configuration identification defines the functional and physical characteristics of an item and identifies these items by the use of unique numbers or names. CM personnel establish the internal configuration identification and all subsequent product baselines of requirements, design and test documentation, hardware drawings, and the physical hardware/software products. The configuration identification responsibilities of CM are to:

1. Define identifiers for the physical identification of documents, software, drawings, test materials, hardware components, and software media.

2. Define configuration baseline items and periods of control for the formal (external) and informal (internal) baselines established for the program.

3. Define and support a system to accept and release software products and their documentation into a controlled environment.

4. Control the buildup of hardware and software configurations.

The foundation of the CM program is the concept of configuration baselines established at major project milestones and payload development milestones. These baselines identify program technical requirements at each stage of design evolution constituting points of departure for subsequent change activities and forming the technical basis for configuration control. There will be four types of baselines for PTC CM as defined below:

1. Functional Baseline - the functional specification that establishes the performance, design, and test requirements for the system.

2. Allocated Baseline - documents that establish the detailed system and software requirements and allocate the requirements to elements of the system.

3. Internal Baseline - items subjected to internal control, as required, to effect order and stability in the development, operations, and maintenance of the PTC.

4. Product Baseline - the final "as-built" software, hardware, and all related documentation

The documentation used to define these baselines will include development and product specifications, software requirements and design documents, interface documents and drawings, and software source code.

Identifiers will be defined for all product elements for which unique identification is required for effective configuration management. Items requiring identifiers include documents, drawings, hardware, software, software media, permanent files, and change control forms. Detailed procedures will be established by the CM organization to provide unique identifiers for each configured or controlled item, document, and associated change paper.

4.6.1.2 Configuration Control

The primary purpose of configuration control is to assure a stable environment in which development, test, or operations can occur and to establish an orderly transition from one baseline to the next in the evolution of a system. The baselines are the configuration identification approval points from which all subsequent changes require change documentation for the proposed change and a review, an impact assessment, approval, and authorization before they can be implemented.

Configuration control for the PTC encompasses the management of the baseline products and documents and the procedures needed for change control. Once a baseline is established, the items constituting the baseline will be subject to the appropriate level of change control. Events such as requirements or interface changes, reporting of problems, review action items, and test/verification results generate documentation (e.g. Engineering Change Requests (ECRs), Preliminary Interface Revision Notices (PIRNs), Problem Reports (PRs), Review Item Discrepancies (RIDs), and Change Requests (CRs)) which must be tracked by CM to

either a dismissal or successful implementation/release of the change. For an operational system such as the PTC, change processing, not the development of the original baselined elements, generates the bulk of CM activities and thus dictates the design of the CM procedures, organization, database, and support tools.

CM will coordinate and control each phase of the change cycle. Computerized change forms will be designed for each type of change that may arise. These forms may be submitted to the PTC CM organization by personnel from the Payload Training Organization, the PTC/SCS Operations Organization, the PED/PI, or other MSFC organizations. CM will ensure that all change documents are properly entered into the CM data base and will maintain current status throughout the assessment and implementation process. After entry into the CM database, the change documents will be distributed to the cognizant PTC technical groups for impact assessment or problem investigation. CM will coordinate the assessments for presentation to the PTC Configuration Control Board (CCB) which includes representatives from the Payload Training Organization, the PTC/SCS Operations Organization, and PTC Management. The PTC CCB is responsible for processing all changes to approved baselines whether external or internal.

The configuration of certain key elements of the PTC such as DMS Kits and ITVE software will be controlled by organizations external to MSFC. Since changes to these elements may have significant impacts on PTC systems and operations, PTC participation in configuration control for these elements is essential. PTC CM will maintain interfaces with the external CM organizations so that changes may be reviewed and impacted by the PTC. The PTC CCB will review and approve all impact assessments prior to transmittal to higher level boards.

The PTC CM organization will implement and establish a Data Management Center (DMC) function that will be responsible for the storage of master copies of all PTC software products, data products, and related documentation. The DMC will provide secure, long-term storage for the released products and shall maintain strict access control for the master copies. The DMC will ensure that disaster copies of the masters are maintained at a site physically removed from the PTC facility.

Files placed under control (i.e. baselined) by the PTC CCB may only be created and changed by the PTC CM organization. Only the CM organization is authorized to make changes to a controlled/baselined master library file. The PTC CCB will authorize periodic updates to controlled files based on a designated set of approved changes. After a file has been updated and approved for release, the file will be released by the PTC CM organization via a Configuration Management Bulletin and a Library Release Notice. All changes which are made in each library release will be documented and archived for change traceability. At the time of a library release, critical masters and critical copies of the controlled documentation and software libraries will be generated and archived in the PTC DMC.

4.6.1.3 Status Accounting

The CM database will provide instant access to the PTC configuration, with versatile reporting capabilities. Periodic status reports reflect the approved

configuration to provide high visibility into the PTC configuration status. The following reports will be available from the CM database:

1. The identification (current version, date, etc.) for each PTC configuration item.

2. Open changes with impact assessments.

3. For every ECR, a description of the work to be done, an impact assessment, work authorization, task verification records, and official release notification.

4. For every PR, a description of the problem, a technical explanation of the solution, correction verification records, and official release notification.

5. A history of every ECR and PR applied against any PTC product, with a record of its final disposition.

6. A list of items released or scheduled for release within a specific time frame.

4.6.2 Maintenance

The maintenance process for various components within the PTC depends on the type of item to be maintained. The majority of hardware in the PTC/SCS is commercial equipment for which maintenance agreements can be obtained from the equipment vendors. This approach provides experienced and timely hardware problem resolution without burdening the PTC/SCS Operations Organization with establishing and sustaining expertise on the varying commercial equipment. The PTC/SCS operations personnel will perform the maintenance on the structure of the trainers (i.e. racks, module mock-ups, etc.). DMS Kits will be maintained by WP02 personnel which are expected to be represented on-site to shorten the recovery time from failures in the Kits. The PTC/SCS Operations Organization is responsible for ensuring that all maintenance performed internally or by external organizations is controlled through the proper CM mechanisms.

All maintenance of SCS operational software will be performed by PTC/SCS operations personnel. This activity will include both the resolution of problems experienced during training exercises and the incorporation of approved enhancements identified for improvement of the trainers. Personnel will check the appropriate software units out of the CM library on the VAX/VMS session management host to ensure that any modifications are applied to the latest release. This software is transfered to the Rational where the software engineer can implement and unit test the changes. Once the software has successfully passed the unit tests, it is transfered back to the VAX/VMS host as a working version where an informal test build can be produced for the target VAX/ELN simulation host. This build is intended to support the development test activity that precedes a formal verification. Once the development testing and associated problem resolution is complete, the software units are

promoted for a test release which will be used for the verification testing. This testing will demonstrate that the changes have been properly implemented and that new errors have not been introduced into the system. At the completion of verification, the software is formally released by CM as a product baseline and made available to the training personnel for operational use. All formal releases will include necessary updates to the software documentation.

The maintenance responsibility for the SSF system simulation software will be dependent on the organization responsible for the original development of any specific system model. Since the SSTF architecture is divergent from the program simulation architecture (i.e. ITVE), SSTF system simulation cannot be transported to the PTC. Most of these models will be obtained from the program participants that develop the flight systems. The models are expected to be available from the developing program participants or from program level facilities such as the Central Software Integration Facility. Since these simulations are targeted for the ITVE architecture which is replicated in the SCS design, the simulations will be executable in the SCS without modification. Maintenance release of the models will be obtained by CM and made available to the PTC/SCS operations personnel for integration and verification testing. Any simulations that are developed internally at the PTC will be maintained by the same process as the operational software discussed in the preceding paragraph.

Locally developed payload simulators will be maintained by the PTC/SCS operations personnel via the same process as for the PTC hardware and operational software. However, the maintenance responsibility for payload simulators developed at PI sites will be shared by the PI site team and the PTC/SCS operations personnel. The PI team will have full responsibility for the payload simulator software since the development environment is located at the PI site. The remote access to the PTC will support the necessary transfer of software files to allow this remote maintenance. The payload simulator hardware will be maintained by the PTC/SCS operations personnel with support from the PI team. This on-site maintenance consists primarily of fault isolation to the component which may be replaced from spares provided by the simulator developer. Repair of replaced faulty components will be performed by the PI team.

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16. Abstract

NASA's Space Station Freedom program (SSFP) planning efforts have identified a need for a payload training simulator system to serve as both a training facility and as a demonstrator to validate operational concepts. The envisioned MSFC Payload Training Complex (PTC) required to meet this need will train the Space Station payload scientists, station scientists, and ground controllers to operate the wide variety of experiments that will be onboard the Space Station Freedom. The Simulation Computer System (SCS) is the computer hardware, software, and workstations that will support the Payload Training Complex at MSFC.

The purpose of this SCS Study is to investigate issues related to the SCS, alternative requirements, simulator approaches, and state-of-the-art technologies to develop candidate concepts and designs.

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