PAYLOAD CREW TRAINING COMPLEX
SIMULATION ENGINEER'S HANDBOOK

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The Simulation Engineer's Handbook is a guide for new engineers assigned to Experiment Simulation and a reference for engineers previously assigned. The experiment simulation process, development of experiment simulator requirements, development of experiment simulator hardware and software, and the verification of experiment simulators are discussed. The training required for experiment simulation is extensive and is only referenced in the handbook.
FOREWORD

The role of the Simulation Engineer in Payload Crew Training Center operations is one of the most challenging jobs within the space field. He or she must become, at once, a multi-discipline and multi-task oriented person gaining experience in computer hardware and software, simulation techniques, scientific experiments, engineering operations, and management. This handbook is written to guide the uninitiated Simulation Engineers and is dedicated to the Simulation Engineers who worked the first Spacelab Mission.
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I. INTRODUCTION

The Spacelab missions, Astro missions, Space Station, and subsequent missions are designed to carry experiments into outer space to conduct scientific investigations. Prior to launch, the crew must be trained to operate and monitor science, astrophysics, medical, and commercial experiments using mockups and experiment simulators (hardware/software devices) which simulate experiment Command Data Management System (CDMS) operations to a training-level fidelity.

The Simulation Engineer's assignment is to develop experiment simulators for use by training personnel in the Payload Crew Training Complex (PCTC). This assignment covers a spectrum of tasks which includes: monitoring or developing experiment simulator model requirements; technical coordination for software development; acceptance of simulator design; preparation of data bases; verification and acceptance of the simulator; and operating the simulator. Details of these tasks and the support provided to perform the tasks are covered in this document.

The Simulation Engineer is both a technical and operational oriented engineer who has been assigned to the PCTC Simulator Development Team. Work assignments in the simulator area and technical supervision will be the responsibility of the Experiment Simulation Lead Engineer.

II. DESCRIPTION OF SIMULATION ENGINEER'S TASK

The Simulation Engineer's tasks are grouped in four major categories: developing experiment simulator modeling requirements; developing hardware/software for the experiment simulator; verification and acceptance of the experiment simulator software; and operating the simulator. A summary of each task is given in this section. The details of each task are covered in Sections III through VII.

A typical Experiment Simulator Development Life Cycle is shown in Figure 1. The Simulation Engineer's participation in the experiment development is indicated by the symbol MSFC. As can be seen, development of the Experiment Simulator Modeling Requirements (ESMR) is the initial task in the development cycle and it is important to note that the modeling requirements are the keystone of a successful experiment simulator. The time required to correct discrepancies in requirements is magnified as the experiment simulator reaches each succeeding step in the development cycle; thus, the Simulation Engineer should concentrate efforts to develop a complete and correct ESMR.

The Simulation Engineer's role in hardware/software development is to act as a consultant in interpreting and clarifying the requirements and in reviewing the design flows. When the hardware/software simulator design is completed, the Simulation Engineer accepts the simulator design and initiates the verification/acceptance phase.
Verification takes place at the completion of the hardware/software development phase and is performed using a set of verification test procedures. If the hardware/software is found to be at an acceptable level of operation, the Simulation Engineer initiates the acceptance phase. When the hardware/software passes the acceptance reviews [Simulator Acceptance Review (SAR) and Simulator Training Acceptance Review (STAR)], the experiment simulator is presumed to be operational.

The Simulation Engineer's activities will then continue into the operational phase in the role of a training consultant. This role is not precisely defined as to participation, consequently, the Simulation Engineer will be expected to respond to training requests when called upon.

On Spacelab 1, a number of experiment simulators were built to support the European Space Agency (ESA) experiments. The development life cycle flow for these experiment simulators is different from the flow of Figure 1, especially from the point of verification to training. These differences are unique to Spacelab 1 and other European supported missions and will not be discussed herein.

There are also a number of Mission Peculiar Equipment (MPE) simulators which have been developed to support the CDMS training. These MPE simulators are NASA Branching Distributor (NBD), ESA Junction Box (EJB), Horizon Sensor (HRZ), Video (VID), Video Tape Recorder (VTR), Orbital Flight Data (OFD), Magnetic Field (AMAG), Payload Thermal Control (PTC), European Standard ECAS (ESE), and Environmental (ENV). All of these simulators were developed in-house using civil service personnel or ESA personnel.

III. EXPERIMENT SIMULATOR MODEL REQUIREMENTS (ESMR)

The ESMR is a set of functional requirements which are the basis for all experiment simulator development. An ESMR may be developed by civil service personnel or by a contractor. Reference 1 contains detailed procedures for ESMR development when done in-house. However, in the past, MSFC has had a contract for support in developing experiment ESMRs. When the ESMR is developed by a contractor, the Simulation Engineer will have direct communication with the ESMR developer and may, also, communicate with the Principal Investigator (PI) through the Program Office to assist in getting clarification or additional requirements.

The Simulation Engineer's role in ESMR development, in this instance, is to make contact with the contractor to determine the person responsible for the ESMR for the assigned experiment. The Simulation Engineer and the ESMR developer will then review the program schedule and plan how to deliver the ESMR on time. All problems in meeting the schedule should be identified and referred to the Experiment Simulator Lead Engineer. A flow of ESMR development is shown in Figure 2.

The Simulation Engineer should review the ESMR as it is being written to facilitate the signoff at delivery. It may be necessary for the Simulation Engineer to clarify the experiment operations to the ESMR developer and, if necessary, the Simulation Engineer may request the Program Office to have the PI or flight software contractor meet with the ESMR developer. The Simulation Engineer should be the key person in arranging PI or flight software contractor meetings and should attend all meetings between the PI, flight software contractor, and ESMR contractor. The Simulation Engineer is also responsible for coordinating with the mockup designers to obtain Control and Display (C&D) panel requirements.
ESMR signoff will be required of the ESMR contractor, the PI, the Experiment Simulation Lead Engineer, and the PCTC manager. Once the document is signed, it becomes a baseline version and will be subject to configuration control requirements. The signed ESMR will then be given to the Software (S/W) contractor and to the Hardware (H/W) developers (MSFC) for building the Experiment Simulator.

There will normally be changes to the experiment flight hardware after the ESMR has been baselined which the Simulation Engineer will be informed of by an approved Engineering Change Request (ECR). The Experiment Simulation Lead Engineer and the Simulation Engineer will need to assess the ECR change as to whether the change significantly affects the experiment simulator fidelity. A decision will then be made as to a change in experiment simulator design based on where the simulator is in the development cycle and the impact on requirements and S/W design resources.

Other changes to the baselined ESMR may be identified by the PI, the Simulation Engineer, the Requirements Engineer, or the S/W designers. The impact of these changes will also be assessed by the Experiment Simulation Lead Engineer and the Simulation Engineer and a decision will be made as to whether resources are available to incorporate the changes.

A special class of changes which must be considered by the Simulation Engineer are Configuration Data Table (CDT) and data base updates. These updates are easily accommodated and are normally incorporated at the first opportune time in the development cycle.

The overriding criteria in the development of experiment simulator requirements and the assessment of changes to the requirements is the need for crew experiment interaction and the associated level of training fidelity needed in the experiment simulator. If the level of fidelity cannot be achieved with the available resources, the Experiment Simulator Lead Engineer should notify the training personnel.

IV. EXPERIMENT SIMULATOR HARDWARE/SOFTWARE DEVELOPMENT

Upon receipt of a signed ESMR, the mockup personnel (MSFC) will build the control display panels necessary to support the Experiment Simulator. The Simulation Engineer's role in hardware development is to be the consultant to the mockup personnel for experiment hardware requirements and to the Host Computer personnel for the experiment hardware/software interface.

The Simulation Engineer's role in software development is to contact the software support contractor to determine the name of the person(s) assigned to develop the software for the experiment. The software programmer will then be given a copy of the signed ESMR and the Simulation Engineer will review the program schedule with the programmer and they will plan the software activities. Any problems in meeting the schedule should be identified and referred to the Experiment Simulator Project Engineer. A flow of experiment simulator hardware/software development is shown in Figure 3.

The software development task should include reviews of the design flow diagrams by the programmer, ESMR developer, and Simulation Engineer. These reviews will help uncover requirement discrepancies as well as programming errors.
After the simulator design is approved by the Simulation Engineer, the software contractor will code the simulator model.

The incorporation of changes to the baselined requirements has a direct impact on software design; therefore, the software designers should be included in the assessment of changes to requirements. The approval of changes to requirements normally results in a redistribution of programming resources and a reassignment of priorities. Consequently, as a rule, changes to baselined requirements should be minimized.

Experiment simulator software may be developed in-house using civil service personnel. When this alternative is used, the assigned personnel should use References 1 and 2 as a guide. Tables 1 and 2 outline the methodology and milestones associated with experiment simulator software development for in-house personnel.

V. EXPERIMENT VERIFICATION AND ACCEPTANCE

The Simulation Engineer's involvement in simulator development will be at a maximum during the experiment verification and acceptance phase. Figures 4, 5, and 6 show the tasks associated with verification, SAR, and STAR.

Prior to verification, the Simulation Engineer must make sure that the experiment simulator files are prepared. The Simulation Engineer will, in most instances, be personally responsible for file preparation as MSFC has no support contract for this effort. There are a number of files and data bases which the Simulation Engineer must become familiar with. Figure 7 is a pictorial representation of the files and data bases required to run the simulator. The end product of this phase of activity should be an ECOS Session File, SDC Display(s), Cross Reference Command File, OCT Format File, and an Experiment Simulator Data Base.

The Simulation Engineer can begin file preparation activities by reviewing the ESMR and software design documents. The Simulation Engineer then builds the appropriate files using the MMU Program [3], TL PREP Program [4], ECOS Mission Data Base and Test ID File [5], and SDC Display [6]. The programmer builds the DDS display format using the Display Background generator [7], the Experiment Simulator Data Base using the File Create Program [8], and finally, the Simulation Engineer can build the Environmental Data Base [9], and the Cross Reference File using the text editor, and then, last, the ECOS Session Data Base [5] is built.

After all files are prepared, the Simulation Engineer is ready for experiment verification. The purpose of experiment verification is to assure that the experiment simulator will actually perform as specified by the ESMR. To verify that all requirements are satisfied, it is necessary to establish some pattern of checking such as proposed in this section. The Simulation Engineer may want to devise another scheme of checking which is permissible if it satisfactorily covers verification of the requirements.

A schematic of a typical experiment simulator is shown in Figure 8. The three modes of verifying simulator operations are to use the Data Display System (DDS) terminal in the mockup, and the LSI terminal or the Simulation Director's Console (SDC) terminal in the Simulation Director's room. Approximately 80 percent of verification will take place using the DDS terminal and about 10 percent each will take place using the LSI and SDC terminals.
Table 3 indicates the functional areas which must be verified. Areas 2 to 6 are based on an understanding of the ESMR, ECOS, and ECAS and constitute the major part of the verification procedures. An outline for Acceptance Test Procedures (ATP) is shown in Figure 9. A sample of acceptance test procedures (ATP) are included in Figures 10 and 11. The Simulation Engineer may want to call upon the ESMR person who is working requirements for the assigned experiment to assist in developing the ATP. The Simulation Engineer will then schedule a verification time with the ESMR Developer and the software contractor. An outline of the acceptance team responsibilities is given in Table 4.

After verification, an experiment simulator is subjected to two major reviews, SAR and STAR. The SAR is conducted at the end of the verification phase to validate the experiment simulator requirements with the PI as shown in Figure 5. The Simulation Engineer will schedule the SAR with ESMR Developer/software contractor/PI. Table 5 is an outline of the steps which the Simulation Engineer must take to conduct the SAR. All discrepancies identified during the SAR will be corrected by ESMR Developer/software contractor prior to the STAR.

The final review for the simulator is the STAR which will determine the fidelity of the simulator relative to the training procedures. The STAR development cycle is shown in Figure 6. The Simulation Director will schedule the STAR and will request the Simulation Engineer’s participation. When the simulator passes the STAR, it is operational and ready for use by training personnel.

One general comment should be made: during the experiment simulator development life cycle, a number of discrepancies to requirements, software, and hardware may be found. These discrepancies to experiment simulator requirements, software and hardware will be handled using the PAR process of Reference 10. If a flight software discrepancy is uncovered, the PCTC Alert Notice (PAN) form will be used.

VI. EXPERIMENT SIMULATOR OPERATIONS

The Simulation Engineer becomes, with the exception of the programmer, the person most knowledgeable of the experiment simulator operations and, thus, will be consulted for expertise and advice relative to assigned experiments. Most of the operations experience will be gained prior to and during the SAR and most of the consulting will take place subsequent to the SAR.

This section of the handbook will address only those simulator operations which are more or less general to all experiments. Unique experiment simulator operations must be learned from the experiment simulator programmer and Host Software Manager.

One operation common to all experiment simulators is start up/shutdown procedure. This procedure has been simplified considerably and a sample of the start up/shutdown procedure can be obtained from the Host Software Manager.

There are a number of commands which can be issued at the SDC console such as loading a program manually, accelerating time, and changing environmental parameters. The Host Software Manager should be consulted for a list of these commands.
There are a number of other more general commands such as bringing up both DDU's in the mockup and changing the GMT time. The Host Software Manager should also be consulted for these commands.

Finally, there is also a set of ECOS commands which the Simulation Engineer should be familiar with. Most of these are covered in the ECOS design manual reference and will be covered during the ECOS training session.

In addition to becoming familiar with the operational simulator commands, the Simulation Engineer must learn how to run all the MPE models listed in Section II. A training session with hands-on training and a thorough review of the MPR User's Guides [11] is the recommended way of accomplishing this.

VII. TRAINING

Simulation Engineers are generally assigned to the Experiment Simulator Team at random times which makes a formal training program unfeasible. The approach to training selected is a combination of assigned reading (Engineer's Handbook and reference documents), individual discussion sessions using the outline of training requirements, Table 6, and on-the-job training. The Simulation Lead Engineer and the Simulation Engineer will be responsible for developing a viable training schedule for the Simulation Engineer which will fit into the overall simulator development schedule. Simulation training will be the responsibility of the Experiment Simulator Lead Engineer; however, actual training sessions may be assigned to any of the other simulation engineers or to the Host/Software/Configuration Engineer.

ECOS operational training is a special type which is conducted by the PCTC personnel. The Simulation Engineer will be scheduled to attend the PCTC ECOS Training Sessions, if possible; however, the Simulation Engineer can gain a degree of ECOS operational proficiency by using the outline and other notes in Tables 7 and 8 and the diagram in Figure 12 along with the ECOS documents to self-learn.

A Training Manual [12] has been developed for use in training Simulation Engineers. It is recommended that the Simulation Engineer use this as a basis for establishing a training program for Simulation Engineers, Software Developers, or ESMR Developers.
TABLE 1. EXPERIMENT SIMULATOR DEVELOPMENT METHODOLOGY

I. ANALYSIS PHASE
   A. Preliminary Document Review
   B. Meetings with Requirements Engineer
   C. Preparation of Structured Analysis
      1. Bubble Charts
      2. Data Dictionary
   D. Analysis Walkthroughs
   E. Documentation of Requirements Feedback
   F. Documentation of Analysis

II. DESIGN PHASE
   A. Preparation of Module Hierarchy
   B. Interface Analysis and Design
   C. Walkthrough of Hierarchy and Interface Design
   D. Preparation of Structured Flowcharts
   E. Preparation of File Description
   F. Design Walkthrough
   G. Performance Estimate
   H. Documentation of Design
   I. Presentation and Review of Design

III. IMPLEMENTATION PHASE
   A. Preparation of Implementation Plan
   B. Coding of Modules
   C. Code Walkthroughs
   D. Preparation of Directed Graphs for Module Testing
   E. Preparation of Test Data
   F. Module Testing (Test Harness)
   G. Preparation of Data Files

IV. INTEGRATED TESTING PHASE
   A. Preparation of Display Skeleton
   B. Preparation of Integrated Test Files
   C. Preparation of Test Data and Test Plan
   D. Integrated Testing (CDB and ECOS)
   E. Software Acceptance Test Support
TABLE 2. SIMULATION ENGINEER'S TYPICAL MILESTONES

<table>
<thead>
<tr>
<th>Phase</th>
<th>Milestones</th>
</tr>
</thead>
</table>
| I. Requirements Analysis | A. Review ESMR  
                          | B. Draw DFD's  
                          | C. X-Ref ESMR  
                          | D. Document  
                          | E. Hold Reqs Anal Review |
| II. Design      | A. Draw Hierarchy Charts  
                          | B. Review Library Routines  
                          | C. Develop Routines  
                          | 1. Initialization  
                          | 2. Run  
                          | 3. Freeze  
                          | 4. Stop  
                          | 5. Hardware  
                          | 6. ECAS  
                          | 7. DEP  
                          | 8. C&D |
| III. Build Files| A. Simulator DB  
                          | B. Experiment Simulator Files |
| IV. Test        | A. ETS  
                          | B. HOST |
TABLE 3 ACCEPTANCE TEST PROCEDURES (ATP)
FUNCTIONAL AREAS

<table>
<thead>
<tr>
<th>Functional Area</th>
<th>S/W</th>
<th>Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MODE Control (I, F, R, H, S)</td>
<td>OCT</td>
<td>SDC</td>
</tr>
<tr>
<td>2. ECOS Data Base (CDT)</td>
<td>ECOS</td>
<td>DDS-SDC DB Preparation</td>
</tr>
<tr>
<td>3. Instrument Model (Manual Commands)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. H/W Model (Nominal and Off-nominal Commands)</td>
<td>ECOS</td>
<td>DDS-(OCT)</td>
</tr>
<tr>
<td>b. C&amp;D Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. DEP Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Exercise ECOS T/L Service (Nominal, Off-Nominal)</td>
<td>ECOS</td>
<td>DDS</td>
</tr>
<tr>
<td>5. Exercise ECAS W/HDWR Model (Display, Item, Type)</td>
<td>ECOS</td>
<td>DDS</td>
</tr>
<tr>
<td>6. Accelerated Time-HDWR/ECAS Models</td>
<td>ECOS</td>
<td>DDS (SDC)</td>
</tr>
</tbody>
</table>

TABLE 4. ACCEPTANCE TEAM SIMULATOR VERIFICATION/SAR

I. PREPARATION TASKS/RESPONSIBILITIES

A. Test Procedures Development - Simulation Engineer/ESSEX
B. Experiment Simulator Ready - Simulation Engineer/BCS

II. VERIFICATION TESTING TASKS/RESPONSIBILITIES

A. Team Position Assignments - Simulation Engineer
B. Test Conductance - Simulation Engineer
   30 Pages/Day Pacing
   Note discrepancies on test procedures
   Record discrepancy time, video tape change times
C. Computer Problems - Host/System Engineer

III. DEBRIEF

Discussion Lead - Simulation Engineer
   Record approved DR's
   Assign actions to ESSEX/BCS to close discrepancies

IV. ENDING TASKS

A. Delog/Distribute Event Recorder Tape - Simulation Engineer
B. Reverification - Simulation Engineer
TABLE 5. SAR PREPARATION/CONDUCT/POST

I. NOTIFICATION OF PARTICIPANTS
   A. Memo/Agency/DOC.
   B. Scheduling the Computer

II. AGENDA
   A. Briefing/Introduction
      1. Purpose
      2. SIM Requirements ESMR (Date) Data Base - CDT
      3. Role of Participants
      5. PAR Process
      6. Reacceptance
   B. Hands-On Testing
      1. Test Procedure Sheets
      2. Informal Testing
   C. Debrief
      Review of PARs

III. SAR MINUTES/DOCUMENTATION
TABLE 6. SIMULATION ENGINEER TRAINING REQUIREMENTS

I. PCTC FAMILIARIZATION
   Layout
   Equipment
   Personnel
   Operations

II. HOST/SYSTEM FAMILIARIZATION
   PDP 11/70 Terminal
   Hardware System
   Software System
      Operator Control Task (OCT)
      Experiment Computer Operating System (ECOS)
      Common Data Buffer (CDB)

III. DOCUMENTATION FAMILIARIZATION
   Reference Documents (Simulation Engineer's Handbook)

IV. EXPERIMENT SIMULATOR
   Hardware Model
   DEP Model
   C&D Panel Model
   ECAS Model
   Data Bases
   External Files
   Configuration

V. FILE PREPARATION
   Mass Memory Unit (MMU)
   ECOS Timeline (TL)
   Simulator Director Console (SDC) Display
   Background Display
   OCT Format
   Cross Reference Command
   Experiment Logic
   Test ID
   ECOS Mission
   Environmental

VI. DATA BASE PREPARATION
   ECOS Session Data Base - ECOS Session Program
   Experiment Simulator Data Base - Create Program

VII. EXPERIMENT SIMULATOR MODELING REQUIREMENTS (ESMR)
   Source Documents
   Development
   Review
   Changes
TABLE 6. (CONTINUED)

VIII. EXPERIMENT SIMULATOR S/W DEVELOPMENT

Requirements Analysis
Design
Reviews
Stand-Alone Testing
Integrated Testing

IX. EXPERIMENT SIMULATOR VERIFICATION AND ACCEPTANCE

Verification - Test Procedure Development
Simulator Acceptance Review (SAR)
Simulator Training Acceptance Review (STAR)

X. EXPERIMENT SIMULATOR OPERATION

DDS (Mockup, SDC, POCC)
SDC

XI. MISSION PECULIAR MODELS (MPE)

NASA Branching Distributor (NBD)
ESA Junction Box (EJB)
Horizon Sensor (HRZ)
Video Monitor (VID)
Video Tape Recorder (VTR)
Orbital Flight Data (OFD)
Magnetic Field Image (AMAG)
Payload Thermal Control (PTC)
European Standard ECAS (ESE)
Environmental (ENV)
<table>
<thead>
<tr>
<th>FUNCTIONAL AREA</th>
<th>SUPPORT MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. BASIC KEYBOARD/SYSTEM LINES</strong></td>
<td>CDT/RAU/HW/ECAS</td>
</tr>
<tr>
<td>Initiator Keys - DISPLAY, ENTER, ITEM, ETC.</td>
<td></td>
</tr>
<tr>
<td>SPL Format</td>
<td></td>
</tr>
<tr>
<td>SPL Errors</td>
<td></td>
</tr>
<tr>
<td>Hidden Page Advisory</td>
<td></td>
</tr>
<tr>
<td>Line 20 - Format, Clearing, Recording Timeline Status</td>
<td></td>
</tr>
<tr>
<td><strong>II. COMMAND KEY USAGE</strong></td>
<td>DEP</td>
</tr>
<tr>
<td>ISS</td>
<td>CDT/RAU/HW</td>
</tr>
<tr>
<td>ISM</td>
<td>ECAS</td>
</tr>
<tr>
<td>WRI</td>
<td></td>
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<tr>
<td>CAN</td>
<td></td>
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<tr>
<td>TER</td>
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<tr>
<td>MON Type</td>
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<tr>
<td>REM</td>
<td></td>
</tr>
<tr>
<td>TLH</td>
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<tr>
<td>TLC</td>
<td></td>
</tr>
<tr>
<td>TLL</td>
<td></td>
</tr>
<tr>
<td>RUN</td>
<td></td>
</tr>
<tr>
<td>MMU</td>
<td></td>
</tr>
<tr>
<td>Syntax</td>
<td></td>
</tr>
<tr>
<td>Contex</td>
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<tr>
<td><strong>III. MEMORY MANAGEMENT OPERATIONS</strong></td>
<td>Multiple ECAS's</td>
</tr>
<tr>
<td>Display (MEM)</td>
<td></td>
</tr>
<tr>
<td>Page Allocation/Deallocation</td>
<td></td>
</tr>
<tr>
<td>Task Management/Priority Levels/Status Error Conditions - Line 20</td>
<td></td>
</tr>
<tr>
<td><strong>IV. EXCEPTION MONITORING</strong></td>
<td>CDT/RAU/HW</td>
</tr>
<tr>
<td>Limit Changes (AI &amp; DI)</td>
<td></td>
</tr>
<tr>
<td>Out of Limit Error Generation</td>
<td></td>
</tr>
<tr>
<td>N Count Change</td>
<td></td>
</tr>
<tr>
<td>Interlock Time Change</td>
<td></td>
</tr>
<tr>
<td>Reset Conditions</td>
<td></td>
</tr>
<tr>
<td><strong>V. CDT DATA</strong></td>
<td>CDT/RAU/HW</td>
</tr>
<tr>
<td>RAU OP/NOP</td>
<td></td>
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<tr>
<td>Display SID on SPL</td>
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</tr>
<tr>
<td>Output Data on Exp't Display</td>
<td></td>
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<tr>
<td>Non-CDT Displayed Data</td>
<td></td>
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<tr>
<td>Line 20 Errors</td>
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</tbody>
</table>
TABLE 7. (Concluded)

**FUNCTIONAL AREA**

### VI. DEP SERVICES
- Protocol-Data Solicit/Initialize Link
- SID OP/NOP - RAU OP/NOP
- SI/SO Channel Traffic
  - Request Message
  - Transmit Message
  - Load DEP
- Line 20 Errors

### VII. DISPLAYS GENERAL
- General Format - Color
- Call-Up
- Missing Data/CDT/Appended Field
- EXPERIMENT FAULT SUMMARY (EFS)
- System Convention
  - ECOS Versus ECAS Pages
  - Special Cases - TLM/TMN

### VIII. TIMELINE SERVICES
- Loading Masters and Subordinates T/L
- Counting MT/L & ST/L EXP'T
- Pending Holds, Conditions for Canceling
- Error Conditions - Line 20
- System Contention (Buffers all filled)

### IX. TIMELINE MAINTENANCE
- Display Output
- All Item Entries
- System Contention
  - 2nd DDS
  - POCC/MDM
  - Timeline in Count
  - XMON Task
  - MDM Buffer
  - Line 19 and 20 Messages

### X. TIMELINE MONITOR
- Display Output
- All Item Entries
- System Contention
  - 2nd DDS
  - POCC/MDM
  - XTLM Task
  - Line 19 and 20 Messages
<table>
<thead>
<tr>
<th>PAGE ID</th>
<th>PAGE NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEM</td>
<td>Memory Page</td>
</tr>
<tr>
<td>NBD</td>
<td>NASA Branching Distributor</td>
</tr>
<tr>
<td>PLS</td>
<td>Payload Status Page</td>
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<tr>
<td>DPM</td>
<td></td>
</tr>
<tr>
<td>EFS</td>
<td>Experiment Fault Summary</td>
</tr>
<tr>
<td>PTC</td>
<td>Payload Thermal Control</td>
</tr>
<tr>
<td>TLM</td>
<td>Timeline Maintenance</td>
</tr>
<tr>
<td>TMN</td>
<td>Timeline Monitor</td>
</tr>
<tr>
<td>EJB</td>
<td>European Junction Box</td>
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</table>
Figure 1. Experiment Simulator Development Life Cycle.
Figure 2. ESMR Development Cycle.

Figure 3. Experiment Simulation HDW/SW Development.
Figure 4. PCTC Verification Test S/W Preparation Tasks.

Figure 5. PCTC SAR S/W Preparation Tasks.

Figure 6. PCTC STAR S/W Preparation Tasks.
Figure 7. Experiment Simulator Configuration/Build Process for Initial Integrated Verification Test and Acceptance.
I. CDT VERIFICATION
A. DO'S  SID
   PA — Pulsed Level
B. DI'S  SID — Allocated
   PA — Allocated and Maintained (most models)
C. AI'S  SID — Allocated and updated, Engineering Units
   PA — Allocated, not maintained dynamically
D. SI, SO'S  SID — Allocated, not maintained dynamically

II. COMMAND/FEEDBACK RESPONSE
A. INPUTS  CMD KEY—ISS, WR1, Etc.
   ITEM ENTRY — (ECOS supported)
   C & D PANEL — Switches
B. OUTPUTS  SPL
   AI, DI
   DISPLAY  AI, DI (ECOS supported)
   C & D — LIGHTS
C. SDC FLAGS/MALFUNCTIONS/DISPLAY PAGE

III. ECOS FUNCTIONS
A. PAGE (ECOS supported) Evaluation
   EXPT Unique — Layout, GIE
   PLS
   PTC
B. Exception Monitor — Display Fields, Message Texts, NCOUNT, INTLK Time
C. RAU — OP/NOP, MMU — OP/NOP

IV. ECAS SIMULATION (IF REQUIRED)
A. Memory Management Functions
B. Command Response
C. Messages

V. TIMELINES

VI. OTHER
POCC SIM Terminal

Figure 8. Experiment Simulator.

Figure 9. Acceptance Test Procedures (ATP).
### PCTC Simulator Acceptance Procedure

<table>
<thead>
<tr>
<th>SEQ #</th>
<th>DDS KB</th>
<th>DDS CMD</th>
<th>COMMAND CONTROL FUNCTIONS/DATA</th>
<th>EXPECTED RESPONSE</th>
<th>CODE</th>
<th>ACTUAL RESPONSE</th>
<th>COMMENTS/ FUNCTIONS AND ACTIVITIES VERIFIED</th>
<th>OR NUMBER</th>
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</thead>
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<td></td>
<td>CA-AK</td>
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<td>INPUT</td>
<td>SYS HDR LINE DISPLAYED</td>
<td>1</td>
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<td>This is always a first step of procedure.</td>
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<td>MSG CLEAR</td>
<td>GMT UPDATING</td>
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<td>RESET</td>
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<td>20</td>
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<td>21-DO-0-ON E</td>
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<tr>
<td>DISP</td>
<td>3211</td>
<td>E</td>
<td>000 I VOLT 000 000</td>
<td>SPL</td>
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<td>CMD</td>
<td>ISS</td>
<td>3171E</td>
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<td></td>
<td></td>
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<td>HDR VERIFICATION:</td>
<td></td>
</tr>
<tr>
<td>DISP</td>
<td>3171</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Use the same cmds as for CDT verification except turn power on/off and note responses.</td>
<td></td>
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</table>

**Code Key:**
- 1-21: LINE NO.
- SPL: SCRATCH PAD LINE 1 OR 2
- BCD: SIM DIRECTOR CONSOLE
- ADD: ADD ON AREA
- C & D: CONTROL PANEL
- PCC: SIMULATED PCC

**Figure 10.** Verification Test Procedures.
<table>
<thead>
<tr>
<th>SEQ #</th>
<th>DDS KG</th>
<th>DDS CMD</th>
<th>COMMAND CONTROL FUNCTIONS/DATA</th>
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<th>CODE</th>
<th>ACTUAL RESPONSE</th>
<th>COMMENTS</th>
<th>FUNCTIONS AND ACTIVITIES verified</th>
<th>OR NUMBER</th>
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<td>E</td>
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<td>SPS. HDR LINE DISPLAYED</td>
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<td>This is always a first step of procedure.</td>
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</tbody>
</table>

CDT VERIFICATION:

DISP 3171 E OFF SPL This is to display a variable (DO) by SID.

CMD ISS

CMD 3171E

DISP 3211 E 000 I VOLT 000 000 SPL This is a cmd to display a variable (AI) by SID.

CM

HDR VERIFICATION:

DISP 3171 E

CMD ISS 3171E

Figure 11. Verification Test Procedures.
REFERENCE DOCUMENTS

1. Experiment Simulator Modeling Requirements
2. Structured Programming
3. MMU Preparation User's Guide
4. ECOS Timeline Preparation User's Guide
5. ECOS Session Preparation User's Guide
6. SDC Display Preparation User's Guide
7. Display Background Generator User's Guide
8. The Create Program
10. PAR Process
11. MPE User's Guides
14. Operation Control Task - Version 2.0
15. PCTC ECOS Data Base Training Course
16. SIM Director's Console User's Guide
17. PCTC/ECOS S/W Design Document
18. ECIO Support Operations Manual for VAX and PDP
19. PS Training Host Simulator Design, Rev. C 8/80
20. PRB Debug Documentation
21. STAT Processing Prog Documentation, Rev. 1 9/81
22. PCTC Image Generation System 6/81
23. VT100 Band Rate Adjust
24. ECOS Offline Session Prep User's Guide
25. PCTC Host Simulator Design, Rev. C 7/81
26. PCTC Checkout Program User's Guide

27. PCTC C&D/Computer Interface Generic Test Model User's Guide

28. Software Configuration Management System
APPROVAL

PAYLOAD CREW TRAINING COMPLEX SIMULATION ENGINEER'S HANDBOOK

By Dr. David L. Shipman

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

G. D. HOPSON
Director, Systems Analysis and Integration Laboratory