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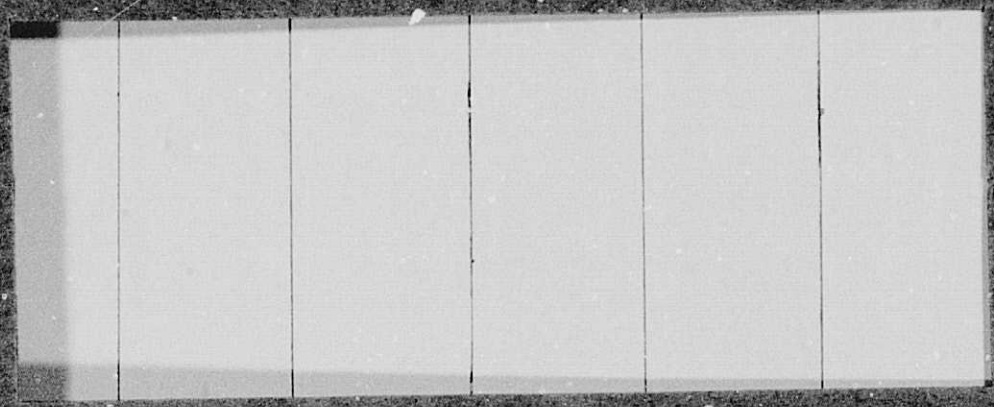

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MCDONNELL DOUGLAS CORPORATION

ADVANCED CREW PROCEDURES DEVELOPMENT TECHNIQUES

FINAL REPORT

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30 October 1975 MDC W0011

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CONTENTS

CONTENTS (Cont'd)

LIST OF PAGES

FIGURES

GLOSSARY

ACPDT	Advanced Crew Procedures Development Techniques Study, Contract NAS 9-14354
Batch	PPP control mode which uses punch card inputs to control the program operations.
CCA	Contract Change Authorization
CDC	Control Data Corporation
CPDT	Crew Procedures Development Technique Study, Contract NAS 9-13660
Criterion Data	Stored parameter values which are used to measure the performance of the vehicle and crew
CRT	Cathode Ray Tube
CUE	A reference identifier initiated by the PPP user to facilitate data retrieval and review at a specified time during a run.
Data Base	The collection of data that is internally accessible by the PPP and on which the PPP operates. Segments of the PPP data base are identified as: 1) Hollerith Statements Data, 2) Numerical and Criterion Data, 3) Format Descriptors, and 4) Reference Procedures Data.
Difference Procedure	A combination of the following data: Hold Configuration Difference, Switch Configuration Difference, Sequence Difference, Detailed Difference Summary, and Summary Procedures Difference
FDF	Flight Data File
Format	The arrangement and general makeup of a data output display as seen by the PPP user.
Format Descriptor	A complete set of user oriented, PPP recognizable, instructions that define a display format in its entirety.
FMT	Alphanumeric Format
GDP	Generalized Documentation Processor
GFM	Graphic Format

Hollerith	Computer representation of alphanumeric characters.
I.D.	Identification number
Interactive	PPP control mode which uses either CDC 211 or CDC 243 interactive terminal inputs to control the program operations.
Nonreal Time	PPP program mode when processing PPP Initialization data, stored SPS data, and PPP Post-Run data.
Performance Data	That data which is the "delayed" result of crew action (e.g., vehicle attitude, airspeed, and sink rate).
Performance Evaluation Data	Data presented by the PPP to provide a measure of crew performance.
PPP	Procedures and Performance Program
PPP User	The PPP user is identified as a Procedures Developer during a procedures generation type run and as an SPS Instructor during a training exercise.
Procedures	Collection of Hollerith statements in a specified format (e.g., detailed procedures, checklists, cue cards, and summary procedures).
Procedures Data	That data which is the "immediate" result of crew action (e.g., switch settings, keyboard entries, and control deflections).
Real-Time	PPP program mode when processing data from an SPS actual or simulated transfer.
Reference Data	Procedures Data from a previous SPS run used as the nominal time history reference for difference comparisons.
Run	SPS real time operation (actual or simulated).
Run Data	Data which is stored by the PPP and represents procedures data and performance data from a SPS run. These data are adequate for the construction of all PPP formats.
SPS	Shuttle Procedures Simulator
SPS Actual Transfer	SPS program is active and generating the data transferred to the PPP.
SPS Simulated Transfer	A magnetic tape containing data recorded from an actual SPS transfer supplies the data transfer to the PPP.

Training Data	Data which tracks the training instructors PPP operations and tracks the SPS utilization.
Tutorial Display	A display that contains information to instruct or "tutor" the user in the operation of the PPP.

ABSTRACT

The Advanced Crew Procedures Development Techniques (ACPDT) Study has resulted in the development of an operational computer program, the Procedures and Performance Program (PPP), which provided a procedures recording and crew/vehicle performance monitoring capability presently used in conjunction with the Systems Management Simulation version of the Shuttle Procedures Simulator (SPS).

The PPP, formerly referred to as the Procedures Generation Program (PGP), provides real time CRT displays (alphanumeric and graphical) and post-run hardcopy of procedures, difference procedures (actual vs. reference), performance, performance evaluation, and training script/training status data. During post-run, the program is designed to support evaluation through the reconstruction of displays to any point in time. A permanent record of the simulation exercise can be obtained via hardcopy output of the display data, and via magnetic tape transfer to the Generalized Documentation Processor (GDP). Reference procedures data may be transferred from the GDP to the PPP.

Section 1
INTRODUCTION

This report presents the final results of the Advanced Crew Procedures Development Techniques Study conducted for the Johnson Space Center of the National Aeronautics and Space Administration under contract NAS 9-14354. The study has been performed by the McDonnell Douglas Technical Services Company, Inc., Houston Astronautics Division.

A synopsis of the tasks performed and technical accomplishments is presented in Section 2. Conclusions and recommendations are discussed in Section 3. An annotated bibliography of the study documentation is presented in Section 4.

Section 2
TECHNICAL SYNOPSIS

The purpose of this study was to modify the baseline Procedures and Performance Program/Shuttle Procedures Simulator (PPP/SPS) system developed under Contract NAS 9-13660 and provide the software integration of two additional terminal devices: (1) an advanced interactive graphics terminal, and (2) the terminal currently in use with the Generalized Document Processor (GDP). This hardware was added to provide the benefits of using advanced hardware systems for the flight techniques and procedures development for the Shuttle program.

The PPP data base was to be modified and maintained relative to the capabilities of the PPP/SPS system. This included the addition of graphics format descriptors for the simulated SPS mission phases and updates to the Hollerith switch labels to accommodate changes in the SPS crew station configuration.

An interpretive software routine was to be developed which provided the capability to transfer procedures data tapes between the GDP and PPP.

Other major tasks to be accomplished during the study included 1) reconstruction of onboard CRT displays, 2) PPP modifications to accommodate a new computer operating system, 3) PPP modifications to accommodate planned SPS capabilities updates, and 4) PPP updates to incorporate expanded design requirements.

Studies were to be performed which investigated the application of the PPP to the field of commercial aviation, and requirements were to be identified for the adaptation of PPP to other simulator systems.

Finally, a demonstration of the PPP capabilities, user training, and updates to existing program documentation were required.

These activities were successfully completed during the contract performance period. The remaining subsections describe the capabilities of the currently operational PPP system, and summarize the technical accomplishments of the various tasks performed during the study.

2.1 PPP CAPABILITIES DESCRIPTION

The Procedures and Performance Program (PPP) capabilities provide real-time CRT outputs and post-run hardcopy outputs of various data associated with SPS operations. These outputs provide valuable information to simulation, training, and procedures development personnel. The following highlights information available and possible usage for each group.

Using the PPP, simulation personnel can verify crew station control inputs and corresponding hardware and software output responses. Alphanumeric procedures data generated by the PPP, provide a record of crew station input/output discrete interaction. These data are time tagged and therefore provide an indication of the reaction time between input and output. Alphanumeric and graphical performance data generated by the PPP, provide a record of the simulated vehicle dynamic characteristics. These data, also time tagged, when combined with the procedures data, represent vital documentation for SPS hardware and software verification. The recording and subsequent hardcopy output of PPP generated data also provide maintenance personnel firm documentation of simulator problems. Problems during simulator operations can be easily duplicated without guessing what prior operations occurred. Finally the PPP recording of simulator operations provides documentation on SPS utilization.

Training personnel can utilize the PPP in many different ways. Prior to each training exercise, the instructor can verify the proper initial SPS crew station configuration. During an exercise, crew operations and vehicle responses are monitored and, if desired, may be compared against an established reference. The reference procedures data provide a check on how closely the crew is following the established operating procedures and the performance evaluation data provide an indication of whether the run is within pre-established criterion for various vehicle parameters. PPP data are available which indicate the crews responsiveness

to vehicle malfunction indications. This real-time data give the training personnel the ability to closely control training sessions, thus allowing early termination of sessions which do not appear constructive. The post-run output provides documentation for crew debriefings and subsequent reviews of a training exercise. Here again, recording simulator operation provides documentation on SPS utilization and also of crew training activities.

Procedures development personnel can utilize the PPP for procedural techniques development and procedures development. Using an abbreviated timeline the procedures developer operates the SPS and then uses the performance data to check and verify the response to new techniques. The PPP recorded procedures data then provide the initial procedures documentation. Subsequent runs may be made to refine the newly developed procedures with the updated procedures immediately documented. Magnetic tape output of the procedures data also provide for direct transfer to the Generalized Documentation Processor (GDP). The GDP then provides the capability to finalize the procedures for Flight Data File (FDF) documentation. Another item worth noting is the consistency of FDF document nomenclature; since all nomenclature is generated from one source, the PPP data base.

2.2 PPP SYSTEM DESCRIPTION

The PPP is a digital computer program and associated hardware system designed to operate in conjunction with the SPS in a real-time mode. During real-time, the PPP accepts actual SPS data transfers or simulated transfers where a magnetic tape represents the SPS data; then monitors, processes, and stores this SPS run data. The system also operates in a non-real time mode for PPP initialization, data reconstruction, and post-run processing. PPP user control is through the interactive control and display stations (either the CDC 211 or CDC 243 terminal) or batch inputs via punch cards. Monitor capability is provided on the CDC 211 or CDC 243 CRT and on hardcopy outputs. The PPP also provides for data transfer to the GDP and for procedures data transfer from the GDP via magnetic tape. The PPP Flight Display Unit contains a Norden CRT, Norden

Keyboard, and a rotary switch which allows the PPP user to monitor the SPS crew station CRT's, direct a display to the left crew station CRT, or call up any SPS flight display independent of the SPS crew station selection. A function keybox provides six switches to key various PPP functions. Presently only two of the keys are operational. One, the CUE key, inserts the time when the CUE key is depressed into the PPP real-time data stream to facilitate returning to a specific data point. The other, the FREEZE key, is used to terminate the real-time CDC 211 or CDC 243 CRT display update.

Figure 2-1 presents a functional description of the PPP system and its interfaces with the SPS and GDP.

2.3 TASK DESCRIPTIONS/ACCOMPLISHMENTS

The following subsections present a technical summary of each task performed during the contract period of performance. Included is a brief summary of the objectives and significant technical accomplishments of each task.

2.3.1 Data Processing Studies

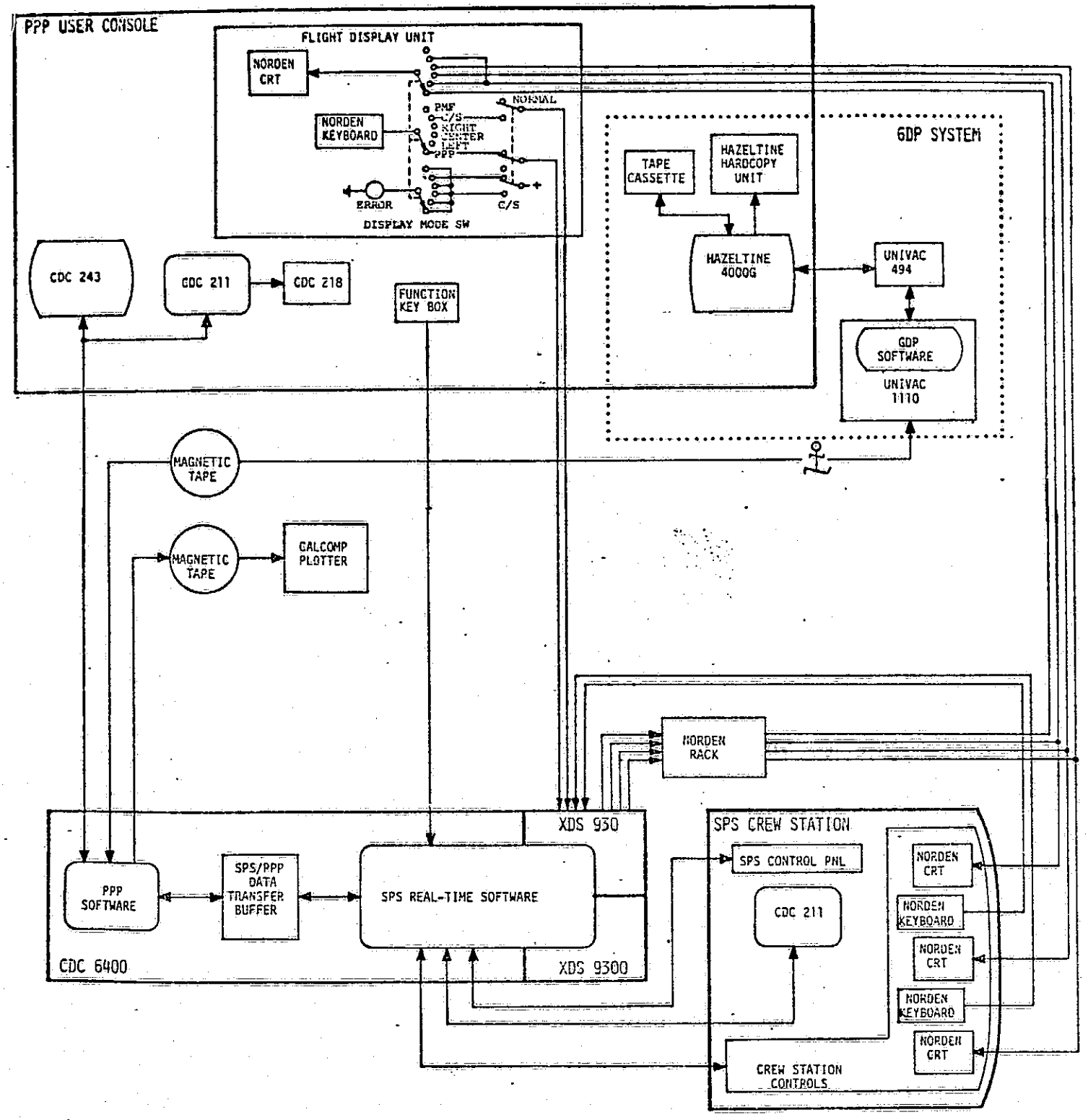
The purpose of these studies were to monitor the computer program development effort in the areas of data file processing techniques and PPP core/time utilization, and to make appropriate design and program modification recommendations when critical problems became apparent.

Two studies were conducted to monitor the core and CPU time utilization of the PPP. The results of these studies were used to identify any potential or existing problem areas; make appropriate design and program modifications where required, and verify that the PPP was operating within its design constraints.

Core Utilization Study

This study was necessitated, primarily, due to the increased amount of core and storage locations needed to support the SPS after the addition of ADLC2 discretes. At the time the study was undertaken, the PPP was

Figure 2-1 PPP/SPS/GDP Functional Diagram



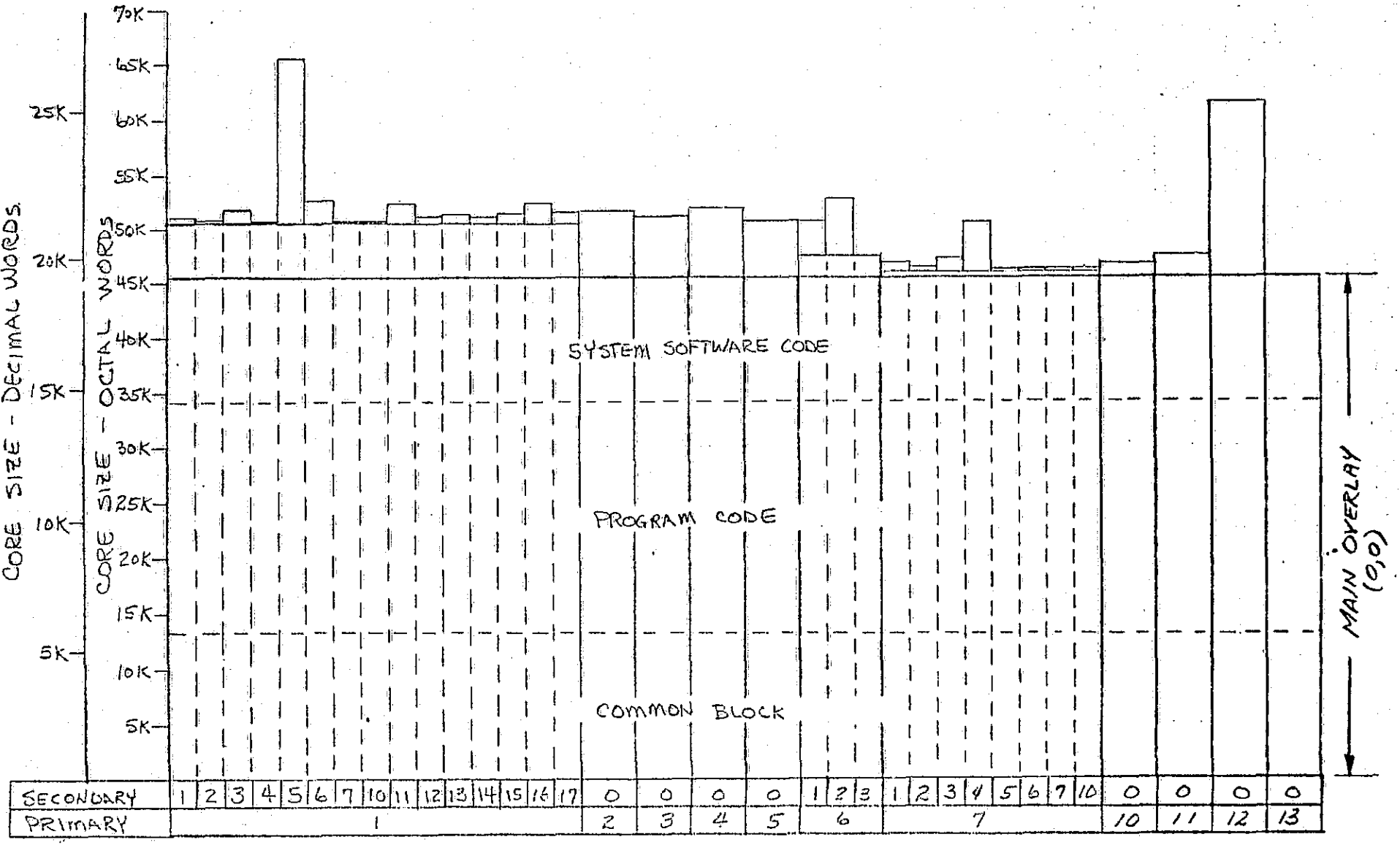
already slightly above its original design goal for core utilization. This in itself was not critical, however, the amount of new software necessary to process the ADLC2 discretes was sizeable and became a prohibitive factor. In addition, the initial design of the PPP called for an event descriptor (English language description) of each discrete to be available, in core, for the Formatter modules. Under these conditions, approximately $12{,}200_8$ additional words of core were required to provide the needed support.

The problem was rectified through program modification and design change. First, all unnecessary software was removed from the primary 0,0 overlay. Since ADLC2 discretes must be processed in the 0,0 overlay, the additional core required here had a direct impact on the overall core requirement. Additional overlays were added, where necessary, and existing overlays were restructured. Secondly, the size of the data buffers, located in the labeled common block section of the 0,0 overlay were reduced to the minimum size possible with guarantee of no data loss. The most significant savings was secured by changing the design philosophy of the event descriptors. Instead of being stored in a 3600_{10} word array, all event descriptors were stored on a file with one 6 word record containing the on/off description for each discrete. No changes were required to the Processor modules and only minor changes were needed by the Formatter modules. This design change resulted in a core savings of approximately 7000_8 words and the added advantage of increased flexibility of the PPP to handle new discretes as they are added or modified. Figure 2-2 presents the resulting PPP core sizing data which resulted from the core reduction effort.

CPU Time Utilization Study

This study was undertaken to verify that the amount of CPU time utilized by the PPP for real-time data processing was within the design goal established by the SPS Resources Control Board. The real-time data processing of the PPP includes the REAL-TIME Interface Module, the Procedures Processor Module, the Performance Evaluation Processor Module, and the Difference Procedures Processor Module. The basic computational

Figure 2-2 PPP Software Sizing Data



R.L. BENBOW
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requirements of these modules are to (1) receive and process the raw data from the SPS, (2) store the processed data for display by the PPP Formatter Modules during the PPP Major Cycle processing, and (3) request mass storage of the processed data arrays during the Real-time I/O Cycle. A complete analysis should have concentrated on the determination of processing time for each of these modules. However, the SPS - Systems Management Simulation used for real-time checkout of the PPP does not provide dynamic performance data; therefore, the CPU timing data analysis that was performed concentrated on the PPP modules which operate on procedures data transferred from the SPS. Since the Difference Procedures Processor module was being updated to correspond to the most recent SPS-SM data transfer buffer, the analysis did not include timing data for the Difference Procedures Module.

The SPS - Systems Management Simulation was used to obtain data for the Real-time Interface Module and to obtain timing data for the various processing paths within the Procedures Processor which corresponds to the different types of switches (crew operations) and the variation of their location in the SPS transfer buffer. Figure 2-3 presents the CPU timing data obtained from this analysis. It was difficult to obtain exact timing data for each option; therefore, in most cases a range (minimum to maximum) is presented.

2.3.2 PPP Program Support Data

The purpose of this task was to develop the data necessary to support the design, development and documentation of the digital computer program, PPP. The scope of the activity included: 1) development of PPP user requirements, 2) CRT display format definition, 3) maintenance of the PPP data base, 4) coordination and definition of the SPS to PPP data transfer, 5) PPP program description documentation, 6) PPP Users Guide documentation, and 7) PPP Math Flow Chart documentation. Details of these activities are summarized in the following discussions.

Figure 2-3 CPU Timing Analysis Data

PPP MODULE - TIMING DATA DESCRIPTION	CPU TIMING UNITS OCTAL	CPU TIME M SEC
REAL TIME INTERFACE MODULE	7 - 10	1.792 - 2.048
PROCEDURES PROCESSOR MODULE		
ADLC1 INPUT DISCRETES		
• 2 POSITION SWITCHES	4 - 6	1.024 - 1.536
• 2 POSITION MOMENTARY SWITCHES	20 - 30	4.096 - 6.144
• 3 POSITION SWITCHES - CONTINUOUS	4 - 5	1.024 - 1.280
• 3 POSITION SWITCHES - SPLIT POSITION	5	1.280
• ROTARY SWITCHES	31	6.4
• SHELLY MODE SWITCHES	20	4.096
• SHELLY SWITCHES	17 - 21	3.840 - 4.352
ADLC2 INPUT DISCRETES		
• 2 POSITION SWITCHES	13	2.816
• 2 POSITION MOMENTARY SWITCHES	26 - 30	5.632 - 6.144
• 3 POSITION SWITCHES - CONTINUOUS	6	1.536
• 3 POSITION SWITCHES - SPLIT POSITION	11 - 16	2.304 - 3.584
ADLC2 OUTPUT DISCRETES	26 - 27	5.632 - 5.888

NOTE: (1) MAX CPU TIME UTILIZATION = REAL-TIME INTERFACE + PROCEDURES PROCESSOR DATA = 10_8 + 31_8 UNITS = 8.448 M SEC

(2) ALTHOUGH THE MAX. CPU TIME RESULTING FROM THIS ANALYSIS INDICATES THE PPP UTILIZATION IS WITHIN THE DESIGN CONSTRAINT (11.520 M SEC), THIS ANALYSIS DOES NOT REFLECT THE PROCESSING TIME FOR THE DIFFERENCE PROCEDURES, PERFORMANCE DATA, OR PERFORMANCE EVALUATION PROCESSORS.

PPP Requirements Definition

The initial requirements of the PPP were developed and documented under the CPDT Study, Contract NAS 9-13660. McDonnell Douglas Report MDC E1006 presented these requirements in complete detail for the eventual desired capability of the operational PPP. A portion of these requirements were implemented in the CPDT study to demonstrate the feasibility, and the remainder were to be implemented during the ACPDT Study.

One of the initial activities of the ACPDT Study was a review and analysis of the un-implemented requirements, and an identification of requirements not specified in the previous study. PPP Working Paper No. 14 documented a portion of this activity. This working paper details the requirements of the CPDT Study which were not incorporated and were determined to be no longer valid or desirable for implementation. The supporting rationale for their deletion is presented.

The requirements for the ACPDT version of the PPP were documented in McDonnell Douglas Report MDC W1006. Included is an identification of new requirements and a re-specification of old requirements to be implemented during the ACPDT Study.

Various PPP and desirable SPS capabilities are presented in the ACPDT requirements document. Section 2 presented the requirements for updating the data transfers to conform to the latest SPS crew station configuration. Also presented are some design goals, dependent upon SPS capabilities, which would improve the PPP operational capabilities. Section 3 presented the usage of the design goal SPS checkpoint resets. Additional capabilities for CDC 211 operations were discussed in Section 4. These capabilities included construction of formats not initially implemented for PPP operations, crew station configuration checks prior to simulation runs, reconstruction of previous PPP displays, and training data which provided an instructor with training scripts and the status of each crewmans' training. Section 5 presented the graphical capabilities of the new CDC 243 graphics terminal. Included in this section are the CDC 243 display capabilities, format construction,

display construction, display reconstruction and the interface commands for user operation. Section 6 presented the two methods of data transfer between the GDP and PPP. The first method is via magnetic tape and the second is via a GDP Hazeltine terminal. Section 7 presented the various output capabilities of the PPP. Finally, Section 8 presented some miscellaneous items which covered the PPP data base, fast-time operations, and user control operations in the batch mode.

CRT Display Definition

As a result of the requirements definition activities, and the requested support of the PPP in conjunction with the SPS systems management simulation, a modified PPP display tree was developed during this contract. Figure 2-4 presents the current definition of the alphanumeric displays available. A separate display tree, shown in Figure 2-5 was developed for the graphical displays. Appendix A is included for further definition of the data output available on the alphanumeric formats during real time.

PPP Data Base

The initial design of the PPP data base consisted of the definition of Hollerith statements data (data reflecting the SPS crew station nomenclature, Shuttle mission events and various miscellaneous statements), numerical data for difference procedures comparison criteria, and data specifying the PPP display formats. The initial PPP design provided these data as random access file data that are read into core when needed. Separate records were provided on this file for each of the display format descriptors and one 3500 word record for the Hollerith statements and difference procedures data.

In the progress of the ACPDT contract, four events occurred which required modification to the original data base design concept. These events were: (1) the SPS crew station update to the 101 configuration, (2) the decision to use the PPP to provide SPS Systems Management Simulation data outputs, (3) the necessity to reduce PPP core utilization, and (4) the incorporation of training statistic data labels to the data base. Events 1, 2, and 4 would have expanded the initial data base requirement from 3500 words to an almost unmanageable requirement. A

Figure 2-4 PPP Alphanumeric Display Tree

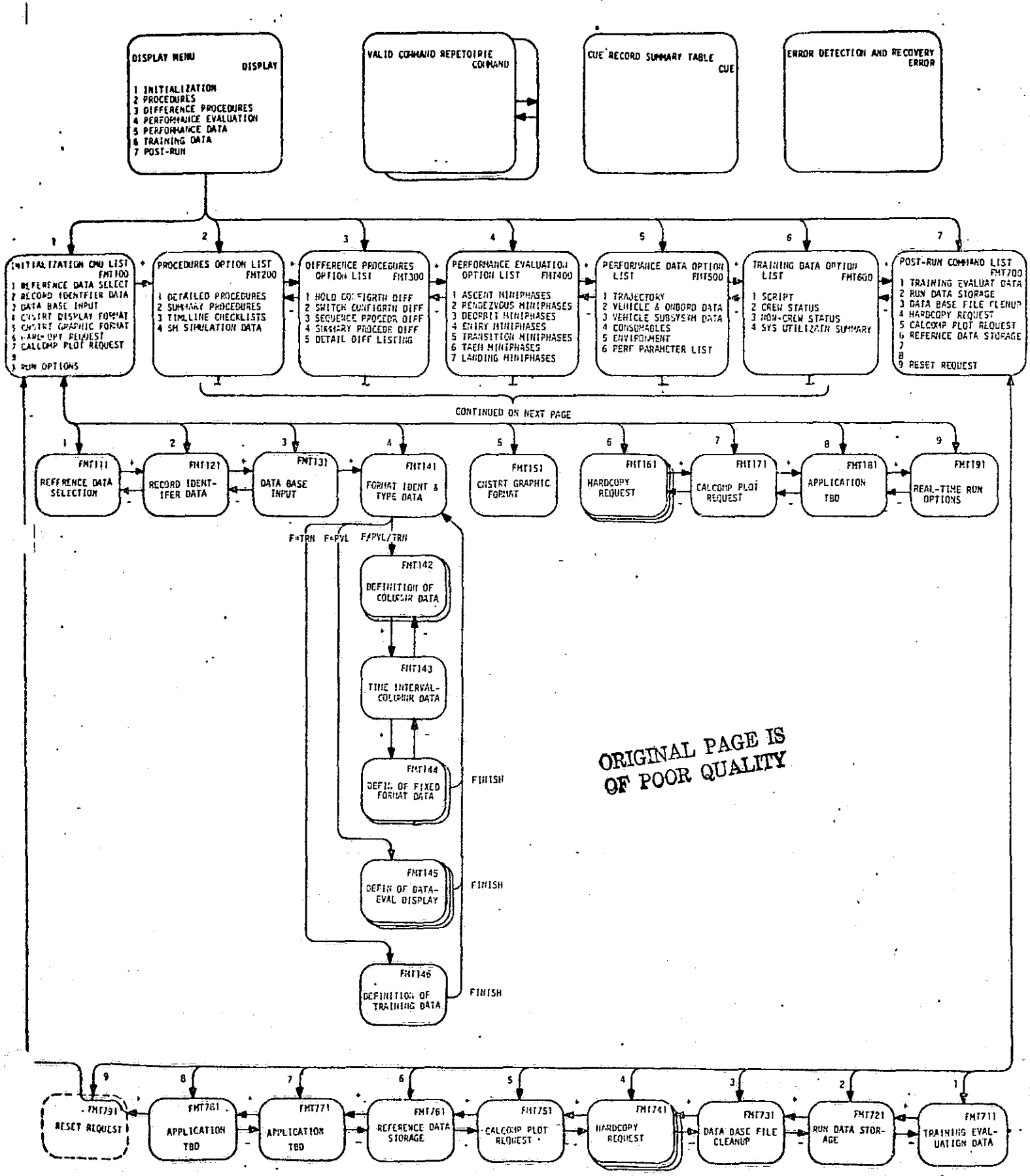


Figure 2-4 PPP Alphanumeric Display Tree (Continued)

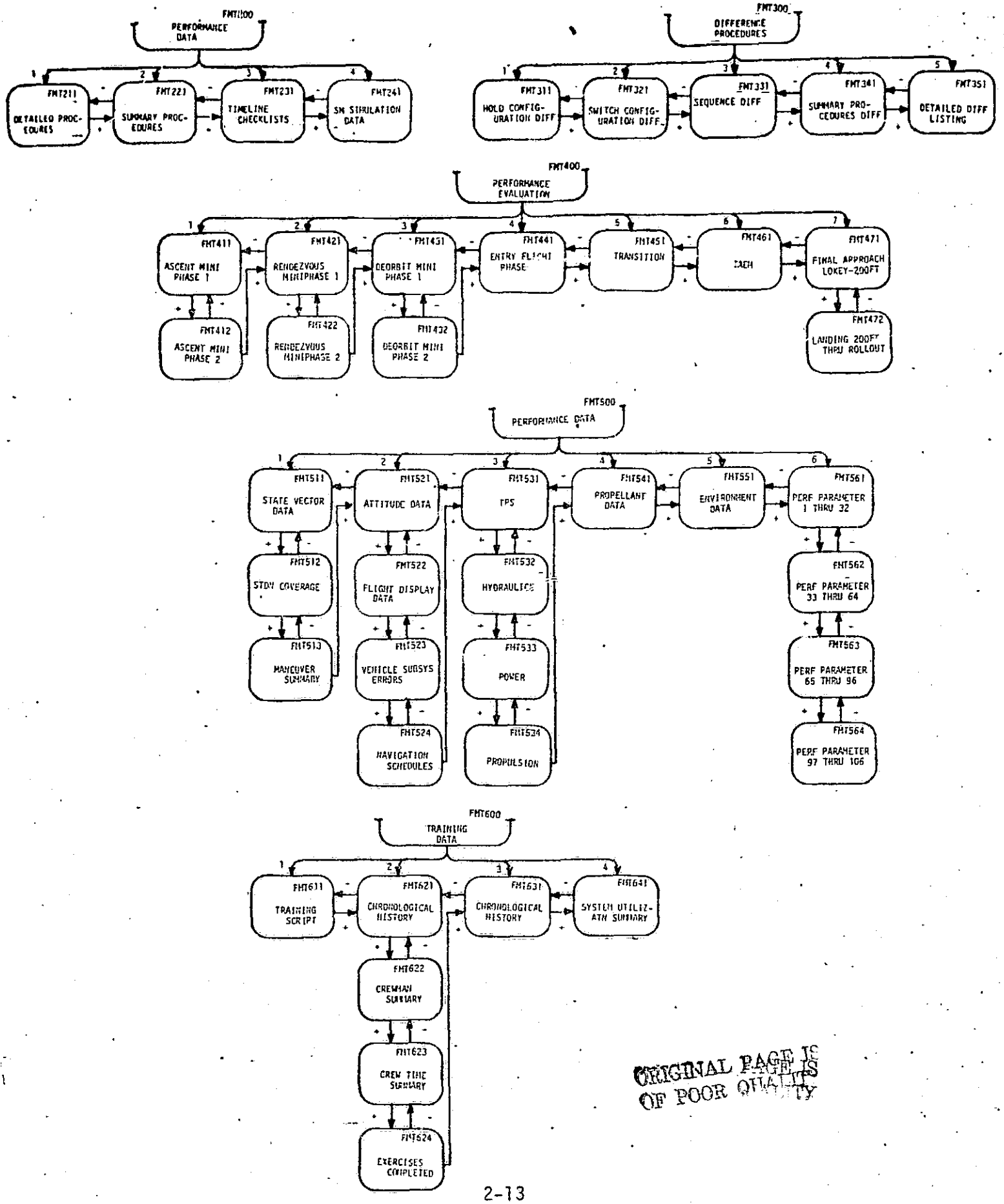
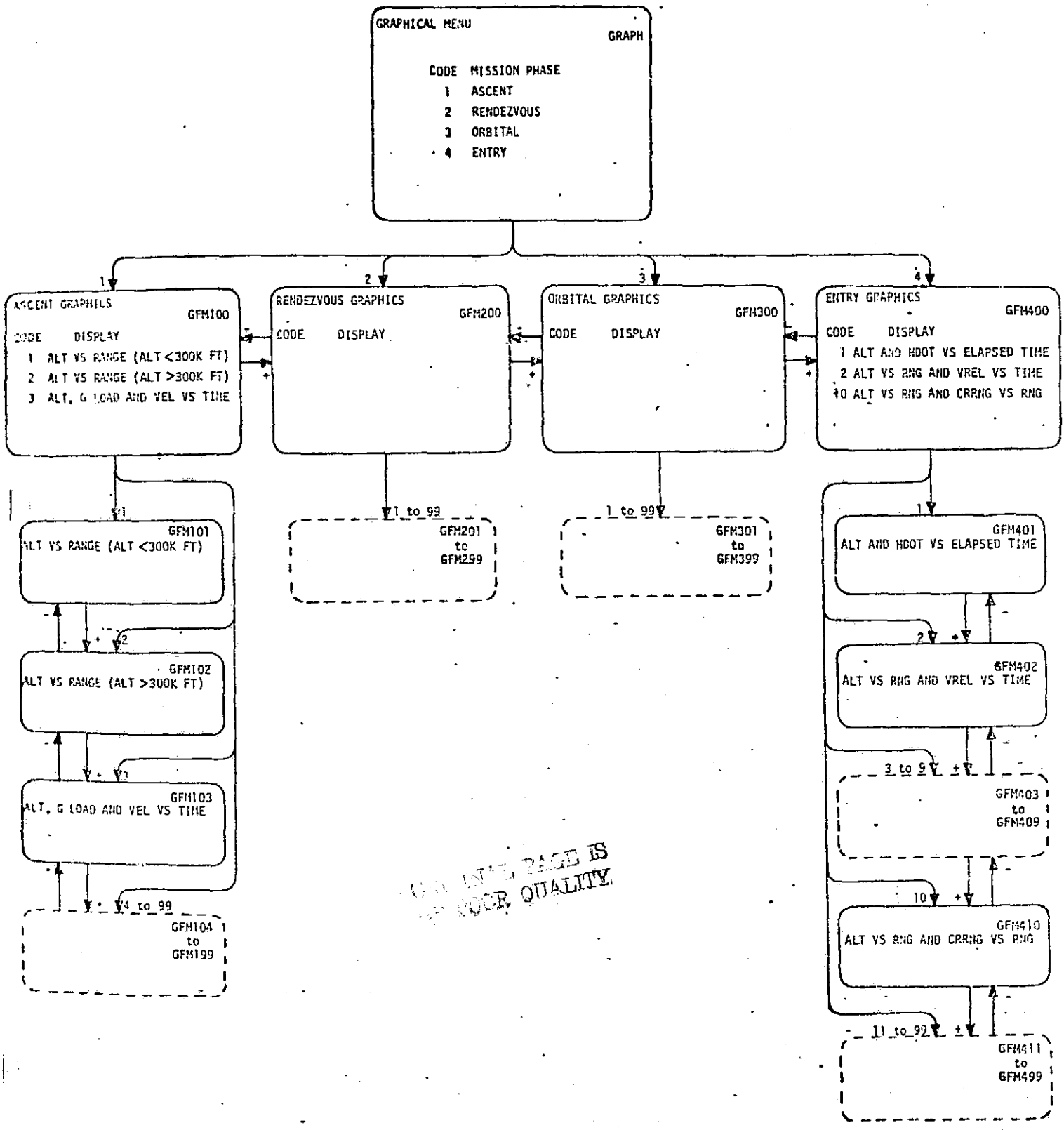


Figure 2-5 PPP Graphical Display Tree



technique was implemented, however, that reduced this requirement to a maximum of 6 words resident in core at any one time for the Hollerith statement data. The design resulted in the definition of a new file containing 1916 records. Each record may be accessed individually by rewinding to the start of the file, skipping to the appropriate record, and reading the desired 6 words into core. The resulting design of the PPP statement data base is shown in Figure 2-6. Presented is the structure, and devisions of the major elements of the PPP statements data base.

Other modifications to the data base during this contract included the addition of training statistics data and graphics format descriptors. Details of these files, their structure, and further definition of the PPP data base may be found in ACPDT Design Note No. 12, "Procedures and Performance Program Description."

SPS Data Transfer Definition

The initial PPP design demonstrated under the CPDT contract monitored approximately 360 switch discretes. The modifications to the SPS crew station, and the decision to attach to the SPS-Systems Management Simulation required the monitoring of a total of 1440 discrete parameters, the addition of malfunction code words, and the addition of CRT format numbers to the procedures data transfer buffer from the SPS to the PPP. No modifications were defined for the initialization and performance data buffers during this contract.

The final design of the SPS/PPP data transfer is summarized in Figures 2-7 thru 2-9. Figure 2-7 illustrates the transfer buffer, which is 59 words long, for the initialization data case and the run data case. For each reset selection, the SPS/PPP buffer is loaded with the appropriate initialization data.

As the simulation goes to run, the transfer buffer is loaded with run data by the SPS during each computation cycle. Figure 2-8 defines the procedures data transfer. The data transferred is maximized by packing

Figure 2-6 PPP Statements Data Base Structure

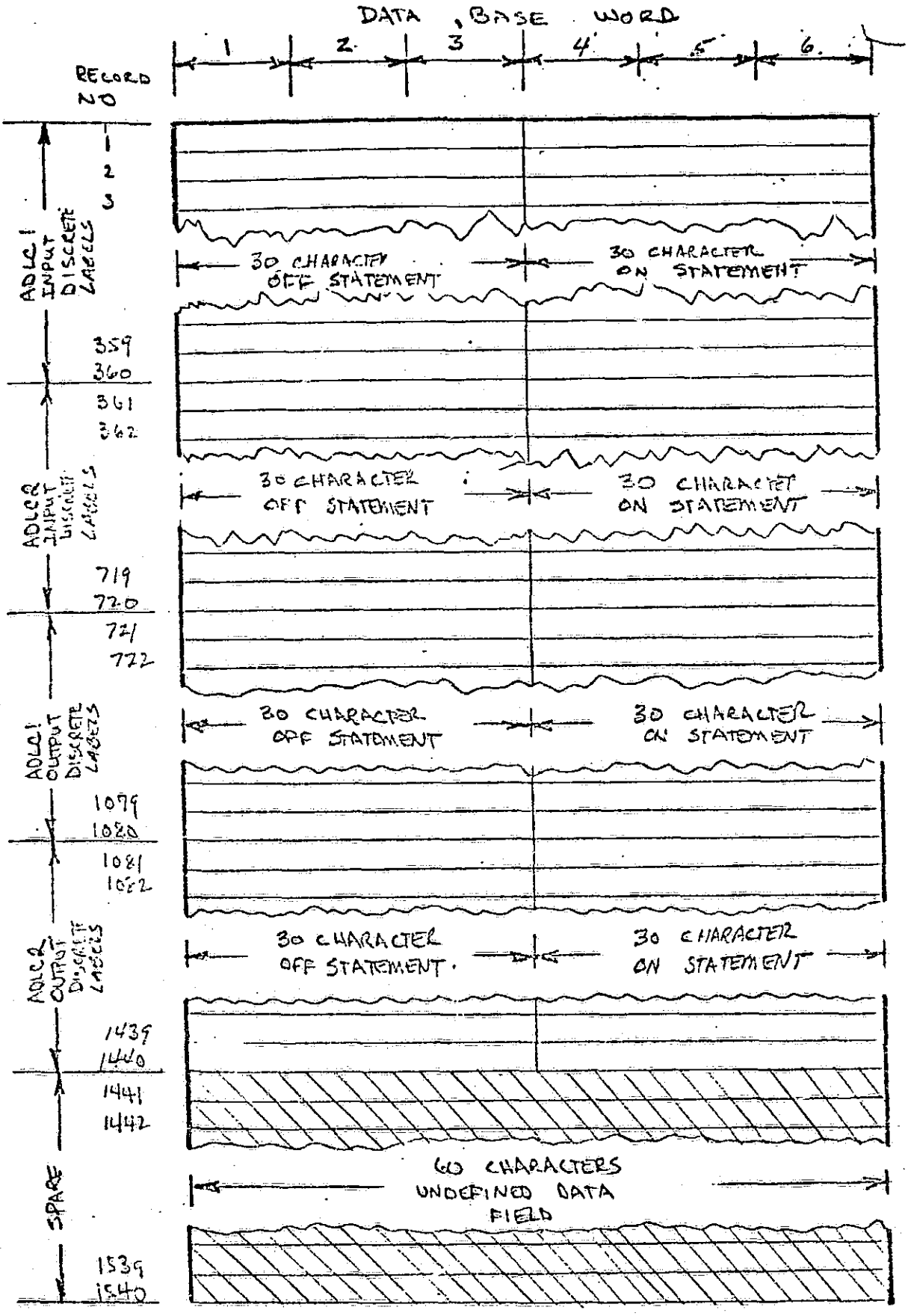


Figure 2-6 PPP Statements Data Base Structure (continued)

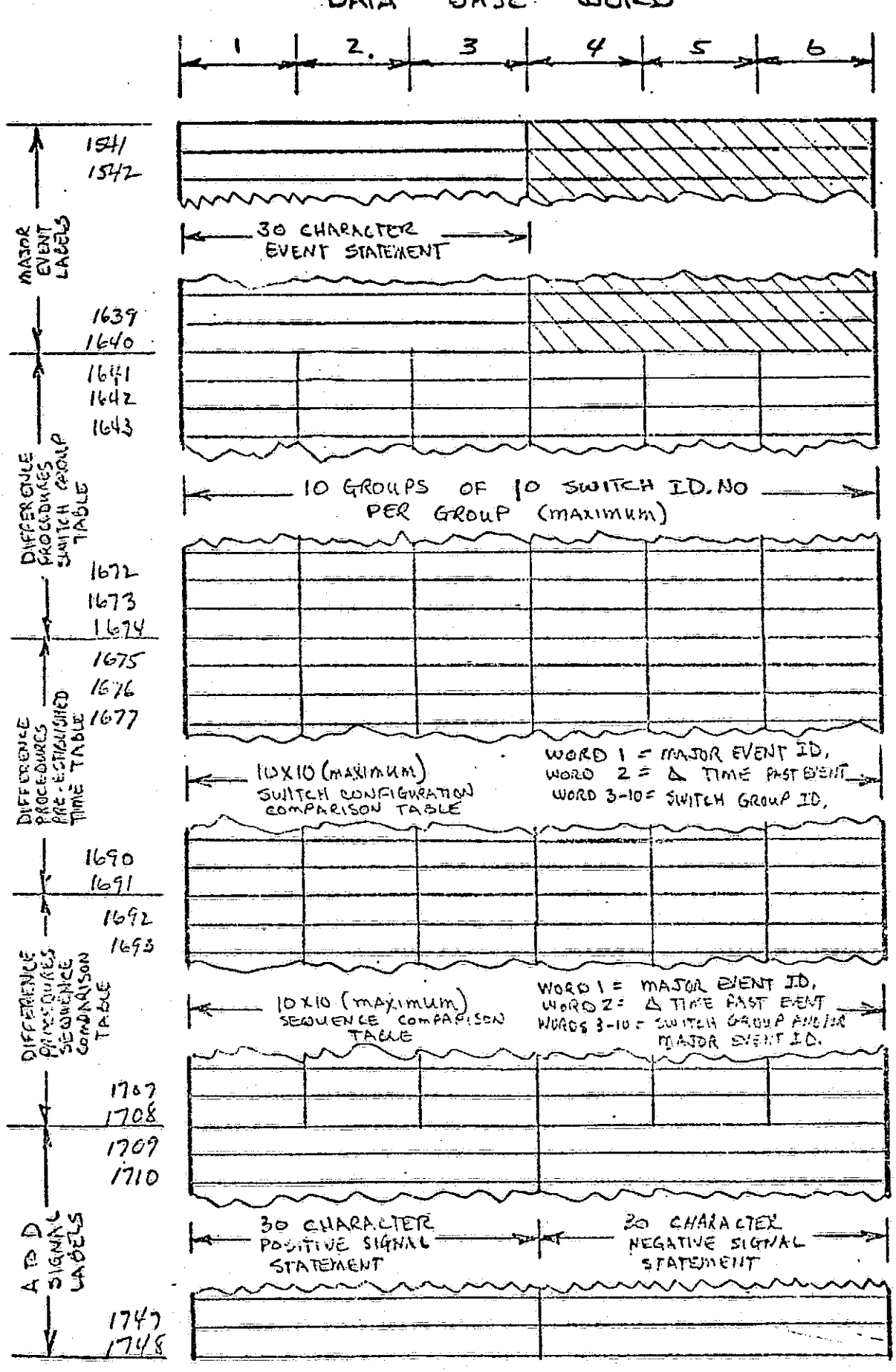


Figure 2-6 PPP Statements Data Base Structure (continued)

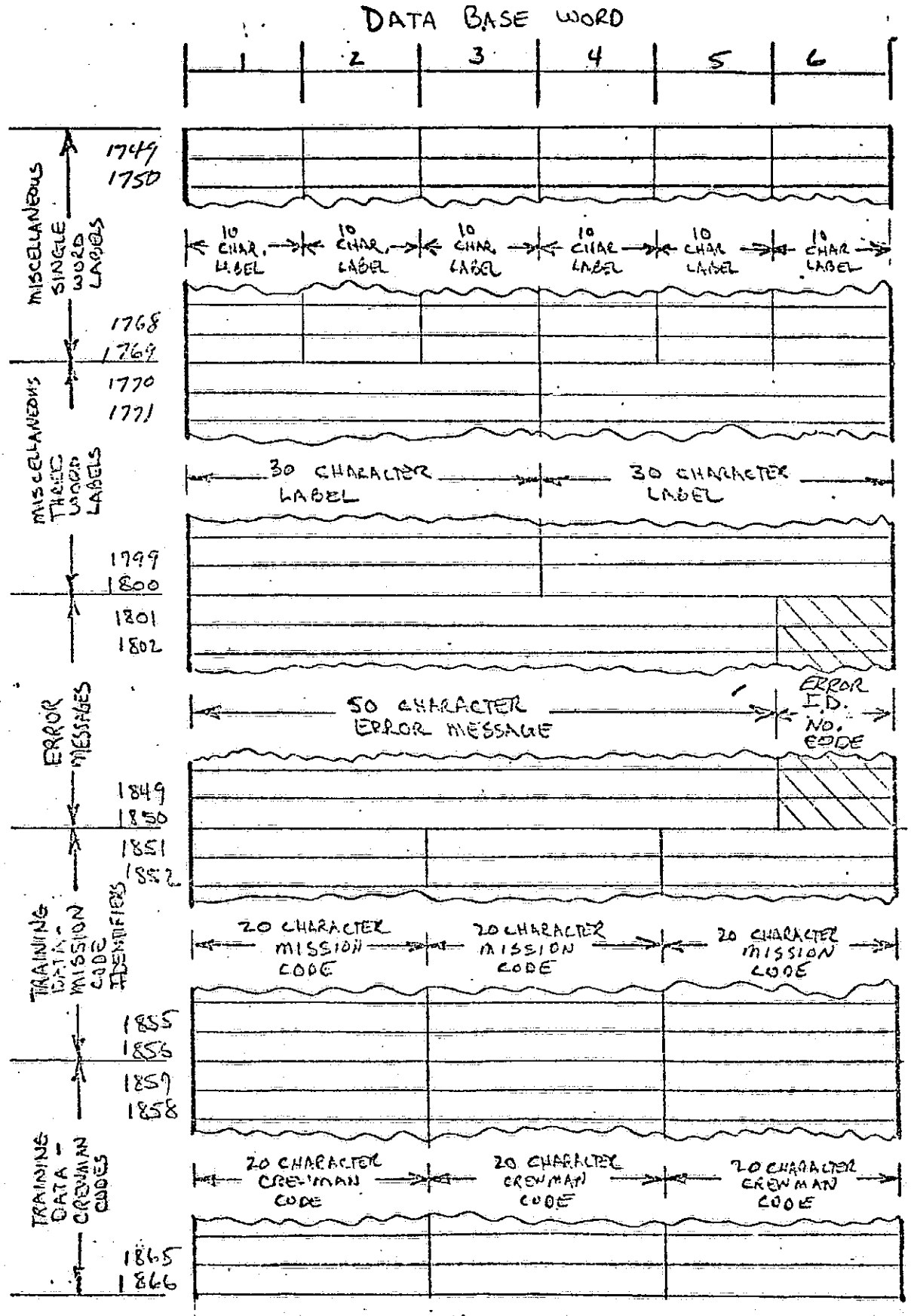
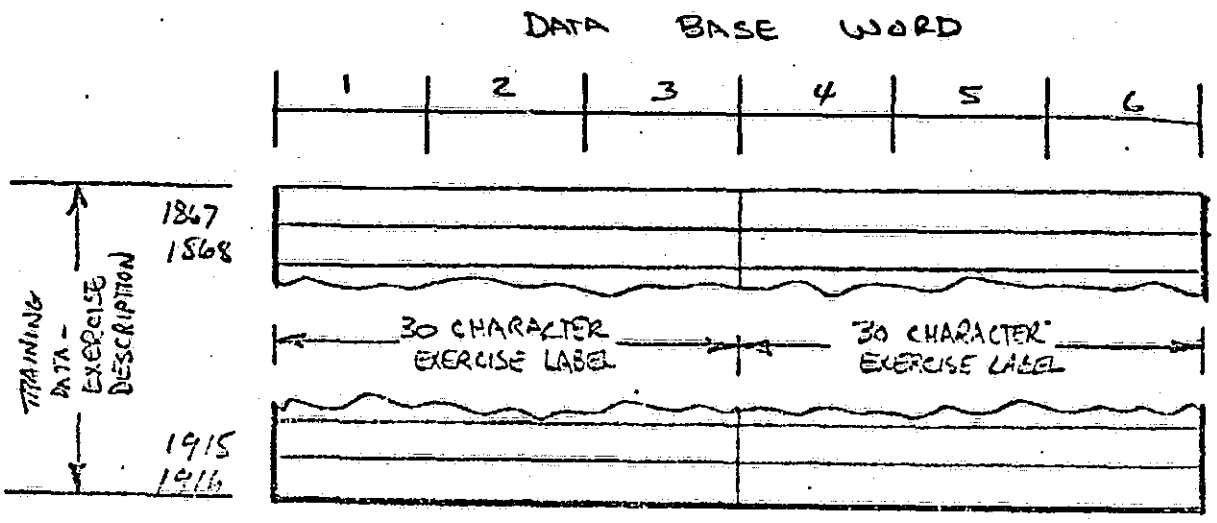


Figure 2-6 PPP Statements Data Base Structure (continued)



NOTE : ▨ - REPRESENTS UNUSEABLE OR SPARE ELEMENTS OF DATA BASE

Figure 2-7 SPS Data Transfer Buffer

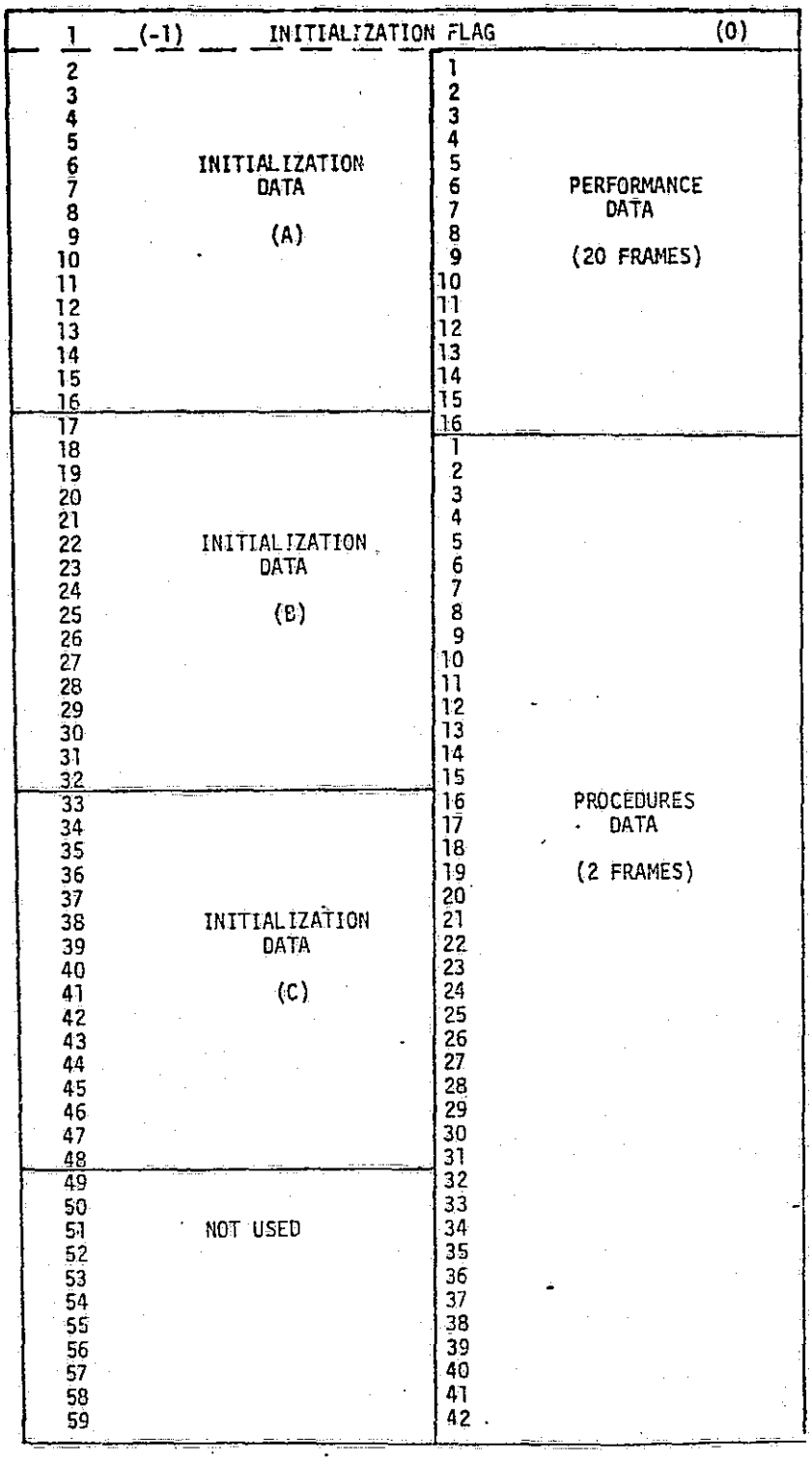


Figure 2-8 DEFINITION OF PROCEDURES DATA TRANSFER

ODD FRAMES

INBUF LOCATION	PARAMETER NAME	PARAMETER DESCRIPTION
1	TIME	SIMULATION RUN TIME
2	IDISIN1 (1)	ADLC#1 INPUT DISCRETES
3	IDISIN1 (2)	
4	IDISIN1 (3)	
5	IDISIN1 (4)	
6	IDISIN1 (5)	
7	IDISIN1 (6)	
8		SPARE
9		SPARE
10		SPARE RESERVED FOR A TO D VARIABLES
11		SPARE
12	RHC (1)	ROTATIONAL HAND CONTROLLER - PITCH
13	RHC (2)	ROTATIONAL HAND CONTROLLER - ROLL
14	RHC (3)	ROTATIONAL HAND CONTROLLER - YAW
15	MODESPS	1 = HOLD 3 = OPERATE SPS MODE FLAG 2 = RESET 10 = ERROR
16	IDISIN2 (1)	ADLC#2 INPUT DISCRETES
17	IDISIN2 (2)	
18	IDISIN2 (3)	
19	IDISIN2 (4)	
20	IDISIN2 (5)	
21	IDISIN2 (6)	
22	IDISOT2 (1)	ADLC#2 OUTPUT DISCRETES
23	IDISOT2 (2)	
24	IDISOT2 (3)	
25	IDISOT2 (4)	
26	IDISOT2 (5)	
27	IDISOT2 (6)	
28	MAL (1)	MALFUNCTION CODE WORD
29	MAL (2)	
30	NCRT (1)	CRT FORMAT NUMBER - LEFT
31	NCRT (2)	CRT FORMAT NUMBER - CENTER
32	NCRT (3)	CRT FORMAT NUMBER - RIGHT
33	NCRT (4)	CRT FORMAT NUMBER - MISSION SPECIALIST
34	NCRT (5)	CRT FORMAT NUMBER - PGP
35	IDISOT1 (1)	ADLC#1 OUTPUT DISCRETES
36	IDISOT1 (2)	
37	IDISOT1 (3)	

Figure 2-8 DEFINITION OF PROCEDURES DATA TRANSFER (continued)

	INBUF LOCATION	PARAMETER NAME	PARAMETER DESCRIPTION
ODD FRAME CONTINUED	38	IDISOT1 (4)	
	39	IDISOT1 (5)	
	40	IDISOT1 (6)	
	41		SPARE
	42	IFRAME	FRAME COUNTER
EVEN FRAMES	1	TIME	SIMULATION RUN TIME
	2	IDISIN1 (1)	ADLC#1 INPUT DISCRETES
	3	IDISIN1 (2)	
	4	IDISIN1 (3)	
	5	IDISIN1 (4)	
	6	IDISIN1 (5)	
	7	IDISIN1 (6)	
	8	STEER	NOSE WHEEL STEERING (OR RUDDER)
	9	FLAP	FLAPS (OR SPEED BRAKE)
	10	BRAKE (1)	LEFT WHEEL BRAKE
	11	BRAKE (2)	RIGHT WHEEL BRAKE
	12	RHC (1)	ROTATIONAL HAND CONTROLLER - PITCH
	13	RHC (2)	ROTATIONAL HAND CONTROLLER - ROLL
	14	RHC (3)	ROTATIONAL HAND CONTROLLER - YAW
	15	MODESPS	1 = HOLD 3 = OPERATE SPS MODE FLAG 2 = RESET 10 = ERROR
	16	IDISIN2 (1)	ADLC#2 INPUT DISCRETES
	17	IDISIN2 (2)	
	18	IDISIN2 (3)	
	19	IDISIN2 (4)	
	20	IDISIN2 (5)	
	21	IDISIN2 (6)	
	22	IDISOT2 (1)	ADLC#2 OUTPUT DISCRETES
	23	IDISOT2 (2)	
	24	IDISOT2 (3)	
	25	IDISOT2 (4)	
	26	IDISOT2 (5)	
	27	IDISOT2 (6)	
	28	MAL (1)	MALFUNCTION CODE WORD
	29	MAL (2)	

Figure 2-8 DEFINITION OF PROCEDURES DATA TRANSFER (continued)

EVEN FRAME CONTINUED

INBUF LOCATION	PARAMETER NAME	PARAMETER DESCRIPTION
30	NCRT (1)	CRT FORMAT NUMBER - LEFT
31	NCRT (2)	CRT FORMAT NUMBER - CENTER
32	NCRT (3)	CRT FORMAT NUMBER - RIGHT
33	NCRT (4)	CRT FORMAT NUMBER - MISSION SPECIALIST
34	NCRT (5)	CRT FORMAT NUMBER - PGP
35	IDISOT1 (1)	ADLC#1 OUTPUT DISCRETES
36	IDISOT1 (2)	
37	IDISOT1 (3)	
38	IDISOT1 (4)	
39	IDISOT1 (5)	
40	IDISOT1 (6)	
41		SPARE
42	IFRAME	FRAME COUNTER

Figure 2-9 DEFINITION OF PERFORMANCE DATA TRANSFER

FRAME	DATA BLOCK RATE	LOCATION #	PARAMETER NAME	PARAMETER DEFINITION	UNITS
1	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #1	2	CR	CROSS RANGE	NM
		3	DR	DOWN RANGE	NM
		4	R	RANGE	FT
		5	QDOT	HEATING RATE	BTU/FT^2-SEC
		6	HDOT	ALTITUDE RATE	FPS
		7	VREL	RELATIVE VELOCITY	FPS
		8	G	G LOAD	G
		9	GX	ACCELERATION IN X-AXIS	G
		10	GZ	ACCELERATION IN Z-AXIS	G
		11	HDTC	COMMANDED ALTITUDE RATE	FPS
		12	ICOORD	COORDINATE FLAG	--
	1/SEC #1	13		NONE	
		14	GMODE	GUIDANCE MODE CHANGES	--
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
2	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC	2	BANK	BANK ANGLE	DEG
		3	ALPHA	ANGLE OF ATTACK	DEG
		4	LATITUDE	VEHICLE GROUND TRACK LATITUDE	DEG
		5	LONGITUDE	VEHICLE GROUND TRACK LONGITUDE	DEG
		6	DELTAL	LOCALIZER ERROR	DOTS
		7	DELTAG	GLIDESLOPE ERROR	DOTS
		8	ELEV	ELEVON DEFLECTION	DEG
		9	DEFLEC	BODY FLAP DEFLECTION	DEG
		10	ALT	ALTITUDE	FT
		11	BCMD	COMMANDED BANK ANGLE	DEG
		12	MACHNO	MACH NUMBER	
	1/SEC #2	13		X	FPS
		14		Y MANEUVER VELOCITY COMPONENTS	FPS
		15		Z	FPS
	20/SEC	16	IFRAME	FRAME COUNTER	SEC
3	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #3	2		MAIN ENGINE GIMBAL ANGLE	DEG
		3		MAIN ENGINE GIMBAL ANGLE	DEG
		4		MAIN ENGINE GIMBAL ANGLE	DEG
		5		MAIN ENGINE GIMBAL ANGLE	DEG
		6		MAIN ENGINE GIMBAL ANGLE	DEG
		7		MAIN ENGINE GIMBAL ANGLE	DEG
		8	PBODY	ROLL RATE	DEG/SEC
		9	QBODY	PITCH RATE	DEG/SEC
		10	RBODY	YAW RATE	DEG/SEC
		11	GCMD	COMMANDED G LOAD	G
		12	VIAS	INDICATED AIRSPEED	KNOTS
	1/SEC #3	13		NONE	
		14		NONE	
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	

Figure 2-9 DEFINITION OF PERFORMANCE DATA TRANSFER (continued)

FRAME	DATA BLOCK RATE	LOCATION #	PARAMETER NAME	PARAMETER DEFINITION	UNITS
4	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #4	2	THETAH	LOCAL HORIZONTAL ATTITUDE θ_{LH}	DEG
		3	PHIH	LOCAL HORIZONTAL ATTITUDE ϕ_{LH}	DEG
		4	PSIH	LOCAL HORIZONTAL ATTITUDE ψ_{LH}	DEG
		5	THETAI	INERTIAL ATTITUDE θ_I	DEG
		6	PHII	INERTIAL ATTITUDE ϕ_I	DEG
		7	PHII	INERTIAL ATTITUDE ψ_I	DEG
		8		COMMANDED ATTITUDE θ_C	DEG
		9		COMMANDED ATTITUDE ϕ_C	DEG
		10		COMMANDED ATTITUDE ψ_C	DEG
		11	RPOT	RANGE POTENTIAL	NM
		12	TLD	TOTAL LIFT TO DRAG RATIO	-
	1/SEC #4	13	RALT	ONBOARD RADAR ALTITUDE	FT
		14	GS	GROUND SPEED	FPS
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
5	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #1	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 1		
	1/SEC #5	13		NONE	
		14		NONE	
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
6	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #2	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 2		
	1/SEC #6	13			DEG
		14		IMU ERRORS	DEG
		15			DEG
	20/SEC	16	IFRAME	FRAME COUNTER	
7	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #3	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 3		
	1/SEC #7	13		ALTITUDE AT VEHICLE APOGEE	NM
		14		ALTITUDE AT VEHICLE PERIGEE	NM
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
8	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #4	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 4		
	1/SEC #8	13			FT
		14		ONBOARD POSITION ERROR	FT
		15			FT
	20/SEC	16	IFRAME	FRAME COUNTER	FT
9	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #1	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 1		
	1/SEC #9	13			FPS
		14		ONBOARD VELOCITY ERROR	FPS
		15			FPS
	20/SEC	16	IFRAME	FRAME COUNTER	

Figure 2-9 DEFINITION OF PERFORMANCE DATA TRANSFER (continued)

FRAME #	DATA BLOCK RATE	LOCATION #	PARAMETER NAME	PARAMETER DEFINITION	UNITS
10	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #2	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 2		
	1/SEC #10	13		HORIZON SENSOR 1 ANGLES	DEG
		14			DEG
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
11	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #3	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 3		
	1/SEC #11	13		HORIZON SENSOR 2 ANGLES	DEG
		14			DEG
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
12	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #4	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 4		
	1/SEC #12	13		INCLINATION ANGLE	DEG
		14	GAMMA	FLIGHT PATH ANGLE	DEG
		15		NONE	
	20/SEC	16	IFRAME	FRAME COUNTER	
13	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #1	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 1		
	1/SEC #13	13	HEAD	HSI MAGNETIC HEADING	DEG
		14	DEV	HSI DEVIATION	DOTS
		15	RI	HSI DISTANCE	NM
	20/SEC	16	IFRAME	FRAME COUNTER	
14	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #2	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 2		
	1/SEC #14	13	X		FT
		14	Y	VEHICLE POSITION VECTOR	FT
		15	Z		FT
	20/SEC	16	IFRAME	FRAME COUNTER	
15	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #3	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 3		
	1/SEC #15	13	XDT		FPS
		14	YDT	VELOCITY VECTOR	FPS
		15	ZDT		FPS
	20/SEC	16	IFRAME	FRAME COUNTER	
16	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #4	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 4		
	1/SEC #16	13		STAR IDENTIFIER	-
		14		AZIMUTH ANGLE TO STAR	DEG
		15		ELEVATION ANGLE TO STAR	DEG
	20/SEC	16	IFRAME	FRAME COUNTER	
17	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #1	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 1		
	1/SEC #17	13	BALT	BARO ALTIMETER READING	FT
		14		BAROMETRIC PRESSURE	IN. HG.
		15		HORIZON SENSOR ERROR	DEG
	20/SEC	16	IFRAME	FRAME COUNTER	

Figure 2-9 DEFINITION OF PERFORMANCE DATA TRANSFER (continued)

FRAME #	DATA BLOCK RATE	LOCATION #	PARAMETER NAME	PARAMETER DEFINITION	UNITS
18	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #2	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 2		
	1/SEC #18	13			DEG
		14		HORIZON SENSOR ERRORS	DEG
		15			DEG
	20/SEC	16	IFRAME	FRAME COUNTER	
19	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #3	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 3		
	1/SEC #19	13	RCS	RCS PROPELLANT USED	LBS
		14		OMS PROPELLANT USED	LBS
		15		ORB PROPELLANT REMAINING	LBS
	20/SEC	16	IFRAME	FRAME COUNTER	
20	20/SEC	1	TIME	GROUND ELAPSED TIME	SEC
	5/SEC #4	2-12	SAME AS 5/SEC PARAMETERS OF FRAME 4		
	1/SEC #20	13		STDN STATION I.O. NUMBER	-
		14		STDN COVERAGE AOS TIME	SEC
		15		STDN COVERAGE LOS TIME	SEC
	20/SEC	16	IFRAME	FRAME COUNTER	

of discrete parameters and through multiplexing techniques. During a simulation run, the transfer buffer is loaded by the SPS and contains alternately odd and even frame procedures data. This provides discrete procedural data every computation cycle, and a complete set of procedures data (analog and discrete) every 2 computation cycles.

Figure 2-9 defines the performance data transfer. During the simulation run, the transfer buffer contains one of the twenty frames of performance data. Each computation cycle, the transfer buffer is loaded by the SPS with a new frame of data which the PPP reads and processes. A complete set of performance data is transferred in 20 computation cycles. The data contents for the performance data transfer contains trajectory related parameters. A review and modification of the performance buffer is recommended to incorporate systems related data.

PPP Program Description

During the performance of the Commercial Applicability task and the Applications to Other Simulators task, discussed in Sections 2.3.5 and 2.3.7 respectively, it was determined that a program description document was needed. This document should contain a detailed description of the PPP software and unique implementation techniques, and should be maintained with the PPP development activities on the same frequency as the user's guide.

ACPDT Design Note No. 7 documents the initial version of the PPP program description. The document was later revised, at the end of the study performance period, and republished as ACPDT Design Note No. 12. The design note includes a brief description of the PPP user interface followed by detailed discussions of the 1) SPS/PPP data transfer, 2) the PPP applications software, 3) utilization of CDC 6400 systems software, 4) PPP data base design, and 5) PPP data file utilization.

PPP User's Guide

McDonnell Douglas Report MDC W0009 (Procedures and Performance Program User's Guide) was prepared to describe the operations required to use the PPP to obtain desired procedures and performance data output. The

material presented provides the PPP user with general information on the PPP system hardware and software and the integrated PPP/SPS system.

Program activation and deck structure discussions are included which describe the initialization, run, and post-run operations. Operations required to activate and terminate the PPP and SPS for an actual or simulated SPS run, as shown in Figure 2-10, are described in detail.

A detailed discussion is presented for the display structure, user command interface, and PPP operational phases: Display contents and available user commands are discussed in detail.

A rigorous discussion of the PPP support data is also presented. Contents of the PPP data base, and procedures for accomplishing PPP/GDP data transfer are discussed.

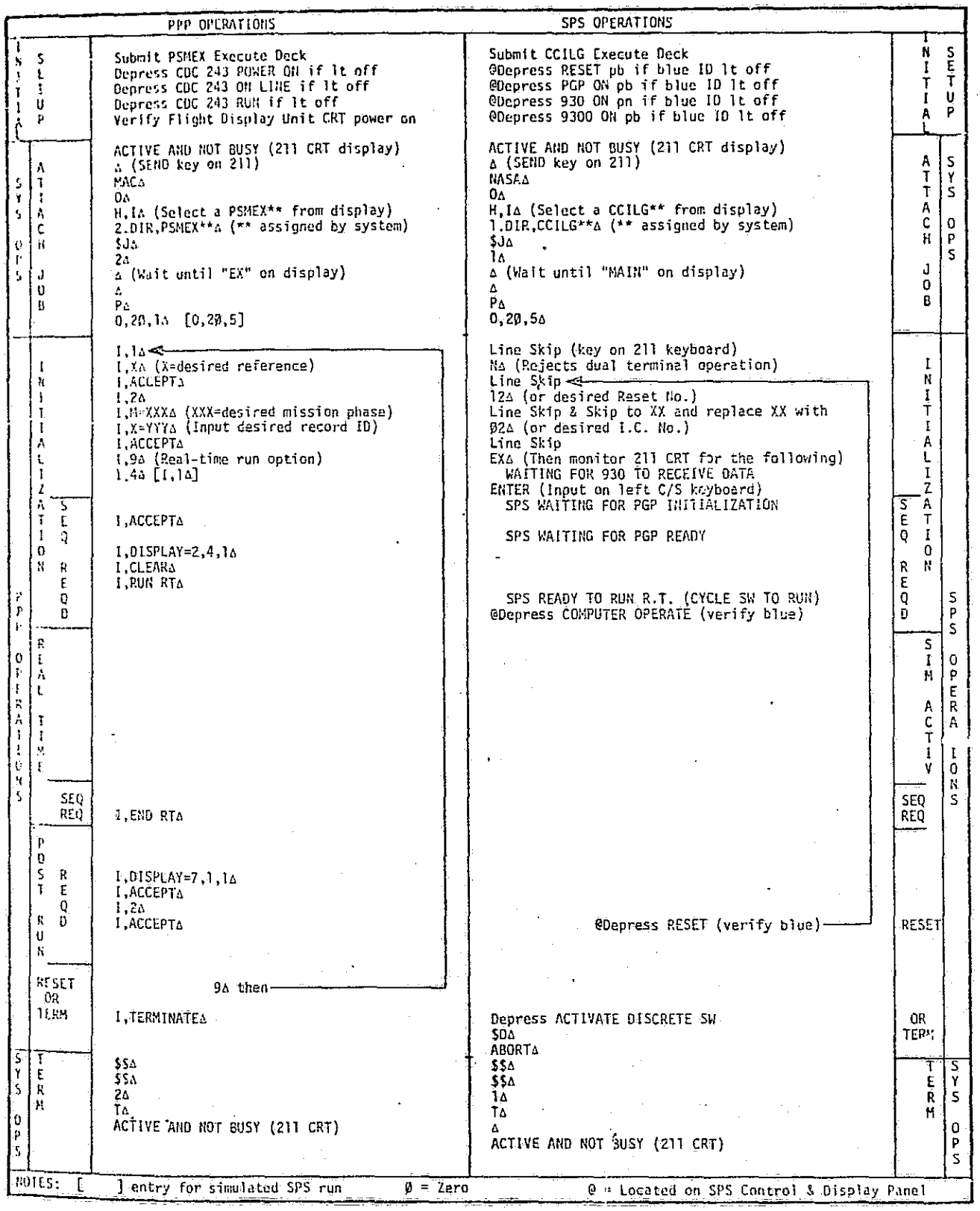
Four appendicies are included which present 1) the PPP execute deck contents, 2) example format descriptors and resultant formats, 3) available PPP data output formats, and 4) SPS performance parameter data.

PPP Math Flow Charts

PPP mathflow charts were developed to serve as the detailed design tool which translates the program requirements into detailed software implementation requirements. These math flow charts not only served as a development aid, but upon contract completion they represent the most detailed documentation of the program with the exception of the computer listing.

McDonnell Douglas Report MDC W0010 (Procedures and Performance Program Math Flow Charts) documents the final version of the math flows and represents the PPP design at the completion of the Advanced Crew Procedures Development Techniques Study.

Figure 2-10 PPP/SPS Operational Procedures



2.3.3 Develop Computer Program

The purpose of this task was to translate the PPP computer program requirements into detailed software requirements consistent with the baseline hardware system and computer system software. The scope of the task included: 1) requirements traceability and top-level functional definition of the software, 2) detailed software design (mathflows), coding and checkout, and 3) coordination of the SPS interface.

PPP Software/Requirements Implementation

PPP is required, due to interface constraints with the SPS and its functional requirements, to execute within 47000_8 ($20K_{10}$) words of core. The program design makes use of overlays where practical in order to stay within this core limitation. Those requirements which must be satisfied continually have been assigned to the main overlay. Those requirements which are satisfied on an as-requested basis are assigned to primary or secondary overlays.

The design of the PGP incorporates four basic features:

1) Modular design to simplify identification of necessary program structures,
2) Real-time processing to provide the interface between the PPP and the SPS,
3) Multi-computational-loops to ensure integrity of required data processing, and
4) Data driven design to allow user definition of critical parameters which define the format of the procedures data and evaluation data.

The PPP has been designed to operate in real-time and non-real time, and to accept user inputs via punch cards or interactive terminals.

Modular design of the PPP has been accomplished by assigning the computer program requirements to nineteen modules, and by further assignment of the requirements to subroutines and subroutine entry points within each module. The nineteen PPP modules that were defined are listed below:

1. Initialization (INITIAL);
2. Sequence Control (SEQCON);
3. Real-time Interface (RTFACE);
4. Input/Output (INOUT);
5. Procedures Processor (PROCPR);
6. Difference Procedures Processor (DIFPPR);
7. Performance Processor (PERFPR);
8. Performance Evaluation Processor (EVALPR);
9. Procedures Formatter (PROCFM);
10. Difference Procedures Formatter (DIFPFM);
11. Performance Data Formatter (PERFFM);
12. Performance Evaluation Formatter (EVALFM);
13. Training Formatter (TRAINFM);
14. Post-Run (POSTRUN);
15. Real-Time Input/Output (RTIO);
16. Graphics Formatter Module (GRAPHFM);
17. GDP to PPP Transfer Processor (GDPPGP);
18. PPP Support Subroutines (SUPSUB);
19. PPP Support Function Routine (SUPFUNC).

The requirements of the ACPDT Study were implemented by first assigning the requirements to the appropriate module within the existing PPP software (i.e., those modules defined on the CPDT Study). In some cases it was necessary to identify new modules to satisfy the requirements. Following this requirements traceability, a top-level functional design and modification or detailed design of the PPP software was performed.

The requirements of the ACPDT Study were assigned to the appropriate module as shown in Figure 2-11. The requirements are listed by paragraph number from the Requirements Document. The columns of the figure represent the modules. A module's area of responsibility is indicated by the requirements subparagraph number. Those requirements which were defined for later implementation are shown in a separate column. These requirements are primarily those effected by the design status of the SPS.

Figure 2-11 Top Level ACPDT Requirements Traceability Matrix

REQUIREMENTS \ MODULES	NOTES	INITIAL	SEQCON	RTFACE	INPUT	RTIO	PROCPR	DIFFPR	PLOTPR	EVALPR	PROCFM	DIFFFM	PERFFM	EVALFM	TRANFM	POSTRUN	GRAPH	GDPPGP	DEFERRED	SPS
SECTION 2 SPS DATA TRANSFER																				
2.1 Procedures Data				1																1
2.2 Performance Data	1																		1	1
2.3 Transfer Rates				1																1
2.4 Miscellaneous Transfers	2			3															1,2,3	1,2,3
SECTION 3 DATA MANIPULATION																				
3.1 Checkpoints	2																		1,2,3	1,3
3.2 Reset	2																		1,2,3	1,3
SECTION 4 CDC 211 CAPABILITIES																				
4.1 Format Construction		1,2,3									1	1	2	2	3					
4.2 Crew Station Configuration Check	2	1	1					1											2,3	2,3
4.3 Display Reconstruction			1-8																	
4.4 Training Data	3		2	3,4	3		4								1,5,8	6				3,4
SECTION 5 CDC 243 CAPABILITIES																				
5.1 Display Capability	4		1														1,2			
5.2 Format Construction		1-5															2			
5.3 Display Construction			1						3								1,2			
5.4 Display Reconstruction			1														1			
5.5 Training Data																	1,2			
SECTION 6 GDP/PGP DATA TRANSFER																				
6.1 Magnetic Tape Transfer					2													1		
6.2 Hazeltine Terminal Transfer	5																		1-9	
SECTION 7 PGP OUTPUT																				
7.1 General	6	2,4	3													2,4			1,5	
7.2 CDC 211 Displays			1																	
7.3 CDC 243 Displays	7																		1	
SECTION 8 MISCELLANEOUS																				
8.1 PGP Data Base	8	3,4																	1,7	1,2
8.2 Real-time Operations	9																		1	1
8.3 Batch Operations			1																	

NOTES:
(1) - NO REDEFINITION OF PERFORMANCE DATA TRANSFER IMPLEMENTED THIS CONTRACT BECAUSE PGP UNABLE TO INTERFACE WITH SPS DYNAMIC SIM. DUE TO CPU TIMING LIMITATION.
(2) - SPS DESIGN CONSTRAINT CAUSED DEFERRED REQUIREMENTS
(3) - REQUIREMENT 4.4.7 SATISFIED BY GDP DOCUMENTATION SYSTEM
(4) - REQUIREMENT 5.1.3 REDEFINED BECAUSE OF SPS COMPUTER FACILITY CONSTRAINT
(5) - INTERCOM SOFTWARE DELIVERED TOO LATE FOR REQUIREMENT IMPLEMENTATION
(6) - REQUIREMENTS 7.1.1 AND 7.1.5 CURRENTLY SATISFIED IN REAL-TIME, FAST-DUMP HARDCOPY DEFERRED
(7) - REQUIREMENT 7.3.1 - TECHNIQUE TO INTERFACE WITH CALCOMP WILL BE DEVELOPED, BUT SOFTWARE IMPLEMENTATION DEFERRED BECAUSE OF LATE DELIVERY OF CDC 243 HARDWARE
(8) - REQUIREMENT 8.1.1 - SPS DESIGN CONSTRAINT CAUSED DEFERRED REQUIREMENT
-REQUIREMENT 8.1.2 - INTERCOM SOFTWARE DELIVERED TOO LATE FOR REQUIREMENT IMPLEMENTATION
(9) - SPS DESIGN CONSTRAINT CAUSED DEFERRED REQUIREMENT

The PPP program design may be summarized by three computation loops: (1) Real-Time Cycle (RTC), (2) Real-Time Input/Output Cycle (RTIOC), and (3) Major Cycle (MC). The RTC provides the interface with the SPS and the processing required to assemble the run data. The RTIOC processes mass storage data transfer of run data. The MC processes user commands, run data selected for display, and data base input/output. The purpose of this multi-loop design is to insure that (1) processing of the SPS data to run data in the RTC is accomplished, and (2) processing of the run data transfer to mass storage in the RTIOC is accomplished regardless of any user intervention within the MC. Figure 2-12 describes the generalized flow of processing and data exchange of the PPP during the real time mode.

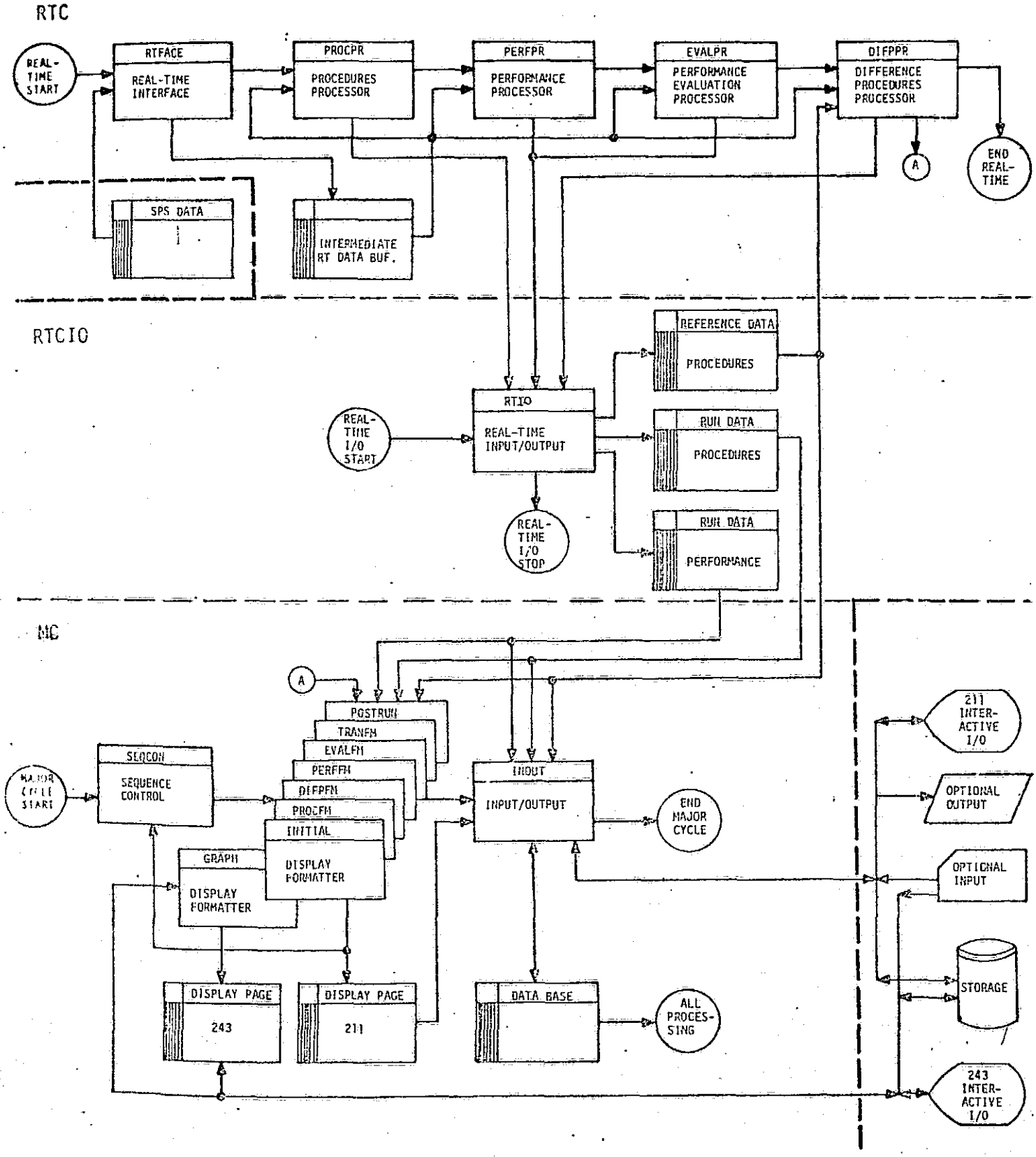
A more detailed discussion of the software design may be found in ACPDT Design Note No. 12 (Procedures and Performance Program Description).

CDC 243 Implementation

One of the major accomplishments of this contract was the incorporation of the CDC 243 graphics display system into the PPP system. Implementation of the CDC 243 required a combined effort of the NASA, CDC analyst, and the PPP staff. Timely procurement of the hardware components was accomplished by NASA; implementation and verification of the CDC 243 hardware and grid resident software (including system modifications) was the responsibility of the CDC analyst; and finally, implementation of the PPP applications software was the responsibility of the PPP software group.

Rapid familiarization and final utilization of the CDC 243 system was obtained by a building block philosophy. Initial familiarization with the system was obtained by the example CDC 243 software applications program QDEMO contained in the CDC 243 Software Reference Manual. The program was a valuable study guide and example for the PPP applications. The second step in the process was the development of an off-line batch program DRAWIT. The program contained a complete display of the CDC 243 format descriptor construction data. This program was used for developing

Figure 2-12 Real-Time Program Flow



1) techniques of communication with the keyboard/lightpen, 2) sensing and processing of commands from the user interface, 3) developing techniques and establishing requirements to read and write display background data to and from mass storage files, and 4) designing the interface with the existing PPP software. This program eventually became an integral part of the PPP and provided the capability to define a graphics format.

The final step in the development of the graphics capability was the design and interface of the graphics system in real time. This was successfully accomplished. The capability is provided to plot a maximum of nine (3 dependent parameters each versus 3 independent parameters) plots on a single graphics display. The user has the capability to define the plot characteristics pre-run.

Currently the graphics capability requires additional core utilization and can only be exercised utilizing the PPP simulated run option. Core reduction in this area was in work at the end of the contract performance period.

PPP/GDP Data Transfer

The ACPDT contract called for the implementation of a capability to provide data transfer between the PPP and the GDP. Two approaches were specified to provide this capability. Approach 1 specified direct transfer from the PPP to the GDP utilizing the Hazeltine 4000G terminal as the interface. Approach 2 specified the capability to exchange data between the two systems via magnetic tape.

Work was not accomplished on Approach 1 because of the failure to provide the MDTSCO requested modification to the CDC 6400 system software. The INTERCOM support software, required in the CDC 6400 to provide communication between the CDC 6400 computer and the Hazeltine 4000G Terminal was not delivered to the PPP staff according to the requested schedule.

Approach 2 however, was successfully implemented. The capability is provided in the PPP to recorded real-time and during post run displays on a mass storage file in a format which when copied to magnetic tape can be read into the GDP system. The capability is provided to transfer to the GDP any PPP generated display format.

An interpretive software program, GDPPGP, was developed during this contract to support the data transfer from the GDP to the PPP. This program reads and interprets a GDP magnetic tape containing a procedures document. The program process the data on this tape and creates a reference procedures data file in the format which is understandable by the PPP.

Training Scripts and Training Status Data

The capability was implemented during this contract to display and record training script and training status data. This information is intended to provide training instructors with a record of their action during SPS/PPP operations and to provide a record of the SPS/PPP training activities.

Training Script data is generated during SPS/PPP operations. The PPP software monitors and records operator actions at the PPP and SPS control consoles. The PPP in the post-run or "Hold" modes can display these operations in a timeline format. Hardcopy output of this script information provides valuable information of the user operations during training exercises.

Training Status data is maintained by the PPP to provide a detailed record of SPS training activities. The data may be presented in a manner, definable by the user, which indicates all crew training activities, each crewmans training activity, each missions crew training status, non-crew related utilization of the PPP/SPS system, or total system utilization.

Candidate training script and training status display formats and their contents are presented in Appendix A.

Display Reconstruction

The purpose of this activity was to design, implement, and checkout the PPP software necessary to support the PPP display reconstruction capability requirement as specified in the PPP Requirements Document.

Implementation of this capability required the development of a file synchronization routine and modifications to existing display formatter modules and the user interface module. The capability was successfully implemented to provide the user the ability to request display reconstruction to any time during simulation for the Procedures, Performance Data, Performance Evaluation and Graphics display formats. The capability is provided during the real time "Hold" and the post run modes of the combined SPS/PPP operations. An automatic sequence capability of the displays to the current time is provided should the user progress to "Run" during a "Hold" reconstruction request.

The display reconstruction capability provides a valuable tool during crew training sessions and for evaluation of procedural and simulation problems during post run evaluation sessions.

Scope 3.4 Modifications

This activity was required during the study contract in order to make the PPP software compatible with the new CDC 6400 operating system. The operating system was changed from Scope 3.3 to Scope 3.4. Minor problems were encountered during the conversion. With the aid of Frank Svejcar (NASA-Flight Simulation Division) these problem areas were easily resolvable. Actual conversion, including checkout, required one month to accomplish.

Software Modifications for SM Simulations

Early in the performance of this contracted effort, the SPS Entry Simulation became obsolete, and was no longer maintained as a production simulation within the SPS complex. Continued development of the PPP required integration with one of the continuing functional simulation loads of the SPS. The Systems Management Simulation was chosen. One of

the main reasons for selecting the Systems Management Simulation was the fact that the sponsor requested output data from this simulation matched directly to the procedures recording capability of the PPP.

In order to become operational with the Systems Management Simulation, PPP software modifications were required to the Real-time Interface, Procedures Processor, Procedures Formatter, Initialization, and Format Descriptor Modules. These modifications were required because of the unique data output requirement and the expanded procedures data sensing requirements.

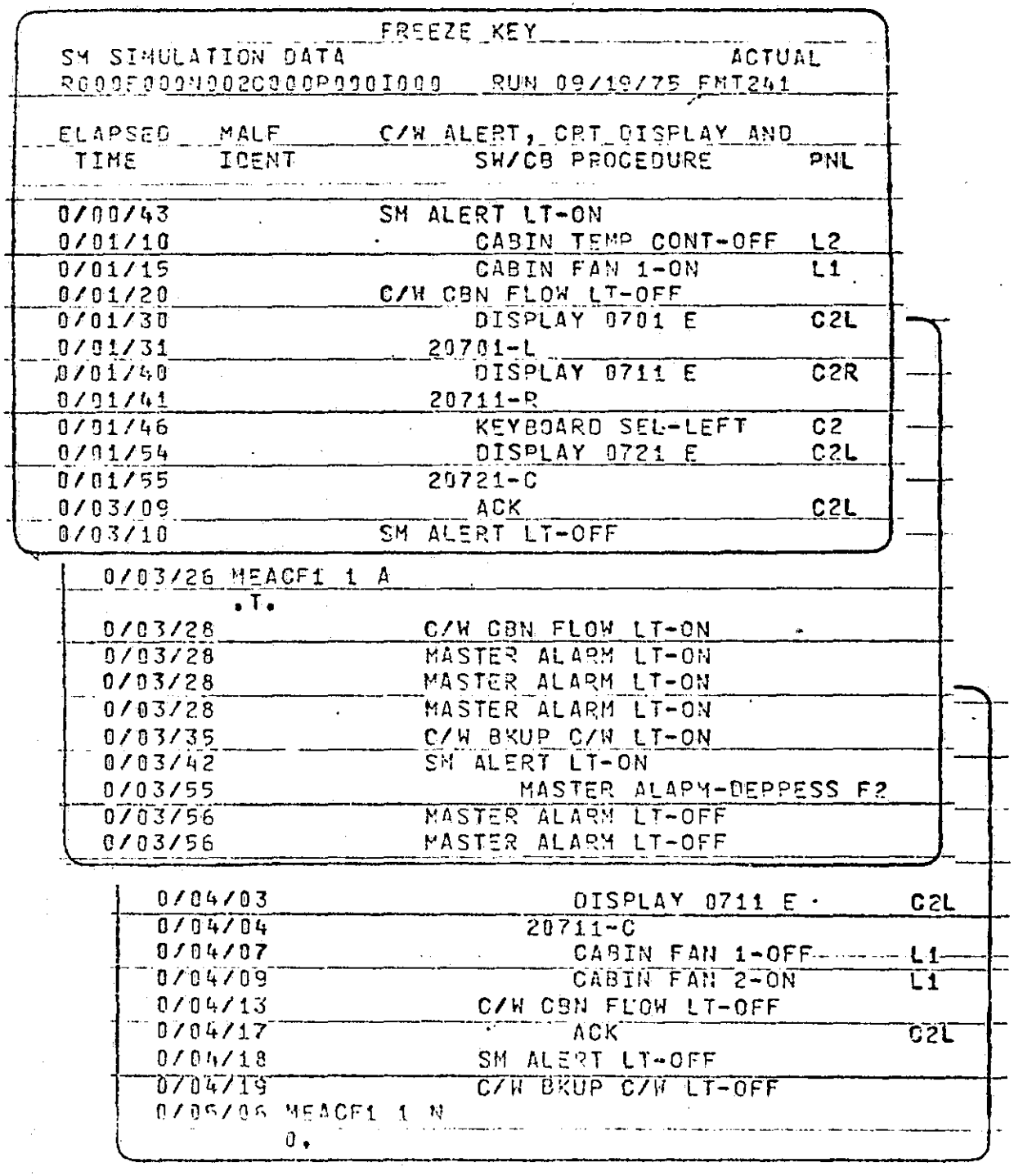
These modifications were successfully accomplished. The resulting Systems Management display format is shown in Figure 2-13. This format is currently being used by the SPS Systems Management Simulation sponsor to document crew training sessions and engineering evaluation runs on the SPS.

Crew Station Configuration Capability

The capability was designed and implemented in the PPP software to detect, on user command, and display configuration differences between the initial SPS crew station configuration and the selected reference data configuration. The capability provides rapid identification of configuration status prior to a run session, and should increase the utilization efficiency of the SPS when used.

The PPP operations to activate this capability were implemented such that (1) PPP user performs the complete initialization operations including the processing of the RUN command, (2) the SPS user performs the necessary operations to place the SPS in the OPERATE mode (initialize all SM systems), (3) the SPS is placed in the HOLD mode (no crew station switch activity should occur between OPERATE and HOLD modes), (4) the PPP user initiates the PPP command ICOMPARE. These procedures result in the automatic display of detected differences on the HOLD Configuration Difference format. The comparison of the HOLD crew station and reference state is performed. A maximum of 60 differences

Figure 2-13 Systems Management Display Format



can be displayed to the user on a total of 3 Hold Configuration Difference formats. As the crew station is configured to correspond to the reference, the 60 differences are updated. Eventually as all differences are removed, the display data indicates that no differences exist.

Develop Program BUILD

Normally the creation of an SPS data tape for PPP checkout would be accomplished by the process of PPP recording as output each data transfer received from the SPS during a real time run. This recorded output is saved on magnetic tape and can be used during a simulated SPS run as input data to the PPP. The simulated SPS capability is used for real time PPP checkout during periods when the SPS crew station is being utilized for applications other than PPP.

Because of the limited time (early in the contract) the PPP had to run with the SPS for checkout in conjunction with the Systems Management Simulation, the recording of an SPS data transfer could not be accomplished. Therefore, it was determined essential to develop an alternate approach of creating an SPS data tape to support PPP checkout. A digital computer program, BUILD, was developed which creates a simulated SPS data transfer. Program BUILD, constructs an SPS data tape containing representative performance data buffer (contains data from an actual SPS Entry Training Session) and a complete scenario of the procedures data buffer (user may specify the initial configuration, and progressively set and unset discrete signals). The program also has the capability to provide a simulated "Hold" mode with or without procedural activities during the "Hold".

This support program was initially essential and has since proven extremely valuable in support of the checkout of the PPP capabilities in connection with the Systems Management Simulation. Checkout of the PPP from the data tapes created by BUILD was so successful that the limited SPS time available for PPP checkout has resulted in minor modifications to the PPP software. In several instances, PPP has worked so well, that PPP has supported the identification of discrepancies in the SPS patching panels and software.

PPP Working Paper No. 18 presents a functional description of Program BUILD, its control parameters, and output data. Mathflows, FORTRAN source code listing, and program control cards are presented.

2.3.4 PPP Real-Time Checkout

The purpose of this task was to define and execute PPP computer program and system checkcases. The intent of these checkcases was to provide the means to checkout and verify PPP operations and the SPS/PPP interface on an integrated basis.

Check Case Preparation

PPP Working Paper No. 38 documents the detailed operations for the checkout and verification of the PPP. These checkcases were developed by modification of the original checkcases developed under the original CPDT Study. The resulting checkcases include verification and checkout of the CPDT and ACPDT capabilities. A comprehensive script of the PPP operations and SPS operations necessary to perform each checkcase was developed and documented.

A total of nine checkcases were developed. The objective of each are described below:

Checkcase No. 1: PPP CRT DISPLAY CHECKOUT - The objective of this checkcase is to verify the display format structure and to exercise display callup and manipulation by all possible methods.

Checkcase No. 2: PROCEDURES DATA TRANSFER AND DISPLAY VERIFICATION - This checkcase exercises: 1) SPS crew station input and output discrete data, 2) SPS CRT display request and response, 3) SPS control station inputs including malfunctions, and 4) PPP user console input data to verify the transfer and display of procedures data. Training data format generation is also verified by this checkcase.

Checkcase No. 3: PERFORMANCE DATA TRANSFER AND DISPLAY VERIFICATION - The objective of this checkcase is to verify the performance format generation. Performance evaluation displays data content and auto sequencing is verified along with the alphanumeric and graphical performance data displays. A secondary objective of this checkcase is to verify the generation of the summary procedures generation capability.

Checkcase No. 4: DIFFERENCE PROCEDURES VERIFICATION - This checkcase supports verification of the difference procedures capability. Hold difference, switch configuration difference, sequence difference, summary difference, and detailed difference listing capabilities are verified. The display data source selection capability is also verified.

Checkcase No. 5: DATA BASE UPDATE CHECKOUT - This checkcase verifies the PPP data base update capability and the display format construction capability.

Checkcase No. 6: RECONSTRUCTION AND OUTPUT CHECKOUT - The objective of this checkcase is to verify the display reconstruction capability for the procedures, performance, performance evaluation, and graphical performance displays. Hard-copy and magnetic tape data output capability is also verified.

Checkcase No. 7: ERROR DETECTION AND RECOVERY CHECKOUT - This checkcase verifies the detection, error display, and recovery procedures. Every user protected error is executed.

Checkcase No. 8: PPP/GDP TRANSFER VERIFICATION - This checkcase verifies the capability to create a magnetic tape of PPP displays to be transferred to the GDP, and the capability to accept from the GDP a reference procedures data tape.

Checkcase No. 9: PPP DATA ACCURACY VERIFICATION - This checkcase verifies the SPS to PPP data transfer during real-time, hold, and post-run operations.

Further details of these checkcases, and a complete understanding of the specific CPDT or ACPDT requirements verified by each checkcase are presented in Figures 2-14 and 2-15. These requirements versus checkcase coverage matrices were developed to guarantee that all requirements have been implemented and verified.

Check Case Execution

The original checkcases were developed to cover the Shuttle return sequence starting at entry interface and continuing thru landing and rollout. The existing PPP operational capability has been developed in conjunction with the Systems Management Simulation which does not provide performance data to the PPP. Therefore, a combination of real-time and simulated real-time runs were used to support checkout. The simulated runs utilize data recorded from a return sequence run made in December 1974. The simulated run allows the capability to checkout all PPP capabilities associated with performance data.

Checkcase execution proceded as expected with the identification of minor program errors. Correction and reverification of these problems is progressing concurrent with the preparation of the final report. No problems are anticipated. It should be noted that the problems that were identified were of such a minor nature that the PPP has already been put into production operations in support of the crew training and engineering evaluation sessions on the Systems Management Simulation.

2.3.5 Commercial Applicability

The purpose of this task was to re-evaluate the applicability of the PPP to the field of commercial aviation, taking into consideration the additional user interface devices (the CDC 243 Graphics Terminal and the Generalized Document Processor Terminal), and the expanded program capabilities developed since the initial evaluation performed under Contract NAS 9-13660.

Figure 2-14 Coverage Matrix: PPP Checkcase Versus CPDS Requirement

PPP REQUIREMENT \ PPP CHECKCASE	1 PPP CRT DISPLAY CHECKOUT	2 PROCEDURES DATA TRANSFER AND DISPLAY VERIFICATION	3 PERFORMANCE DATA TRANSFER AND DISPLAY VERIFICATION	4 DIFFERENCE PROCEDURES VERIFICATION	5 DATA BASE UPDATE CHECKOUT	6 PERMUTATION AND OUTPUT CHECKOUT	7 DETECTION AND RECOVERY CHECKOUT	8 BPROCS TRANSFER VERIFICATION	9 PPP DATA ACCURACY VERIFICATION	REMARKS
SECTION 2 PROCEDURES REQUIREMENTS										
2.1 Data Transferred from the SPS		1								2 & 3 specify xfer rates and techniques (not checked in detail)
2.2 Data Storage Requirements				2		1,2				
2.3 Display Capability		1				1				
2.4 Display Construction		1				2,3				
2.5 Data Manipulation						1				
2.6 CPDS Data Transfer								1,2		
2.7 Hollerith Statements		1	3							Item 2 & 4 deleted as requirements
2.8 Edit										Design/Requirements Change - Edit Deleted
2.9 Reset										Checkpoint reset not available in SPS
2.10 Checkpoint										Checkpoint not available in SPS
2.11 Cue Insertion						1				
2.12 Time					1,2					
SECTION 3 PROCEDURES FORMAT REQUIREMENTS										
3.1 Procedures Format Selection	1,2									
3.2 Procedures Format Construction	1,2				3,4					
3.3 Detailed Procedures Format	1	1								
3.4 Summary Procedures Format	1		1							
3.5 Timeline Checklist Format	1	1								
SECTION 4 DIFFERENCE PROCEDURES REQUIREMENTS										
4.1 General Requirements	1			1,2						
4.2 Data Transferred from the SPS				2						Item 1-Reset xfer not implemented in SPS
4.3 Hold Configuration Difference Requirements				1,2,4, 5,7,8						Items 3 and 6 - Checkpoint capability not implemented in SPS
4.4 Switch Configuration Difference Requirements				1-3						
4.5 Sequence Difference Requirements				1-3						
4.6 Detailed Difference Summary Requirements				1						
4.7 Summary Procedures Difference Requirements				1						
SECTION 5 DIFFERENCE PROCEDURES FORMAT REQUIREMENTS										
5.1 Difference Procedures Format Selection	1,2									
5.2 Difference Procedures Format Construction	1,2				3,4					Items 3 and 4 checkout implied by 3.2-3 and 4 operations
5.3 Hold Configuration Difference Format	1			1						
5.4 Switch Configuration Difference Format	1			1						
5.5 Sequence Difference Format	1			1						
5.6 Detailed Difference Summary Format	1			1						
5.7 Summary Procedures Difference Format	1			1						
SECTION 6 PERFORMANCE DATA REQUIREMENTS										
6.1 Data Transferred from the SPS									1-3	Note: Some data not available in SPS
6.2 Data Storage Requirements			3		2	1			3	Graphics on CDC 243 not Nordeen. Item 3-storage freq. variation not tested
6.3 Data Computation Requirements										
6.4 Display Capability			1			1				Graphics on CDC 243 not Nordeen
6.5 Performance Evaluation	1		1-3			3				
6.6 Performance Parameter Display Construction	1		1			2				Graphics on CDC 243 not Nordeen
6.7 Graphical Display Construction										Checkpoint reset capability not implemented in SPS
6.8 Reset										
6.9 Cue Insertion						1				
SECTION 7 PERFORMANCE FORMAT REQUIREMENTS										
7.1 Performance Format Selection	1,2		2,3							Item 2 graphics on 243 not Nordeen
7.2 Performance Format Construction	1,3,5		5		4					Item 4 checkout implied by items 3 & 4
7.3 Performance Evaluation Formats	2		1			1				
7.4 Performance Parameter Formats			1						2	
7.5 Nordeen CRT Performance Formats	2,3					1				Graphics on CDC 243 not Nordeen
SECTION 8 DISPLAY DEFINITION AND USER INTERFACE REQUIREMENTS										
8.1 Batch Operations										
8.2 Interactive Operations	1,4,6				2,6					Item 3 not addressed
8.3 Real-Time Operations	3,4,5	1,6	1	1,6	5	2		3		Item 1-Last two & 2 checkpoint reset not implemented in SPS. Item 7 test via DSM.
8.4 Error Detection and Recovery	2						1,2			
8.5 PGP Data Base Input	2				1,3					
8.6 User Interface Displays	1-3					2				
8.7 Display Format Standards	1	2								
8.8 Display Format Descriptions	1,2				1					
8.9 Display Format Selection	1,2,6					3,6				
8.10 PGP Output	1					1,2		1		Item 3 Calcomp plot deferred
SECTION 9 RECERTIFICATION REQUIREMENTS										
9.1 Training Script	1	2,3				4,5				
9.2 Training Status										Updated by [4.4]
SECTION 10 [illegible] REQUIREMENTS										[illegible]

Figure 2-15 Coverage Matrix: PPP Checkcase Versus ACPDT Requirement

PPP REQUIREMENTS DOCUMENT-MSC M2006-20 DECEMBER 1974-ACPDT STUDY

PPP REQUIREMENT \ PPP CHECKCASE	1 PPP CRT DISPLAY CHECKOUT	2 PROCEDURES DATA TRANSFER AND DISPLAY VERIFICATION	3 PERFORMANCE DATA TRANSFER AND DISPLAY VERIFICATION	4 DIFFERENCE PROCEDURES VERIFICATION	5 DATA BASE UPDATE CHECKOUT	6 RECONSTRUCTION AND OUTPUT CHECKOUT	7 DETECTION AND RECOVERY CHECKOUT	8 GPS/GPP TRANSFER VERIFICATION	9 GPP DATA ACCURACY VERIFICATION	REMARKS
SECTION 2 SPS DATA TRANSFER										
2.1 Procedures Data		1							1	
2.2 Performance Data										
2.3 Transfer Rates										
2.4 Miscellaneous Transfers		3								Not checked in detail Item 1-Not in SPS Item 2-Checkpoint capability not in SPS
SECTION 3 DATA MANIPULATION										
3.1 Checkpoints										Checkpoint capability not implemented in SPS
3.2 Reset										Reset to start of run only-no checkpoint
SECTION 4 CDC 211 CAPABILITIES										
4.1 Format Construction					1-3					
4.2 Crew Station Configuration Check				1						Reset not available
4.3 Display Reconstruction						1-8				
4.4 Training Data	2	1,3,4				1,5				
SECTION 5 CDC 243 CAPABILITIES										
5.1 Display Capability	1		1,2							Item 3 deleted
5.2 Format Construction					1-5					
5.3 Display Construction	1,2		3							
5.4 Display Reconstruction						1				
5.5 User Interface	1,2									
SECTION 6 GDP/PGP DATA TRANSFER										
6.1 Magnetic Tape Transfer								1,2		
6.2 Hazeltine Terminal Transfer										Requirement deferred
SECTION 7 PGP OUTPUT										
7.1 General	1,2,4					1,3		1,2		Item 5 not exercised
7.2 CDC 211 Displays						1		1		
7.3 CDC 243 Displays						1				
SECTION 8 MISCELLANEOUS										
8.1 PGP Data Base	1									Items 2-4 requirements deferred Not available in SPS
8.2 Real-Time Operations										
8.3 Batch Operations										

The original scope of this task included the continuation of the subcontract effort from United Airlines to investigate the application of the PPP to current and future airline pilot training programs. However, after several lengthy discussions involving the PPP staff, NASA and United Airlines personnel, the general consensus was that a modified task was desired.

A contract change authorization (CCA) was prepared which redefined the scope of this task. The modified task required that the PPP staff prepare and present to a technical symposium a paper describing the PPP and its application to the field of commercial aviation. A partial survey of scheduled symposiums was taken and an abstract of the technical paper contents developed. PPP Working Paper No. 24 documents the abstract.

As a result of potential program cost overruns, this task was eventually deleted by another CCA.

2.3.6 Onboard Display Reconstruction

The purpose of this task was to develop the most feasible design approach and requirements, and to provide the design and implementation plan for the necessary hardware and software to provide the capability to reconstruct the on-board CRT displays in the SPS.

The need for the capability to record and reconstruct onboard CRT displays became apparent early in the ACPDT requirements definition activities. This capability would considerably increase the efficiency of the SPS as an instruction facility, as a tool for developing crew procedures and techniques, and as a tool for engineering analysis. The increase in efficiency would result from the elimination of SPS reruns due to the inability to reconstruct a situation.

PPP Working Paper No. 32 documents the work performed relative to onboard CRT reconstruction capability for the SPS. A detailed set of requirements and the most feasible design approach are documented in the working paper.

Hardware and software design and implementation of the capability was to be the responsibility of the SPS support contractor with a target date for completion set for September 1975. The capability, however, was never implemented.

2.3.7 Applications to Other Simulators

The purpose of this task was to provide an input to the Shuttle Mission Simulator (SMS) Statement of Work (SOW) that specified the requirement for a PPP capability. Hardware and software requirements for the SMS were to be specified in order to accommodate the PPP.

ACPDT Design Note No. 6 documents the results of this task. The requirements are presented for providing the capability to use the existing crew procedures development and evaluation digital computer program, designated the PPP in conjunction with the SMS. The requirements were documented in an SOW format. The study contract technical monitor, Don Lewis, later participated in a review and verified that a capability very similar to that provided by the PPP was included in the actual SOW for the SMS.

2.3.8 PPP Demonstrations

The purpose of this task was to develop a demonstration plan and to perform actual demonstrations which would introduce the capabilities of the PPP to potential users within the Crew Training and Procedures Division and other interested NASA personnel.

Exercise No. 2 Demonstrations

CPDT Design No. No. 8 documents the Procedures Generation Program Demonstration Plan. Two exercises (Exercise 1 - PPP Operations: Procedures Generation and Performance Monitoring, and Exercise 2 - PPP Difference Procedures) were planned to demonstrate the feasibility and potential applications of the PPP. The plan was executed as part of the Crew Procedures Development Techniques Study, Contract NAS 9-13660; however, due to the unavailability of the SPS, only one session was scheduled and executed for the Exercise 2 demonstration.

Additional Exercise 2 demonstrations were performed under the Advanced Crew Procedures Development Techniques Study: The results of these demonstrations were documented in PPP Working Paper No. 17. Figure 2-16 presents the schedule and list of attendees at each of the demonstration sessions. A total of 11 people attended these demonstrations.

ACPDT Demonstration Plan

The demonstration of the expanded capabilities of the PPP developed under the ACPDT contract was scheduled for the period of 8 September thru 19 September 1975. A demonstration plan was developed and documented in ACPDT Design Note No. 11 to support these objectives. The demonstration was designed to be performed in one exercise session consisting of two parts.

Part I of the exercise demonstrated the capabilities of the combined real-time SPS/PPP system. Included was a presentation of the PPP capabilities for 1) initial crew station configuration verification, 2) PPP flight display unit, 3) SPS instructor and crew station procedural recording, 4) reconstruction of PPP generated alphanumeric formats, and 5) training script and training status display formats.

Part II of the exercise demonstrated the graphical data capability of the PPP, and utilized the simulated SPS data capability to provide dynamic data. Included was a presentation of the 1) PPP graphical data formats, 2) PPP user interface with the CDC Interactive Graphics System, and 3) reconstruction of graphical display formats.

ACPDT Demonstration Exercises

The proposed demonstration plan was successfully executed as scheduled and proposed. A total of 54 potential users and managers attended the different demonstration sessions. Figure 2-17 presents the resulting schedule and list of attendees at each session.

During final checkout of the ACPDT demonstration, it was identified that the PPP Flight Display Unit was not functioning as specified in the original PPP requirements. The ability to callup an onboard CRT format

Figure 2-16 PPP Exercise 2 Demonstration Schedule and Attendees

JANUARY 1975

SUN	MON	TUES	WED	THURS	FRI	SAT
1-12	1-13	1-14	1-15	1-16	1-17	1-18
1230 HR			DRY RUN D.L.LEWIS-CG2 PGP STAFF	W.W.HAUFLER-MDTSCO M.R.CZARNIK-MDTSCO R.T.HAMM-MDTSCO J.W.KNORI-MDTSCO	UNSCHEDULED	1230 HR
1400 HR				C.A.JACOBSON-MDTSCO S.G.PADDOCK-MDTSCO		1400 HR
1-19	1-20	1-21	1-22	1-23	1-24	1-25
1300 HR	SCHEDULED-NO SHOWS	UNSCHEDULED	D.K.MOSEL-CG2 J.T.WHEELER-AT2	UNSCHEDULED	UNSCHEDULED	1300 HR
1400 HR	SCHEDULED-NO SHOWS		D.C.SCHULTZ-CG2 D.L.BENTLEY-CG2 M.C.GREMILLION-CG5			1400 HR

Figure 2-17 ACPDT Demonstration Schedule and Attendees

SEPTEMBER

SUN	MON	TUE	WED	THUR	FRI	SAT
	1	2	3	4	5	6
7	8 1400 HR K. MANSFIELD-FE3 A. NOLTING-FE3 1500 HR M. HAWK-MDC	9	10 W. LEVERICH-EJ6 C. THOMAS-EJ6 P. ANDERSON-SINGER C. SHAFFER-SINGER D. SCHULTZ-CG2 G. SHINKLE-CG2 M. GREMILLION-CG5 K. PATTERSON-CG5	11	12 T. HOLLOWAY-CG5 D. HAMM-MDC J. WEGENER-CG2 D. MOSEL-CG2 G. GENTRY-CG5 J. BAIN-CG5 W. MUSIAL-MDC R. RUDA-MDC P. GREEN-MDC	13
14	15 1400 HR S. PADDOCK-MDC J. WALKER-MDC D. FREEMAN-MDC H. JACKSON-MDC R. ANDERSON-MDC 1500 HR W. HAUFLER-MDC W. HINTON-MDC G. BELL-MDC J. RIORDON-MDC H. BARNES-MDC A. ZOOK-MDC	16	17 P. KRAMER-EJ6 E. PIPPERT-CG5 J. McKEE-CG2 G. BOERSIG-CG2 D. BALLARD-CG2 P. COLLECTOR-CG2 S. FABER-FE2 W. WILLIAMS-FE2 J. KOLNICK-FE2 R. ZEDEKAS-CG2 C. STOUGH-CG5	18	19 C. WOODLING-FE D. WARREN-CG2 C. LEWIS-CG2 D. BENTLY-CG2 R. HOLKEN-CF5 J. MILL-CF6 A. ACCOLA-CG6 T. GUILLORY-CG5 J. COTTER-CG5 M. HOLLARS-CG5 T. CALVELLO-MDC A. JOHNSON-MDC	20
21	22	23	24	25	26	27
28	29	30				

30 October 1975

from the PPP station was not implemented. The capability to allow independent callup from the PPP station was provided in the SPS prior to the CCI (Crew Computer Interface) capability incorporation in the Systems Management Simulation. It is recommended that this capability be re-implemented.

2.3.9 User Training

The purpose of this task was to develop and exercise a PPP User Training Plan which introduces and trains potential users in the operation of the PPP.

User Training Plan

In support of PPP operational activities, a plan was developed to train potential users in the structure, capabilities, and mechanics of PPP operations. ACPDT Design No. No. 13, documents the details of this PPP training plan. The plan consists of five sessions to familiarize users with the PPP system. The PPP User Guide, MDC W0009, is used extensively to support each session.

Each training session is designed to provide the user knowledge in the use of the PPP system. The first session provides a detailed description of PPP hardware, program structure, program activation, initialization and termination operations, typical display format content, and operations associated with display format selection. Session two provides the operations to access and a detailed look at the procedures, performance (alphanumeric and graphical) and training data available during real-time and post-run activities. Session three provides details on difference procedures capabilities and operations including reference data output and difference procedures test data construction. Session four provides the operations associated with data transfers between the PPP and GDP systems. Finally, session five provides the details on user format construction and data base definition capabilities.

User Training Sessions

No formal training sessions were held during this contract. The contract Technical Monitor, however, received several hours of informal user training in the operations of the PPP. His training was obtained during the execution of the checkcases in support of PPP verification.

Section 3
CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The PPP has been developed and documented in complete satisfaction of the Advanced Crew Procedures Development Techniques contract requirements.

Demonstration of the feasibility of an automated procedures recording and evaluation digital program was accomplished under the Crew Procedures Development Techniques Study, Contract NAS 9-13660. The basic objectives of this the Advanced Crew Procedures Development Techniques Study, Contract 9-14354, were 1) to expand the initial program capabilities, 2) to provide an operational computer program to support the Shuttle Procedures Simulation, and 3) to incorporate new user interface devices which expend the capabilities of the baseline system. Successful completion of these objectives are demonstrated by current operational support the PPP is providing to the production simulation exercises of the Systems Management load of the SPS.

Development and utilization of the PPP indicates that a valuable support tool now exists for simulation, training and procedures development personnel on the SPS.

3.2 RECOMMENDATIONS

A number of new and modified requirements have been identified thru the PPP development and utilization. These requirements are currently being studied and incorporated into the PPP under separate contract. The program in its operational state is being utilized to support SPS production simulation exercise. Therefore, as the users of the PPP identify additional desired capabilities, it is recommended that they be studied and appropriate requirements implemented.

The SPS provides several different functional simulation loads (ASCENT, ENTRY, SYSTEMS MANAGEMENT, etc.). However, due to computer facility resource constraints of available core and processing time, the PPP is

is not able to run in conjunction with all of these loads. It is recommended that the SPS design be analyzed for potential reductions of core and time utilization so that a combined SPS/PPP capability may be provided for all simulation loads.

It is recommended that the PPP performance data transfer buffer be redefined to incorporate systems related data (i.e., fuel cell, propellant, and electrical power systems data).

PPP design recommendations have been established for the capability to reconstruct onboard flight CRT's. It is recommended that these requirements and proposed design be studied and implemented in the SPS.

It is recommended that the capability to access onboard CRT display formats from the PPP user console be re-implemented in the SPS.

It is recommended that activities continue on the activation of the INTERCOM software capability on the CDC 6400. Upon completion of that activity, it is recommended that PPP modifications be defined and implemented to provide direct data transfer between the GDP and PPP.

It is further recommended that the PPP, or a system with similar capabilities, be incorporated in the various simulators which support the Shuttle program development. Design evaluation, procedures development, and crew training activities on the various simulators would be more effective and useful if a procedures and performance system similar to the PPP were provided.

Section 4
BIBLIOGRAPHY

Several different documentation formats have been used to publish the progress and results of the Advanced Crew Procedures Development Techniques Study. These documentation formats and a summary of their contents are as follows:

MDC Reports - These documents correspond to the line item reports specified in the Data Requirements List of the contract. Delivery of these reports to NASA represents satisfactory completion of a major milestone of the project schedule.

Design Notes - These documents present technical information resulting from the completion of specific tasks performed on the study. They include topics concerning program verification, program development, data processing, simulation results, hardware modification, user aids, advanced techniques, commercial applications, and application to other simulators.

Working Papers - These documents represent informal publication of work as it is in progress within the PPP technical staff. Draft material documenting the development of a PPP Module or subroutine, or documentation of technical data to be exchanged among the PPP staff is published in a working paper.

Miscellaneous - Several reports required by the contract do not logically fall into any of the above categories. These include computer listings and tapes and status reports of the contract.

A complete annotated bibliography of the documentation prepared under the Advanced Crew Procedures Development Techniques Study is presented in Figure 4-1. Included in the figure is the report title, number, date of publication, list of authors, and synopsis of the contents of each of the documents written. The bibliography is subdivided according to the four format categories described above.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
MDC REPORTS			
MDC W1006 - PROCEDURES GENERATION PROGRAM REQUIREMENTS DOCUMENT	20 DECEMBER 1974	J. D. ARBET R. L. BENBOW M. L. HAWK	This document defines the computer program software requirements for the Advanced Crew Procedures Development Techniques Study version of the Procedures Generation Program. These requirements define the capabilities which are to be added to those implemented in the Crew Procedures Development Techniques version of the Procedures Generation Program. Implementation of these additional capabilities provides the desired operational Procedures Generation Program System.
MDC W0009 - PROCEDURES AND PERFORMANCE PROGRAM USERS GUIDE	29 AUGUST 1975	J. D. ARBET R. L. BENBOW A. A. MANGIARACINA	This report describes the operations required when using the Procedures and Performance Program to obtain the desired procedures and performance data output. General information on the PPP system hardware and software and detailed information on the PPP operational requirements are presented.
MDC W0010 - PROCEDURES AND PERFORMANCE PROGRAM MATHFLOW CHARTS	3 OCTOBER 1975	R. L. BENBOW A. A. MANGIARACINA J. L. McGAVERN M. C. SPANGLER I. C. TATUM	This report contains the mathflow charts for the subroutines contained in the Procedures and Performance Program. These mathflow charts represent the status of the PPP as of the completion of the Advanced Crew Procedures Development Techniques Study.
MDC W0011 - ADVANCED CREW PROCEDURES DEVELOPMENT TECHNIQUES STUDY FINAL REPORT	30 OCTOBER 1975	J. D. ARBET R. L. BENBOW A. A. MANGIARACINA J. L. McGAVERN M. C. SPANGLER I. C. TATUM	This report summarizes the work performed on the Advanced Crew Procedures Development Techniques Study. A technical synopsis, abstract, conclusions, recommendations, and annotated bibliography are included.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
DESIGN NOTES			
ACPDT DN NO. 6 - SMS REQUIREMENTS FOR PGP IMPLEMENTATION	20 SEPTEMBER 1974	J. D. ARBET R. L. BENBOW M. L. HAWK	This Design Note presents the requirements for providing the capability to use the existing crew procedures development and evaluation digital computer program, designated the Procedures Generation Program, in conjunction with the Shuttle Mission Simulator. The document presents requirements which may be inserted into the SMS statement of work.
ACPDT DN NO. 7 - PROCEDURES GENERATION PROGRAM DESCRIPTION	20 SEPTEMBER 1974	J. D. ARBET R. L. BENBOW M. L. HAWK	This Design Note describes the Procedures Generation Program (PGP) as designed to operate in conjunction with the Shuttle Procedures Simulator (SPS). Included is a functional description of the PGP user interface, the SPS/PGP interface and the PGP software.
ACPDT DN NO. 11 - PROCEDURES AND PERFORMANCE PROGRAM DEMONSTRATION PLAN	15 AUGUST 1975	J. D. ARBET R. L. BENBOW	This Design Note describes the Procedures and Performance Program (PPP) demonstration plan scheduled for the period from 8 September to 19 September 1975. The plan demonstrates the expanded capabilities incorporated under Contract NAS 9-14354. A script of the planned exercise and a proposed schedule is presented.
ACPDT DN NO. 12 - PROCEDURES AND PERFORMANCE PROGRAM DESCRIPTION	26 SEPTEMBER 1975	J. D. ARBET R. L. BENBOW A. A. MANGIARACINA	This Design Note describes the Procedures and Performance Program as designed to operate in conjunction with the Shuttle Procedures Simulator. Included is a description of the PPP user interface, the SPS/PPP interface, and the PPP applications software. This document supercedes ACPDT DN NO. 7.
ACPDT DN NO. 13 - PROCEDURES AND PERFORMANCE PROGRAM: USER TRAINING PLAN	17 OCTOBER 1975	J. D. ARBET R. L. BENBOW	This Design Note describes the PPP training plan. The document contains an overview of the contents of each training session and a detailed outline to be used as the guideline for each session.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS			
PPP WP NO. 10 - HAZELTINE INTERFACE REQUIREMENTS	4 OCTOBER 1974	J. D. ARBET	This Working Paper presents the interface requirements associated with implementing the Hazeltine system.
PPP WP NO. 12 - SOFTWARE DESIGN: GDP/PGP PROCEDURES DATA TRANSFER	22 OCTOBER 1974	M. C. SPANGLER	This Working Paper describes the top-level design of the interpretive software programs necessary to provide data transfer capability between the PPP and GDP systems.
PPP WP NO. 13 - CDC 243 GRAPHICS TERMINAL INTERFACE REQUIREMENTS	1 NOVEMBER 1974	J. D. ARBET	This Working Paper presents the interface requirements associated with implementing the CDC 243 Terminal. The terminal is to provide the user graphical displays of the performance data parameters.
PPP WP NO. 14 - CPDT: PGP REQUIREMENTS DOCUMENT DELETIONS	6 DECEMBER 1974	J. D. ARBET	This working paper details the requirements of MDC E1006 which were not implemented and are deleted. The supporting rationale for their deletion is included.
PPP WP NO. 15 - PGP FORMAT FOR SPS/SM SIMULATION DATA	28 JANUARY 1975	J. D. ARBET	The "Presimulation Report, Systems Management Simulations, Systems Management 1" document identifies a requirement and format for printout of certain simulation data. This Working Paper presents two possible PPP formats to provide the desired output.
PPP WP NO. 16 - SPS TO PPP DATA TRANSFER MODIFICATIONS TO SUPPORT SYSTEMS MANAGEMENT SIMULATION	10 FEBRUARY 1975	R. L. BENBOW	This Working Paper describes the modifications to the SPS/PPP software design and data lists necessary to support the Systems Management Simulation.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS (contd.)			
PPP WP NO. 17 - PPP DEMONSTRATION RESULTS: EXERCISE 2 - DIFFERENCE PROCEDURES	26 FEBRUARY 1975	R. L. BENBOW	The original PPP demonstration plan was executed as part of the Crew Procedures Development Techniques Study, NAS 9-13660. Due to unavailability of the SPS, only one session was scheduled and executed for the Exercise 2 - Difference Procedures Script. The results of the additional Exercise 2 demonstrations performed in January 1975 are documented in this Working Paper.
PPP WP NO. 18 - PPP DIGITAL SUPPORT PROGRAM DESCRIPTION - PROGRAM BUILD	27 FEBRUARY 1975	R. L. BENBOW	Program BUILD was developed to provide a checkout capability to support the Systems Management Simulation. This Working Paper presents a functional description of the program, its control parameters and data. Mathflows, FORTRAN source code listing, and program control cards are presented.
PPP WP NO. 19 - PRE SPS-SM SIMULATION DATA BASE UPDATE	26 FEBRUARY 1975	J. D. ARBET	This Working Paper identifies the changes made to the PPP data base to support the Systems Management Simulation. A detailed listing of the data base is presented for the Hollerith statements and difference procedures criteria data.
PPP WP NO. 20 - SUMMARY OF PPP CORE REDUCTION MODIFICATIONS	19 MARCH 1975	A. A. MANGIARACINA	The desire to meet the design goal of $20K_{10}$ words for PPP core utilization plus the necessary addition of considerable new software to satisfy additional unplanned requirements implementation in support of the Systems Management required considerable PPP core reductions. This Working Paper describes the core impact of the new requirements, action taken to reduce the core utilization, and summarizes the PPP structure.
PPP WP NO. 21 - PRE SPS-SM SIMULATION DISPLAY FORMATS	20 MARCH 1975	J. D. ARBET	This Working Paper presents the revised PPP display formats in support of the SM simulation and additional PPP requirements. Included is the PPP display format revisions, lineprinter outputs containing the background data for all display formats and the updated display tree.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS (contd.)			
PPP WP NO. 22 - PPP/ SPS-SM SIMULATION PROGRAM OPERATIONS	24 MARCH 1975	J. D. ARBET	This Working Paper presents the operational procedures required to utilize the PPP and SPS in support of the Systems Management Simulations.
PPP WP NO. 23 - GDP to PPP DATA TAPE: CREATION AND TRANSFER PROCEDURES	27 MARCH 1975	M. C. SPANGLER	This Working Paper describes the use of the Hazeltine 4000G terminal and associated tape-cassette unit for creating new procedures documents in the GDP and the procedures necessary to have the document stored on magnetic tape and transferred from the GDP to the PPP.
PPP WP NO. 24 - PPP APPLICATIONS: CONFERENCE PAPER ABSTRACT	31 MARCH 1975	R. L. BENBOW	The PPP Applications task specifies that MDTSCO prepare and present a paper describing the PPP to a technical symposium. This Working Paper documents the abstract prepared for submittal to candidate conferences,
PPP WP NO. 25 - TRAINING FORMATS	18 APRIL 1975	J. D. ARBET	This Working Paper presents a detailed description of the PPP training formats to be implemented to satisfy the ACPDT requirements presented in MDC W1006 report.
PPP WP NO. 26 - RESULTS OF PPP TIMING ANALYSIS	18 APRIL 1975	R. L. BENBOW	The SPS Resources Control Board established the design goal of 1/4 CPU time utilization for the PPP. Development activities indicated that the PPP was approaching this limit. This Working Paper documents the results of the analysis performed to determine actual CPU time utilization.
PPP WP NO. 27 - FAILURE TO REPLACE CDC 6400 COMPUTER WITH CYBER 74	21 APRIL 1975	M. L. HAWK	This Working Paper describes the advantages and disadvantages associated with several avenues which could be taken due to failure to replace the CDC 6400 with the CYBER 74.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS (contd.)			
PPP WP NO. 28 - TOP LEVEL DESIGN OF PPP GRAPHICAL DISPLAY CAPABILITY	14 MAY 1975	A. A. MANGIARACINA	This Working Paper documents the initial top level design of the CDC 243 related to PPP software. Included is the discussion of the Format descriptor definition and display construction/user interface software routines.
PPP WP NO. 29 - GRAPHICAL FORMATS	30 APRIL 1975	J. D. ARBET	This Working Paper presents the PPP Graphical Display Tree, a description of PPP graphical operations and commands, and representative graphical formats which will be used for checkout of the PPP graphical capability.
PPP WP NO. 30 - NAS 9-14354 TASKS WHICH CANNOT BE COMPLETED	20 MAY 1975	M. L. HAWK	The subject contract describes capabilities to be implemented into the PPP which depend on capabilities existing in the SPS and the availability of GFP. This Working Paper itemizes the capabilities described in the subject contract which cannot be completed and discusses why.
PPP WP NO. 31 - ACPDT REQUIREMENTS TRACEABILITY AND TOP-LEVEL SOFTWARE IDENTIFICATION	8 MAY 1975	R. L. BENBOW	A complete set of requirements for the ACPDT contract was defined and documented in MDC W1006. This Working Paper presents the requirements traceability (maping of requirements into PPP software modules) and a complete software identification chart of the PPP software.
PPP WP NO. 32 - ONBOARD CRT DISPLAY RECONSTRUCTION	16 MAY 1975	M. L. HAWK	The need for the capability to record and reconstruct the on-board CRT displays became apparent when the Crew Procedures Development Techniques Study was initiated. This Working Paper summarizes the work done on on-board CRT reconstruction capability for the SPS. The recommended SPS design approach is documented.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS (contd.)			
PPP WP NO. 33 - TOP LEVEL DESIGN OF PPP TRAINING DATA CAPABILITY	13 JUNE 1975	M. C. SPANGLER	This Working Paper documents the top level design of the PPP software which satisfies the Training Data Requirements. Included are: 1) a requirements traceability matrix, which identifies specific routines to satisfy each requirement, and 2) an in-depth discussion of the routines. The information presented for each routine is of sufficient detail to guide the development of the detailed design and software implementation.
PPP WP NO. 34 - MINUTES OF SPS COORDINATION MEETING: 13 JUNE 1975	17 JUNE 1975	R. L. BENBOW	This Working Paper documents the PPP staff understanding of the topics discussed, the conclusions reached, and resulting action items of the 13 June 1975 SPS/PPP Coordination meeting.
PPP WP NO. 35 - PPP CAPABILITIES DESCRIPTION	30 JUNE 1975	J. D. ARBET	This Working Paper was prepared at the request of NASA to supply a brief description of the PPP capabilities. The contents of this Working Paper were incorporated into the SPS Development Plan document.
PPP WP NO. 36 - DATA BASE UPDATE	8 JULY 1975	J. D. ARBET	The SPS crew station changes and the addition of PPP training and graphical format capabilities require revisions and additions to the PPP data base. This Working Paper documents the current data base.
PPP WP NO. 37 - TRAJECTORY PROGRAM INTERFACE WITH PPP	21 JULY 1975	A. A. MANGIARACINA R. L. BENBOW	A preliminary study was performed to investigate the techniques and preliminary interface design of the PPP with a non-real time trajectory program. The results of that analysis is documented in this Working Paper.
PPP WP NO. 38 - ACPDT PROGRAM VERIFICATION AND CHECKCASE DEFINITION	8 AUGUST 1975	J. D. ARBET	This Working Paper documents the checkcases to provide total checkout and verification of PPP operations and the SPS/PPP interface on an integrated basis.

Figure 4-1 Bibliography of Advanced Crew Procedures Techniques Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
WORKING PAPERS (contd)			
PPP WP NO. 39 - PPP PERFORMANCE DATA ERROR DETECTION CAPABILITY: PROGRAM ENTRY	29 AUGUST 1975	I. C. TATUM	This Working Paper documents the support computer program developed to explore the PPP/SPS Simulated Run data file to isolate bad performance data values.
PPP WP NO. 40 - PPP PERFORMANCE DATA ERROR CORRECTION CAPABILITY: PROGRAM DOTHIS	29 AUGUST 1975	I. C. TATUM	This working paper documents the support computer program developed to correct bad performance data values found in the PPP/SPS simulated data files.
PPP WP NO. 42 - PPP PROCEDURES PROCESSOR UPDATES FOR A SPS CREW STATION RECONFIGURATION	10 OCTOBER 1975	J. L. MCGAVERN	This Working Paper describes the contents of the procedures data transfer and the necessary parameter tables that must be derived to respond to an SPS procedures data transfer update. The methods used in monitoring the procedures run data are also discussed.
PPP WP NO. 43 - PPP TRAINING DATA FILE GENERATION	22 OCTOBER 1975	I. C. TATUM	This Working Paper documents the digital computer support program, PGPTRFI, that was developed to generate typical training data files for checkout of the Training Data Format capability.
MISCELLANEOUS			
ADVANCED CREW PROCEDURES DEVELOPMENT TECHNIQUES PROGRESS REPORTS - NUMBER 1 TO 15	MONTHLY		These reports summarize the progress of the work effort each month. A brief summary status of the technical work accomplished during the reporting period is discussed.
PROGRAM LISTING	31 OCTOBER 1975	A. A. MANGIARACINA	This is a computer listing of program instructions of the Procedures and Performance Program.

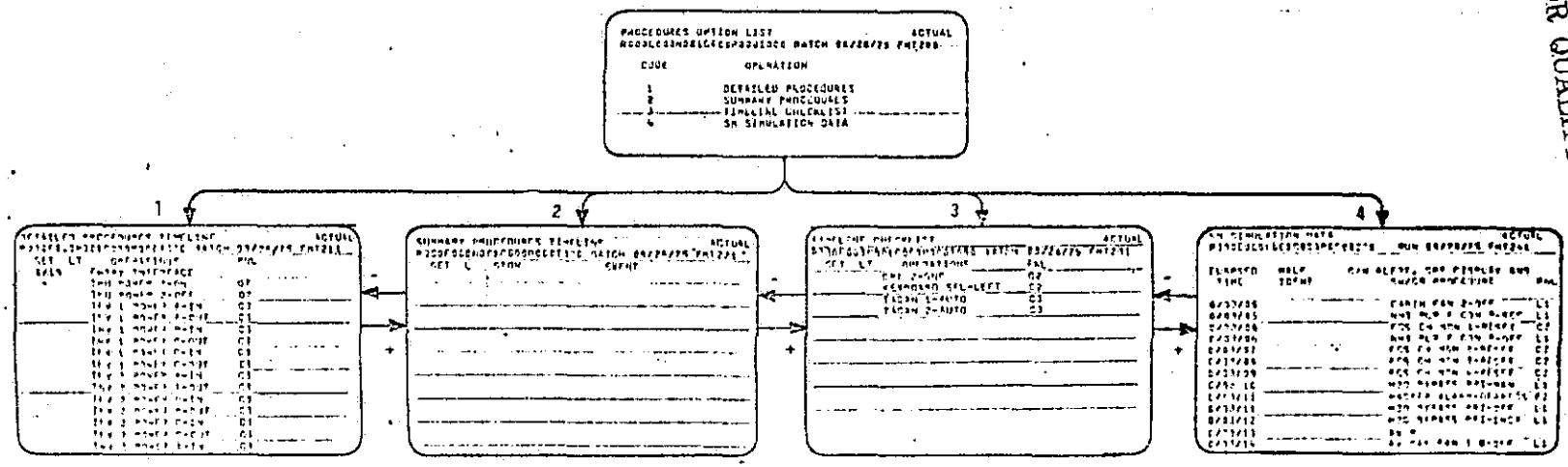
Figure 4-1 Bibliography of Advanced Crew Procedures Technique Study Documentation (continued)

DOCUMENT-TITLE	DATE	AUTHOR	SYNOPSIS
PROGRAM TAPE	31 OCTOBER 1975	A. A. MANGIARACINA	This is a computer listing which documents the common block parameters within PPP. The name, dimension, common block location, and definition of each parameter in PPP is presented.
SUMMARY OF NEW TECHNOLOGY REVIEW ACTIVITIES REPORT	5 SEPTEMBER 1975 (ANNUAL) 30 OCTOBER 1975 (FINAL)	R. L. BENBOW	This report provides information reflecting the activities in complying with the New Technology Clause. This was an interim report, and a final report is in preparation concurrent with this report.

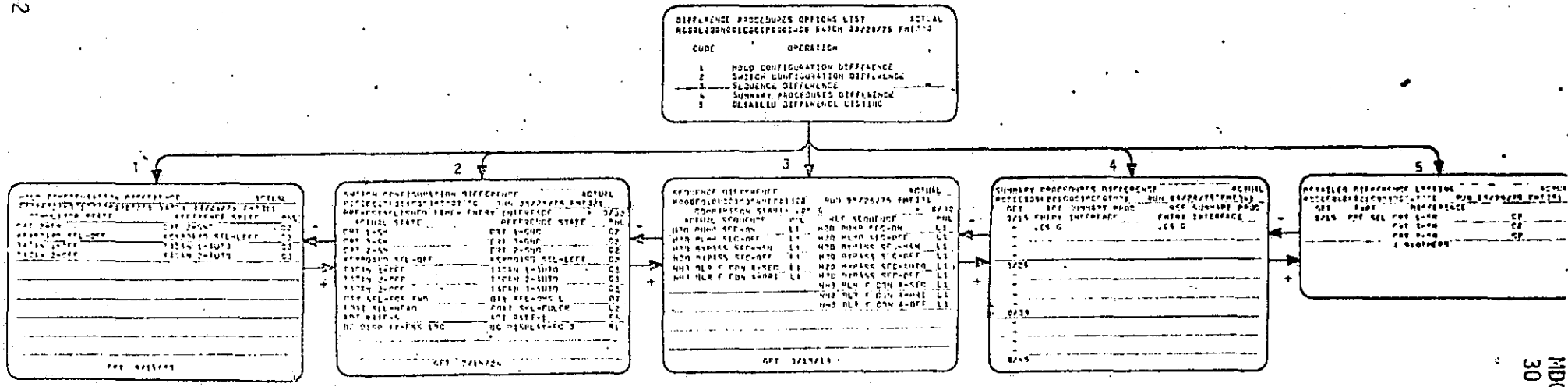
APPENDIX A

FORMAT DATA OUTPUT

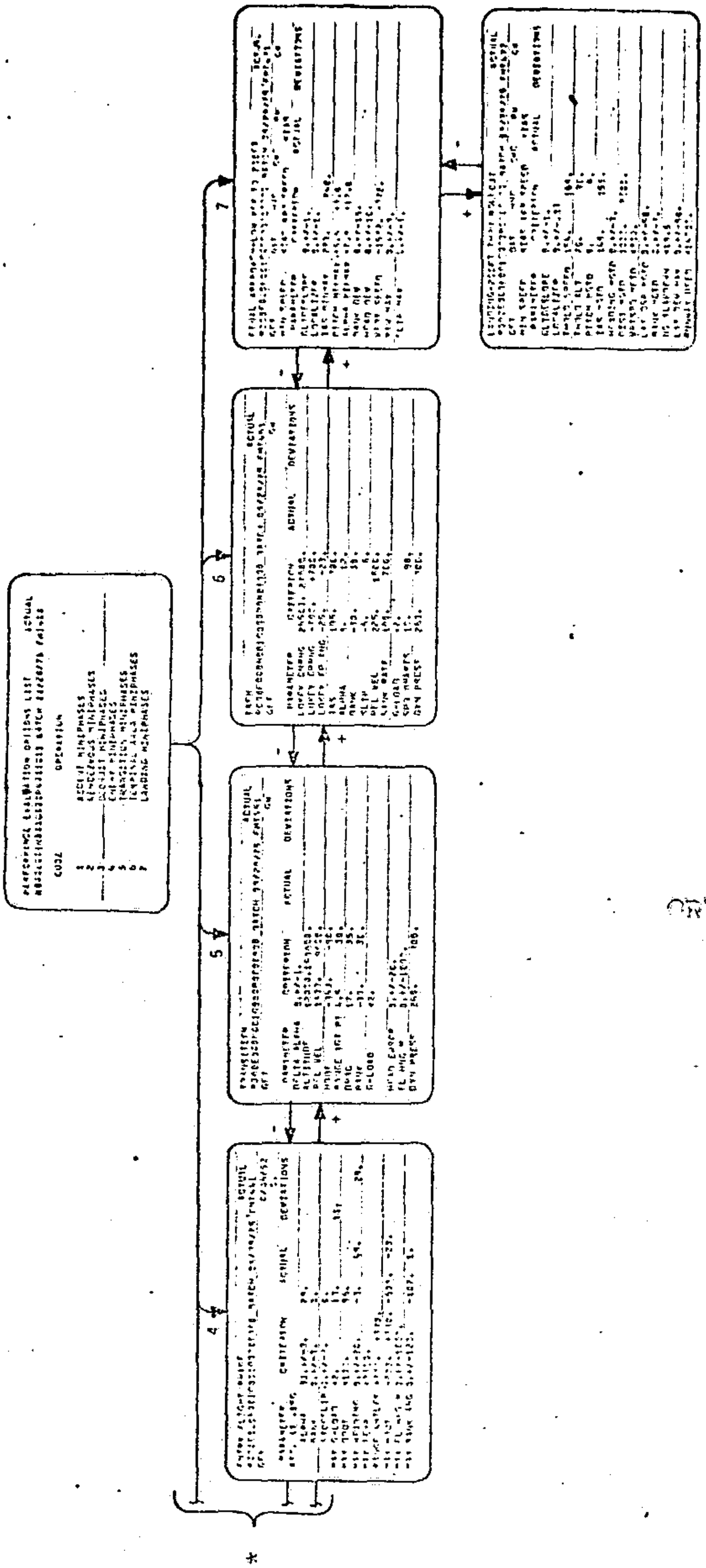
A.1 PROCEDURES DATA OUTPUT



A.2 DIFFERENCE PROCEDURES DATA OUTPUT



A.3 PERFORMANCE EVALUATION DATA OUTPUT



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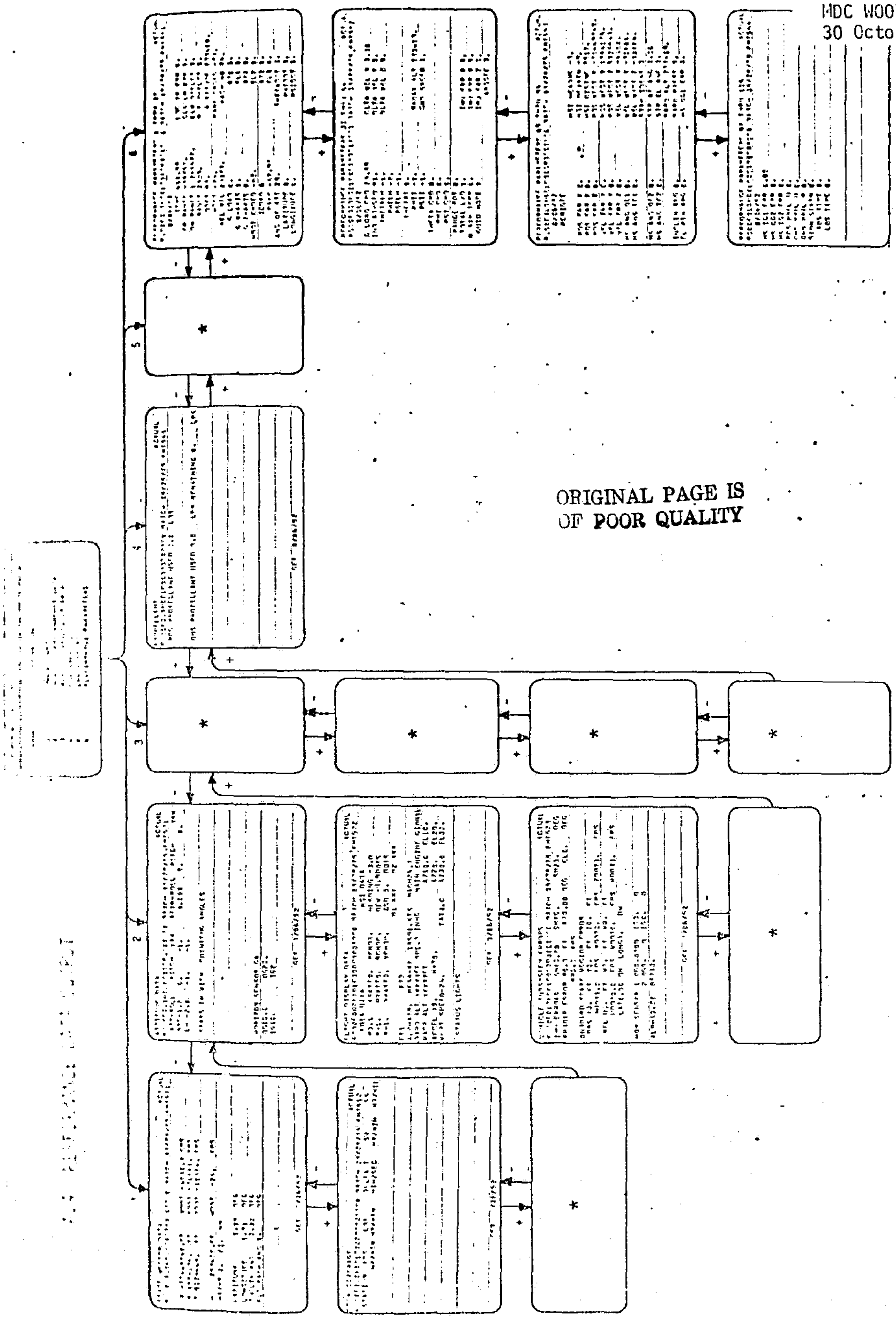

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A.5 TRAINING DATA OUTPUT