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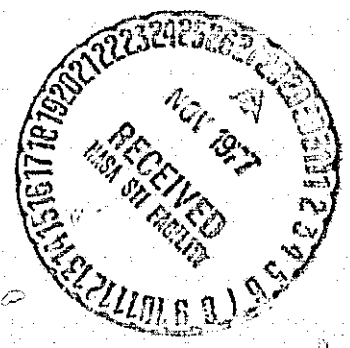
(NASA-CR-151531) FLIGHT DESIGN SYSTEM
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FLIGHT DESIGN SYSTEM
REQUIREMENTS EVALUATION PROGRAM
FINAL REPORT

October 7, 1977



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Flight Design System Requirements Evaluation Program

Final Report

NASA CONTRACT NAS-9-14350

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1. Task Background

The Mission Planning and Analysis Division (MPAD) of NASA is responsible for developing flight plans, performing flight design, for all manned space flights. Flight Design is the selection or development of time lines for vehicle trajectories, attitudes, and consumable usage. With the advent of the Shuttle Transportation System (STS), studies have shown that the flight design procedures and support software used for earlier programs (Gemini, Apollo, Skylab and ASTP) are not adequate to support the much higher flight rates anticipated with the Shuttle Program. In addition, the planning environment must be standardized to a degree not achieved in the past.

A review of the flight planning tasks indicate the need for new concepts for performing the flight design function. A computer based system is needed that exhibits the following characteristics:

- o Interactive computations
- o Multiple concurrent user support
- o Useable by a variety of skill levels
- o Data Base interface
- o Launch-through-Landing flight design capability
- o User control over system function sequences
- o Independence of individual computational processors via standardized and generalized interfaces
- o Independent concurrent development of major components
(processors)

A NASA/IBM effort developed a comprehensive user interface technique and dialogue which in turn helped to establish detailed user requirements for such a system. This system is designated the Flight Design System II (FDS-II).

Recent advances in computer technology have produced small computers (mini's) having many of the capabilities of the older, larger general purpose computers. As a cost effective measure, NASA determined that this new technology should be evaluated as a candidate host for FDS-II. Subsequently, IBM was given the task of evaluating the FDS-II requirements in this area.

2. Task Objectives

The objectives of this task were to support NASA/MPAD to:

- 1) establish a technique for a computer based, time shared, interactive flight design system based on the accepted FDS-II user interface.
- 2) implement selected portions of the technique as a bench program (FDS-I) to establish a base for evaluation of FDS-II requirements
- 3) use FDS-I to provide an objective evaluation and refinement of FDS-II requirements.

3. Task Approach

The general task approach was to analyze flight planning requirements, define a candidate computer system architecture that supports presently defined user/computer dialogues, implement various components of the dialogue and provide objective evaluations of, as well as suggest refinements to, the requirements for the proposed FDS-II. To accomplish this task, four sub-tasks were established that could be easily monitored. Each task had a defined deliverable product.

3.1 Subtasks

3.1.1 Architecture

The goals of the architecture subtask were to:

- 1) Define a candidate architecture for a GFE mini-computer system consistent with published FDS-II computational and user dialogue requirements,
- 2) Assist NASA in prioritizing the components and functional elements of the architecture for development by identifying those elements necessary to evaluate FDS-II requirements.

The purpose of the architecture is to evaluate FDS-II Level A and B requirements, prior to Level C requirements definition.

3.1.2 Design (Executive PDL)

The design subtask was to produce program design logic consistent with the prioritized functional elements of subtask 3.1.1. This design was restricted to the FDS Executive portion of the architecture. NASA personnel were to implement applications derived from existing flight design computer programs.

3.1.3 Implementation (Executive Code)

The implementation subtask was to implement the designed program elements of subtask 3.1.2 on the specified GFE computer and assist NASA in evaluating FDS-II requirements.

3.1.4 Analysis (FDS-II Analysis)

The analysis subtask was to document recommendations for FDS-II computer system requirements resulting from the FDS-1 development experience. Recommendations were to cover basic hardware, operating system, system support software, and applications executive design.

3.2 Schedules

The FDS Requirements Evaluation Program task was active from November 29, 1976 to October 1, 1977. (The final deliveries were accomplished on October 7, 1977.) A schedule by subtask is presented in Figure 3-1.

3.3 Status Reviews

To maintain comprehensive communications between NASA and IBM during the course of the task, bi-weekly on-site status reviews were held. A documented status report was presented by IBM to NASA at each of the 19 meetings. The reviews covered the following areas:

- 1) Administrative
- 2) Configuration Control
- 3) Financial

3.3.1 Administrative Status

Each subtask was addressed as required in terms of current status, outstanding issues, and immediate as well as overall schedules.

3.3.2 Configuration Control

A mechanism was established and used by which problems and/or desired modifications would be reported for hardware, delivered software, and published documentation. A two function form (FDS Problem - Deviation - Query Form (PDQ)) was developed by which a problem, change, or query could be both described and answered (see figure 3-2). All logging of PDQ's and the coordination of their disposition was accomplished through a close interaction between designated NASA and IBM coordinators. The use of the PDQ forms provided visibility and a

		1976		1977							
NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT
ST1	3 ▲ Architecture						10 ▲			19 ▲	
ST2	Executive PDL						30 I ▲		31 II ▲		7 III ▲
ST3	Executive Code						30 I ▲		31 II ▲		7 III ▲
					ST 4	FDS-II Analysis			12 ▲		
									Final Report		7 ▲
	I = Delivery I of the bench program										
	II = Delivery II of the bench program										
	III = Delivery III of the bench program										

FDS Requirements Evaluation Program - Schedule

Figure 3-1

FDS PROBLEM-DEVIATION-QUERY FORM

1. ORIGINATOR NAME / ORGANIZATION / PHONE / DATE

PDQ NO. _____

2. TYPE: PROBLEM - H/W , S/W , DOCUMENT
 DEVIATION - NEW , REVISION
 QUERY -

3. DESCRIPTION OF REQUEST / PROBLEM

ORIGINAL PAGE IS
OF POOR QUALITY

4. NASA COORDINATOR - NAME / PHONE / DATE

5. IBM COORDINATOR - NAME / PHONE / DATE

6. REPLY - ACTION TAKEN

7. PROGRAMS /
DOCUMENTS
ADDED / MODIFIED

8. RELEASE NO.

9. CLOSED BY: NAME / PHONE / DATE

10. DISPOSITION

REJECT

11. CLOSED BY COORDINATOR - NAME / PHONE / DATE

IMPLEMENT

Figure 3-2 PDQ Form

historical record of problem areas, design/requirement changes, and items for future consideration. Open PDQ's were discussed at the bi-weekly status reviews.

3.4 Financial

Total funding of the task was from two sources. The majority of the funds were RTOP funds with supplemental funds coming from DTMO.

Funds budgeted and spent are summarized below:

RTOP FUNDS	113,900
DTMO FUNDS	<u>23,000</u>
TOTAL	136,900
EXPENDITURES	<u>128,000</u>
REMAINING	8,900

Total manhours expended = 4,400

4.0 Task Results

The objectives of the FDS Requirements Evaluation Task were to design a computer technique accomplishing interactive Flight Design and to implement sufficient code to determine the feasibility of the design. These objectives were achieved with the planned output of the four sub-tasks. The MPAD's Hewlett Packard 21 MX mini-computer and associated peripherals were used as the development computer for the task.

4.1 Architecture Subtask

The result of the architecture subtask was the design of a system consisting of two classes of program:

- 1) A library of applications processors, each designed to do a specific flight design computational or analysis function.

2) an FDS executive that provides the following capabilities:

- o Concurrent use of the system by multiple independent users
- o User communications with the system, both executive and processors
- o Ability to execute the applications processors, individually or in a sequence
- o Communications between processors
- o Data management and retention of data from one terminal session to another.
- o Flexibility to easily extend system capabilities through the addition, modification or deletion of processors

As the design effort progressed, the following executive software functional areas were defined:

Multiple Tasking and Management

- o Configuration Manager (dynamic system configuration)
- o FDS Manager (dynamic data management and processor sequencing)
- o Attention Functions (Asynchronous program status and control)
- o System services (program to program communications)

Executive Primary Functions

- o Terminal Communications and Lexical Analysis
- o Interface Table Editor (processor input/output definition)

- o Sequence Table Editor (specification of processor execution sequences)
- o Execution Controller (automatic processor sequencing)

The output product of the architecture subtask was the generation of section 6.2 of the FDS-I System Design Document entitled, "System Architecture and Executive." This documentation was delivered to NASA on December 3, 1976 and subsequently updated to keep it current with the actual implementation.

4.2 Design (Executive PDL) Subtask

As the architecture phase of the task matured into the design phase, seven of the eight functional software areas defined in 4.1 resolved into 44 program modules. To date, the Sequence Table Editor functional area has not been implemented. Before coding each routine, a complete detailed design was developed using the Program Design Language (PDL). Each design was then reviewed by at least one other member of the task. By keypunching the PDL statements on cards and utilizing a batch program (PDLIST), a structured PDL listing was generated for each program. These listings constituted the design documentation for each program and were the deliverable output of the FDS-I system, i.e., Build I (6/30/77), Build II (8/31/77), and Build III (10/7/77).

4.3 Implementation (Executive Code) Subtask

The implementation subtask was the mechanization of the design for each module into executable code. Both FORTRAN and assembler

language were used in the task. Of the 44 modules, 15 were coded in assembler language and 29 in FORTRAN. In total, 4848 lines of PDL and 9249 source lines were generated. Each module was unit tested by the originating programmer. As the modules were integrated into a system, comprehensive independent verification was performed at the system level. A complete set of program listings and disk files containing all of the source, relocatable, and executable code was delivered for each incremental system delivery.

4.4 Analysis (FDS-II Analysis) Subtask

After the first increment of FDS-I had been coded, tested, and delivered, several discussion sessions involving all task personnel were held in order to consolidate ideas on requirements for FDS-II.

Topics covered were:

- o Hardware
- o Operating System
- o System Support Software
- o Documentation
- o Executive Design

Recommendations were gathered for each function and each was assigned a relative importance, i.e.,

- 1) Mandatory
- 2) Necessary for reasonable development
- 3) Highly Desirable
- 4) Desirable

The resulting document was published and distributed to NASA on August 12, 1977.

4.5 Related Task

In order to take advantage of the program modules implemented under this task, a companion task (Flight Planning System Development) was performed concurrently. This task developed additional support and utility software. The combined outputs of the two tasks together with applications software developed by NASA will result in a system capable of supporting interim operational Flight Design until FDS-II is completed.

5. Future Considerations

Items for future consideration include refined and extended requirements identified during the implementation phase of FDS-I and items identified in the FDS-I design, but due to prioritization of components, were not implemented during the FDS Requirements Evaluation Task. Yet to be considered are:

- 1) Batch Execution - the capability to schedule a job to be run in the background asynchronously with the interactive FDS.
- 2) Mixed Formats - the capability of supporting user defined data arrays containing a variety of data formats, e.g., integer, double precision, character data, etc., that occur in predefined fixed patterns.

- 3) Extended Prompts - a capability whereby a user may, at any point in his dialogue with the system, request additional tutorial information by entering a simple request, e.g., a ? symbol.
- 4) Sequence Table Editor - the capability for users to generate and maintain tables in which a series of processor execution commands are stored. This provides the users with the capability of storing and executing standard sequences of commands as logical entities, i.e., standard flight phases.
- 5) Semi-Automatic and Automatic Mode - the execution of series of processors using all or part of specified prestored sequence tables.
- 6) Utility Processors - a set of processors that allow the user to accomplish on-line storage allocation, basic mathematic computations, execution sequence control, message outputs, and parametric data generation.
- 7) Job Accounting System - the capability for FDS to automatically collect and store statistical information about the usage of of the system, length of terminal session, CPU usage, I/O frequency, etc.

6. References

6.1 Documents used as input data for the task

- 1) Flight Design System-I, System Design Document Volume 1, Section 3, "User Interface," April 19, 1977, NASA/MPAD, IN 77-FM-19.
- 2) Flight Planning System II - Level A Requirement for Flight Design System (FDS), August 10, 1976, IBM, MIB-01, W. A. Young.
- 3) Task Order - FDS Requirements Evaluation Program, November 23, 1976, NASA/MPAD, TIRF No. 2924.
- 4) Task Order - FDS Requirements Evaluation Program, May 18, 1977 NASA/MPAD, TIRF No. 2927.

6.2 Documents resulting from task performance

- 1) FDS System I Status, IBM, R. W. Turner produced on the following dates:

12/03/76	2/11/77	4/08/77	6/03/77	7/29/77
12/17/76	2/25/77	4/22/77	6/17/77	8/12/77
01/14/77	3/11/77	5/06/77	7/06/77	8/26/77
01/31/77	3/25/77	5/20/77	7/15/77	9/09/77
				9/23/77

- 2) Flight Design System I, System Design Document, Volume IV, Section 6, "System Architecture and Executive," December 3, 1976 and July, 1977, NASA/MPAD, IN 77-FM-18.

- 3) Flight Design System -2 Requirements Recommendation,
August 12, 1977. IBM, RES 55-1-39
- 4) Proposed FDS-I Schedule and Build Content, March 21, 1977
and July 15, 1977, IBM, Briefing.
- 5) FDS-I Fortran Coding Hints, March 25, 1977, IBM, Briefing.
- 6) Complete set of PDL listings, program listings, disk files
of source, relocatable and executable code and operational
notes for each of three system deliveries.

Build I = June 30, 1977

Build II = August 31, 1977

Build III = October 7, 1977