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TECHNICAL ADVISEMENT MEMORANDUM NO. 171-7

ONBOARD CHECKOUT AND DATA MANAGEMENT SYSTEM (OCDMS) PREFERRED COMPUTER MANUFACTURER-SUPPLIED SOFTWARE

PRC D-2001

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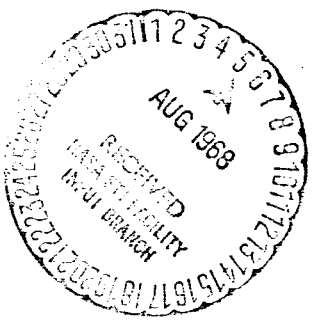

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TABLE OF CONTENTS

REFERENCE

1. PRC D-1180, Technical Advisement Memorandum No. 171-5, "Onboard Checkout and Data Management System (OCDMS), Computer Selection Criteria," 25 August 1967.

I. GENERAL

Software motivated criteria for selection of a computer for the Onboard Checkout and Data Management System (OCDMS) has been established and reported by PRC Technical Advisement Memorandum No. 171-5, reference 1. Major areas of selection concern dealt with the compatibility with OCDMS operating concepts, the availability of manufacturer-supplied software and the cost implications of supplementing that software. This memorandum expands on the results of this analysis relative to the latter two areas, and identifies the computer program components (CPCs) which are preferably obtained from computer manufacturers.

In general, these CPCs will be characterized as highly machine-dependent, and usually classified as general purpose. The programs and routines that fit this category include the following:

- Assembly Programs
- Loader Programs
- Diagnostic Routines
- Computer Utility Programs
- Simulation Programs

The manufacturer-supplied software is expected to become for the most part functional elements of the OCDMS Support System. However, certain CPCs may have application within the Supervisory System, and may be separately treated because of computer-orientation rather than OCDMS-orientation. This will most likely be the case if the same computer serves both as the on-line and off-line processor.

This memorandum summarizes the software support currently provided by the two main contending manufacturers for the OCDMS computer, IBM Corporation and Litton Industries. A subsequent section then discusses the preferred CPCs.

II. MANUFACTURER-SUPPLIED SOFTWARE

A. IBM Software Support

Computer programs are supplied with the Model EP computer to enable system programmers to transform their problem definitions efficiently and rapidly into computer programs. Included in the software package are:

- Symbolic Assembler
- Compiler
- Mathematical Subroutines
- Utility Programs
- Diagnostic Programs

The symbolic assembler converts an assembler language program into a machine code program. The assembler language is a set of mnemonic symbols which represent machine operation codes and operations to be performed by the assembler program. The language is augmented by other symbols, supplied by the programmer, that are used to represent storage addresses and data. The assembler provides auxiliary functions that assist the programmer in checking and documenting programs, in controlling address assignment, in data and symbolic definition, in generating macro-instructions, and in controlling the assembler itself.

Decimal, binary, hexadecimal, or character representation of machine language binary values may be employed by the programmer in writing source statements.

The Model EP addressing structure requires the designation of a base register and a displacement value in specifying a storage location. The assembler assumes the clerical burden of calculating storage addresses in these terms for the symbolic addresses used by the programmer. The programmer retains

control of the base register usage and the values entered herein, thereby providing a relocatable feature.

The language also provides for partial control of the assembler output by the programmer; he may identify the assembly listing and designate how much detail is to be included in the assembly listing. The source program is analyzed for errors and detected errors are indicated in the assembly listing. The resultant object program is then processed by the relocatable loader and executed on the Model EP computer.

The Model EP compiler converts source langauge programs into machine language compatible with the real-time operation of the computer. The source langauge is P/I. The object program is produced in relocatable code. Complete control of output formatting is provided. Source language error detection is performed and diagnostic messages provided to simplify debugging. The compiler provides Boolean algebra as well as conventional arithmetic statement capabilities.

Some trigonometric subroutines have been programmed in detail to provide storage and execution time for use in Model EP application programs. The functions which have been completed are sine, cosine, tangent, and arctangent. The routines have all been coded as closed subroutines and made extensive use of the general purpose registers. If all used registers are saved, the routines are re-entrant; only one copy of each need be in storage for all usage.

A library of utility programs are provided with this computer. Included will be a relocatable loader, input data conversion, and storage dump.

Two types of diagnostic programs are provided, functional test programs and fault location programs. The functional test programs are designed to exercise every possible computer

circuit in a worst-case binary pattern using each computer instruction. Various parts of the computer are exercised in a progressive manner. Fault location programs are used in conjunction with the computer support equipment to isolate failures.

B. Litton Software Support

Litton has developed an entire software package for its airborne computer systems. Because the computer development paralleled the software development, there is also available programs which may be run on IBM System 360 commerically available equipment. Included in the software package are:

- Assemblers and Interpreters
- Operational Simulation Programs
- Service Programs
- Utility Programs
- Fault Isolation Programs

The assembler system is similar to IBM assembly language program, and, indeed, there is a version for execution on an IBM System 360. In addition to the assembly programs, an IBM 360/L-304 Interpreter Simulator is included in this package.

The Operational Simulation Program consists of subprograms that include:

- Correlation and association routines
- Tracking program
- Navigation program
- Universal load program
- Post processor (data edit)

The service programs include:

- Mathematical subroutines
- Debugging aids
- I/O control
- Conversion routines
- Supervisor routines

Utility programs are divided into three main sections:

- Pre-processor routines
- Post-processor routines
- Simulation control routines

The fault isolation support programs consit of two sets:

- Logic sort programs
- L-304 Micro-op Simulator (on System 360)

In addition to the above set of Software Support Programs, Litton has developed a set of computer programs referred to as Hardware Support Program. These consist of:

- Computer Tests
  - Instruction tests
  - Interrupt tests
  - Memory tests
- Peripheral Diagnostics
  - Controls
  - Card reader diagnostics
  - Card punch diagnostics
  - Printer diagnostics
  - Magnetic tape diagnostics

III. PREFERRED PROGRAMMING APPLICATIONS

The software support elements available from IBM and Litton for their respective machines are par as far as can be established without performing machine tests or actual execution evaluations. Furthermore, it is not likely that more analysis would indicate any significant difference. In the event that either machine is selected for the OCDMS application, the complete software package summarized in the preceding section should be supplied in conjunction with the computer procurement.

However, there is in each case of the computer in question, a considerable potential for use of certain application-oriented CPCs. The Litton L-304 airborne computer system is used in an integrated man-machine system. Functional activities include automatic detection acquisition, identification, and tracking of targets; reporting and display of target information; and control of interceptors.

Specifically, the L-304 computer and software system is responsible for the following actions which have an obvious parallel to certain OCDMS applications:

a. Maintaining within its memory a current and readily accessible digital description of all tracks (orders and track reports).
b. Filtering and correlating data reports on geographical area, track identifier, track-versus-report coordinates, track description, and track quality.
c. Servicing all input and output buffers in an optimum manner.
d. Satisfying control and display functions as initiated by operator-controlled equipment external to the computer.
e. Monitoring and controlling orders.

f. Maintaining ownship position via inputs derived from analog navigation devices.

g. Controlling select interceptors' flight paths as directed by the console operator.

h. Monitoring system performance and performing diagnostic recovery actions.

On the other hand, the IBM 4π-EP computer has been selected for the Air Force MOL Program. This application uses dual-computer systems in a redundant fashion for control and communication operations with both the experimental Laboratory Module and the Mission Module. Thus, the mission objectives are very similar to S/AA, and in many respects, then, the OCDMS software development will be comparable.

For example, IBM is currently developing an Executive Control System and Operational Utility Program to be used in conjunction with the Data Computation Subsystem Group (DCSG) On-Orbit Software. This group of programs will initiate, sustain, and terminate the execution of operational programs similar to the OCDMS Supervisory System. It also provides for the orderly handling of the information and control interfaces between programs and Laboratory Vehicle Subsystems and for a set of programs to supply basic mathematical services to other programs.

Comparisons have been made between the Part I Specifications for OCDMS and the DCSG Executive Control System (ECS). Although similar in many general considerations of system executive routines, memory management, and centralized input/output, some significant functional differences exits. The ECS concepts relegate a number of functional activities identified as supervisory control functions for OCDMS. These include:

- Provision for on-line language statement interpretation;
- Communication facilities for a Control Display Unit;
- Compatibility with existing hardware/software systems for uplink and downlink communication;
- Command, control, list process, and data compression techniques for implementing data management functions;
- Buffer provision for data handling when communication is restricted between the spacecraft and ground stations;
- Man-machine adaptive behavior by query and response and other techniques;
- Dynamic program linkage and communication by other than system macro-instructions;
- Monitoring and exceptional condition handling for difference between "actual" and "predicted" response profiles.

As the design and implementation subphases of the OCDMS and DCSG On-Orbit Software acquisition proceeds, these differences will undoubtedly lead to considerable variation in performance and design characteristics. No exact determination, of course, is possible unless actual machine tests or operational simulations are performed.

The point of the above discussion is to explicitly indicate that significant advantage may be gained by having manufacturer-supplied software not only contains the standard software support packages, but also to include other application-oriented CPCs. The selection of these CPSs, however, must be supplied on a basis of exact qualifications to perform necessary functions. Qualification tests should verify

that proper performance will be obtained. The procuring agency should review procedures and audit results of critical demonstration tests which as a minimum should include:

a. System compability: All computer program components (CPC's) shall be tested for proper program linkage and operation of the functional hardware units.

b. Man-machine relationships: Particular emphasis shall be given to qualifying the man-machine compatibility, and the adequacy of the man-machine to fulfill the mission requirements.

c. Simulated environment: Emphasis shall be given to simulating the most adverse conditions possible for the computer and other OCDMS hardware elements during demonstration of the application-oriented CPCs.

The activity to develop quantitative measures for selection of the OCDMS computer and associated software has been a joint MSFC/PRC effort. In the process of doing this, the relative importance of manufacturer-supplied software packages has been established. These are listed below in order of their relative importance.

(1) Diagnostic Routines

(2) Supervisor Subprograms

- Input/Output Communication
- Interrupt Management
- Schedule Management
- Memory Management
- Language Processing
- Job/Task Management
- Data Management
- Program Test and Verification
- Program Production

(3) Assembly Program
(4) Debugging Aids
(5) Compiler
(6) Job Management Routines
(7) Task Management Routines
(8) Data Processing Routines
(9) Simulator Programs
(10) Mathematical Routines