ADVANCED MEDIUM SCALE REAL-TIME SYSTEM

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ABSTRACT

The requirement for real-time decisions during flight testing of Helicopters at Edwards AFB, and remote test sites has placed a tremendous burden on the telemetry processing system. The Telemetry Processor not only has to have sufficient computer power to give real-time data read outs for the test conductor to make these decisions, but also must be portable to support remote sites.

This type of support normally requires two distinctly different systems. The one system for remote support would be a small computer controlled system that digitizes the data, formats all data to digital tape, and gives some limited quick look capability. The data processor would be a large batch processor centrally located in a laboratory, where the digital tapes are returned and the data processed into a meaningful format for the Test Conductor. This does not allow for very many real-time decisions at remote sites, while tests are being conducted.

This paper describes the Real-Time Data Acquisition and Processing System (RDAPS) which EMR is delivering to the Army for quick look and processing of the data at remote sites. This is a computer controlled Telemetry System that is portable, while having sufficient power to convert all data (up to 50K word rate) to engineering units, and process and display on CRT's and in graphic form selected parameters that are essential for in-flight decisions. This same system will be used to process all of the data between maneuvers and after a flight. Two identical systems support two tests simultaneously.

BACKGROUND

The United States Army Aviation Engineering Flight Activity (USAAEFA) was formed in 1960 to perform flight test evaluations of Army aircraft. It is located at Edwards Air Force Base, California, about ninety miles north of Los Angeles, in the Mojave Desert. Although the complexity and quantity of work has increased through the years, the mission remains basically unchanged. It is to plan and conduct airworthiness qualification flight tests of air vehicles which are proposed, developed or procured for Army application, or which incorporate advanced concepts having potential military application. This necessitates the production of quantitative test data on aircraft performance, stability and control, vibration, and stress analysis.

As with most groups chartered to conduct flight test programs, USAAEFA has made a continuing effort to modernize airborne instrumentation and data reduction systems. The early airborne systems were oscillograph recorders with a mix of transducer inputs. Transcription of data from the oscillograph trace to tabular form was a post flight process accomplished by hand reading. Limited computer analysis was performed.

In a large scale commitment to improving all aspects of data collection and processing, USAAEFA acquired new airborne and ground-based systems in 1969. Updated transducers, signal conditioners, PCM and FM encoders, magnetic tape recorders, and telemetry transmitters replaced the oscillograph airborne systems. To enhance data reduction, a permanent telemetry front end/computer installation was made at Edwards Air Force Base, and three mobile telemetry front end/computer vans were procured for work away from Edwards. These facilities were almost identical and provided the next logical step for data analysis capability.

For the first time, the flight test analysis personnel could monitor real-time data through the use of the telemetry link. This capability was primarily used for safety of flight work, and took the form of strip chart output of key parameters, with some minimal amount of real-time analysis by computer. Much larger quantities of data could be ingested expeditiously, and analysis performed using that data could be done effectively. A measurable increase in accuracy was also achieved.

Although updating the scheme of data collection and reduction in 1969 was obviously warranted and worthwhile, some basic advantages from the flight test engineering standpoint were lost. Control of the data analysis process by flight test engineering personnel became diluted by transferring the bulk of data processing to a newly formed data systems entity. The flight test community could not afford to invest the manpower required to educate personnel as both systems analysts and flight test engineers, and therefore they were forced to become indirect users of the data system. New and sometimes wasteful concepts of data processing developed as a result. Since tabulation of data was automated and large quantities of data were available with minimal flight test personnel effort, the practice of requesting large quantities of unnecessary data as insurance against omission of desired information became common. Since the system was actually a general-purpose computer with an interface to a telemetry front end, data analysis routines tended to be customized to the operational concepts of the flight test personnel involved in a particular program. As a result, the data system routines must be altered constantly to meet new requirements. Although these problems are somewhat controllable through management, they are a result of the flight test personnel having too little understanding and control of the system. Attempts to correct this situation through operational system changes have been made without much impact.

Design Concept for this System

In 1977, USAAEFA began an investigation into the possibility of replacing the previous system due to the age and lack of growth potential. A number of general guidelines for the investigation were established by management. Choice of a replacement system should be the responsibility of a five-man committee, with three members coming from the flight test user groups. An architecture should be chosen which would not utilize hardware or software capabilities considered to be “pushing the state-of-the-art”. Data acquisition systems used by other Government agencies and major airframe manufacturers supplying Army aircraft should interface to the system. This would include a multitude of PCM and FM systems with data rate requirements to 50,000 samples per second. Primary input sources would be magnetic tape and L-band or S-band telemetry. Intermediate results and unnecessary outputs should be minimized, with the intention of saving manpower and reducing data analysis turnaround time.

Definition of Optimum System

A comprehensive investigation of part USAAEFA data processing and flight tests was conducted in an attempt to define the optimum data processing system. Every effort was made to avoid confusing desires or habits with true functional needs. Concurrent with this in-house investigation, tours of other flight test facilities were made, and discussions with suppliers of such systems were held. By an integration of the facts and ideas derived from all of these input sources, the following general system characteristics began to develop:

- The system should be a flight test engineering tool, with the flight test engineer in control of the data analysis process through real-time system interactivity.

- It should reduce manpower required for basic operation to one flight test engineer and one telemetry technician.

- Man-machine conversation should be via graphic CRT’s in aero engineering terminology for the flight test engineer and straight-forward systems language for the telemetry technician.

- Real-time analysis should emphasize display of analytical results rather than raw data, in an effort to complete all processing requirements, including hard copy output, during the flight test mission.

- Summation of data types.

- All system configuration information should be stored on system files for rapid setup of a particular flight test mission. This should include a library of flight test analysis routines.

- The system should provide user logs for review by management to maximize system productivity.

- In a non-flight test mission support situation, the system should perform as a time-share system, capable of normal computer work. This should include interactive program and plot development.

Focal Point of System Design: Engineering Interaction

As these desirable characteristics were examined in detail, one stood out as the focal point for the system design. This characteristic was that of tailoring the system to be an aero engineering tool. It soon became apparent that a major shortcoming of the present telemetry/computer system was a lack of user involvement. The old-fashioned oscillograph data acquisition system with manual reduction of data (previously mentioned) offered direct control of analysis by the engineer, and to this day has a loyal following for this reason. If the new telemetry/computer system were to offer this control, a number of real-time interactive/display capabilities would be required:

- A display in engineering units of a selected number of measurement parameters must be available continuously for monitoring and directing flight profiles.

- Parameters exceeding predetermined safety-of-flight limits must be flagged by the system and displayed to the engineer immediately.

- Time history presentations of selected measurement parameters from a maneuver must be available on demand after the maneuver is finished.

- The system must provide the capability for producing multiple plots in various output formats of data analysis, and include extrapolation of curve fits for test point build-up.

- A capability to overlay plots from previous flight test missions for comparison must exist.

- Dynamic alteration of plot scales must be available.

- A high-quality hard copy output for CRT presentations must be available on request, with little or no impact on the dynamic update of the screen.

- The system must be capable of storing, for review, all measured parameters passed through any compressor, and statistical data must be computed using these same measured parameters.

Man-Machine Interface

It was felt that the capabilities of the system must be controllable in a straight-forward manner to guarantee acceptance by flight test personnel. In an effort to provide the greatest degree of flexibility for the user and yet minimize setup time, a system of menus were selected as the primary man-machine interface. The telemetry operator must provide all necessary information for the basic system configuration through a menu process controlled at his CRT. Once this basic configuration is complete, control of the system will be turned over to the flight test engineer and he will proceed in specifying all data analysis requirements for the test mission via menu selections on his CRT. Both of these resulting menu specifications are stored on system files to be recalled for selective editing to meet future test mission system configurations. Frequently used functions, such as CRT hard copy, reset of limit checks, selection of CRT presentations, and plot scale changes, must be provided at a single key stroke via a special function keyboard. The engineer must be able to revert to his configuration menu during a flight test without re-starting the system. All files are to be appropriately noted, and the flight test continued upon exit from the menu. As previously mentioned, all menus and system prompts are to be in a straight-forward terminology with the complexity manual entry for an appropriate response minimized. After proceeding through the flight test mission using the available system resources, the engineer will have completed all the necessary data analysis for that test.

SYSTEM DESCRIPTION

Simply stated, the actual system which resulted from this definition incorporates all of the features which have just been described. More than most other real-time telemetry/computer systems in existence, this one provides the combination of pre-processor and processor power required by a flight test organization, while emphasizing the man-machine interface for control of the equipment and display of meaningful data as it occurs.

The system can be considered in three sections:

1. Telemetry Acquisition Subsystem, powerful and versatile yet comfortably within the state of the art, and

2. Pre-processing Subsystem, a unique combination of hardware devices to take repetitive tasks off the computer, and

3. Computer Subsystem, using a large and powerful “super-mini” and a variety of peripheral storage and display devices.

The Telemetry Acquisition Subsystem accepts PCM or FM data from an aircraft or tape, merges it with time, and prepares it for entry into the Pre-processing Subsystem. Control of this subsystem is accomplished by the operator from the keyboard or from previously-stored setup files.

Special equipment in the Pre-processing Subsystem has the ability to merge separate data channels and time, to perform compression algorithm testing on any measurements, and to discard meaningless or redundant words. Interesting data is output to the computer in raw form, or is converted to engineering units in the hardware pre-processor, or is compiled into arrays for hardware spectral analysis.

An unusually versatile Computer Subsystem processes important data in real time and displays the results for the Flight Engineer and the Telemetry Operator. The former has graphics display, time, events, strip charts, and a plotter/printer. The latter includes graphics, time, and status lights. In addition, maneuvers of up to 10 minutes duration at maximum data rate can be stored on a disk and replayed for analysis. Also, data can be archived on an output tape for off-line analysis.

TELEMETRY ACQUISITION SUBSYSTEM

The Telemetry Acquisition Subsystem is composed of data routing, data receiving, data recording, timing, PCM data, FM/analog data sections, and communications, as shown in Figure 1. The data routing section is structured around a 40 x 40 microprocessor-controlled switching matrix which provides flexibility for system configuration, and setup control from the computer. Appearing as inputs on the switching matrix are: communication input, analog tape unit inputs, time code translator input, PCM bit synchronizer input, the multiplex for the FM discriminators inputs and auxiliary analog inputs for the analog-to-digital converter. Appearing as outputs from the matrix are the receiver output, time code generator output, analog tape outputs, communications output, PCM simulator output, FM calibrator outputs, and the serial output from the analog-to-digital converter. The matrix has several spare inputs and outputs for future expansion.

The RF section contains a discone antenna and receiver. The discone antenna covers the RF signal range of 1435-2300 MHz. The receiver has a 4 MHz IF amplifier, an L-band tuner and S-band tuner with a maximum often pre-selected frequencies in each band. The receiver also includes a spectrum display unit.

The data recording section contains two 14-track analog tape recorders. One of the recorders may be selected by the telemetry operator, and specific time intervals located for playback by the tape search unit. Start and stop times are computer or front-panel controlled, as is the operating mode.

The timing section includes a time code translator, tape search unit and time code generator. Imbedded time in the PCM data stream is stripped out and used to preset the time code generator via the program control setup bus. This generated time or recorded time from the analog tape recorder is merged with the data streams. Several outputs are generated by the time code equipment; parallel time data is routed to the engineering units converter to be merged with the data. A slow code is output to the strip chart recorder. Time is displayed on the front panel of the time code equipment and at the remote Flight Engineer Station. Time is also presented to the search unit for the control of analog tape recorders. The telemetry operator controls the selected “pre-set start” and “pre-set stop” times for tape search, and all operating modes via the tape search unit. The time code generator also provides a serial carrier IRIG A, B, or C code output suitable for recording on the analog tape recorder when the system generates a tape.

The PCM section contains a bit synchronizer, frame synchronizer, simulator, data distributor and 24 digital-to-analog converters (DAC’s). For the main data path into the telemetry preprocessing subsystem, the appropriate signal (receiver output or tape output) is selected at the switching matrix for input to the bit synchronizer. The bit synchronizer obtains bit sync, reconditions, and outputs the signal along with clock to the frame synchronizer. The frame synchronizer obtains frame/subframe sync, performs serial-to-parallel conversion, and outputs parallel data through two output ports. One outputs all data to the telemetry pre-processing subsystem; the second outputs selected data to the digital-to-analog converters. The frame synchronizer is capable of handling data formats with variable word lengths.

The data distributor accepts the selected data along with appropriate timing signals from the frame synchronizer, and selects data words for specific digital-to-analog converters or discrete outputs for display. The digital-to-analog converters may accept raw data from the data distributor or scaled data from the computer. The outputs of the digital-to-analog converters are input to strip chart recorders via a patch panel. To perform subsystem testing, the PCM simulator generates simulated input signals. All units are programmed from the computer, and can operate at input rates up to 5 megabits per second.

The FM/analog section is composed of twenty subcarrier discriminators, two reference discriminators, twenty tunable analog filters, two calibrators, and a programmable multiplexer-encoder. The subcarrier discriminators are divided into two groups, ten channels of PBW and ten channels of CBW. They provide the demultiplexing and conversion of the FM signals to analog for strip chart recording and digitizing. The discriminators also have interchangeable channel selectors and low pass filters that provide the versatility to meet the requirements of varied systems and demodulation formats. The reference discriminators compensate for errors that might be induced in the data discriminators by tape recorder wow and flutter errors. Outputs from the subcarrier discriminators are connected directly to twenty tunable analog filters. These filters condition the analog signals that are fed to the multiplexer-encoder, and to the strip chart recorders via the patch panel. The two five-point frequency calibrators help to set up the FM subsystem.

The multiplexer-encoder accepts the analog data inputs performs time-division multiplexing, and converts the data to equivalent parallel and serial PCM data streams. The encoder digitizes the analog data to 12 bits at rates up to 400K samples per second. The digital words are then input to the telemetry pre-processing subsystem. The multiplexer-encoder and FM calibrators are programmed from the computer.

PRE-PROCESSING SUBSYSTEM

The Pre-processor Subsystem, shown in Figure 2, contains an EMR 715 Engineering Units Converter Unit, a CSPI Array Processor, and interfaces to the computer. This subsystem is unique in concept and greatly improves the total system processing power and throughput capability. The Engineering Units Converter performs several functions normally accomplished in the computer. By performing these functions in front, it removes much of the load on the computer.

The Engineering Units Converter (EUC) accepts up to six streams of parallel digital data, ID tags each parameter, and merges time every millisecond. Each parameter may have a different algorithm applied, depending on the EUC programming. This may be a compression algorithm and/or an EUC algorithm. Conversion may be linear, non-linear or table look-up, and may be preceded or followed by a compression algorithm. Each sample of converted data (a floating point number with tag and time) is output to one or more of the three output ports. Discrete data may be checked for bit changes and passed, or may be passed without a check. This allows the EUC unit to select and distribute selected data to different locations in the memory of the computer, relieving the computer of the burden of sorting data. Port three outputs selected data, tag and time for real-time displays, port two outputs all data for the time history file, and port one outputs selected data to an external buffer memory for the array processor.

The EUC unit accepts data with different numbering systems: straight binary, 2's complement, discrete, binary coded decimal, and sign-magnitude. The maximum throughput rate is 100K words per second to 400K words per second (dependent on the algorithm mix). Algorithms are microcodeable. The unit has input and output FIFO's that allow burst data at higher rates than this throughput limit.

The Engineering Units Converter also builds arrays in an external buffer memory for the array processor. The buffer memory will double-buffer 28 arrays of 1024 words per array.

The array processor is a CSPI MAP 200, programmed from the computer prior to test initiation. During a flight test maneuver, the array processor reads arrays from the buffer memory, performs spectral analyses, and outputs the results to the VAX upon command. During non-real-time operation the computer builds arrays from the time history file and feeds them back to the array processor for spectral analysis.

The MAP 200 uses bipolar integrated memory with a 125 nanosecond cycle time and MOS memory with a 500 nanosecond cycle time. The arithmetic unit performs 32-bit self-nomalizing floating-point mathematical operations.

The host interface is the processor through which the MAP 200 and the VAX 11/780 computer communicate. It performs three functions: (1) It transfers blocks of data between VAX memory and MAP memory. (2) It transforms data formats between the VAX and MAP to make them compatible. (3) It provides control lines through which VAX may initiate data transfer for loading programs initially, and for performing certain diagnostic routines, and to bootstrap-load the MAP. It also provides control ports that allow the VAX to control the MAP processor or permit the MAP processor to interrupt the VAX computer.

The interface between the telemetry acquisition equipment and the VAX 11/780 computer is comprised of five EMR 760 Universal Data Channels. These are high-speed, bidirectional, direct-memory-access channels. Each channel has two 16-bit parallel data input ports and one 16-bit parallel data output port, and interfaces to the Unibus of the computer.

One of the channels accepts the real-time display data, tag, and time from port three of the Engineering Units Converter and generates a “current-value-table” (CVT) in the computer memory. The tag is used to address a specific memory location to insert the data in memory. By using this mode of operation, the CVT is updated with the most recennt data value for processing. A second channel accepts all EU data, tag, and time from port two of the Engineering Units Converter, and triple buffers the data in computer memory. The buffer lengths and location are determined at setup, and the channel is programmed accordingly. This data generates the “time history file” in the computer. The third channel loads and verifies the Engineering Units Converter memory, while the fourth reads time to the computer under software control. The fifth channel reads telemetry front-end status into the computer. This is used to verify proper setup and operation of the telemetry equipment.

The output ports of two of the channels are used to setup and control the Telemetry Acquisition Subsystem.

COMPUTER SUBSYSTEM

The Computer Subsystem, shown in Figure 3, features a Digital Equipment Corporation VAX II/780 high-performance multi-programming computer. The VAX combines a 32-bit architecture, efficient memory management, and a virtual memory operating system to provide essentially unlimited program address space. The 11/780 has 1.256 megabytes of MOS memory and 8 kilobytes of cache. It also contains a powerful instruction set of 243 instructions that include integral decimal, character string, and floating point instructions. VAX has an integral memory management system, sixteen 32-bit general registers, and 32 priority interrupt levels. There is an integrated console subsystem which consists of an LSI-11 microprocessor with 16K bytes of read/write memory and 8K bytes of ROM to store the LSI diagnostic, the LSI bootstrap, and console routines. The console uses a floppy disk for the storage of basic diagnostic programs and software updates, a terminal , and a remote diagnostic port. A Floating Point Accelerator (FPA) is included to increase processing speed. The FPA is an independent processor that works in parallel with the main processor to execute the standard floating-point instruction set. While the FPA is executing, the processor can be performing other operations.

Communication among the main processor, main memory, and peripheral devices is performed over the Synchronous Backplane Interconnect (SBI). The SBI is the primary control and data transfer path in the computer; it is 32 bits wide and has a transfer rate of 13.3 megabytes per second. Unibus and Massbus devices are connected to the SBI via special buffered interfaces called adapters. Two Unibus adapters are provided for the system to minimize the activity on any given bus. The pre-processed data is transferred into the computer from the Telemetry Pre-processor via Unibus number one, processed, and output over Unibus number two. This increases total system throughput rate over what it would be with one Unibus handling both input and output.

A disk system with a storage capacity of 67 megabytes is provided to store system software and picture data to be hardcopied. The disk has a peak transfer rate of 1.2 megabytes and operates on the Massbus which has a transfer rate of 2.0 megabytes.

Two digital tape recorders, 125 ips, 800/1600 bpi , and a 600-card-per-minute reader are interfaced through Unibus number one. These are used in non-real-time setup, so they do not affect the throughput rate.

Two 300 megabyte disks are located on Unibus number two; these are used to store the time history file. These disks provide a peak transfer rate of 1.2 megabytes/second.

Two operator stations are interfaced to Unibus number two; “The Telemetry Operator’s Station” and “The Flight Engineer’s Station” (see Figure 4). The Telemetry Operator’s Station consists of an operator’s control panel with a time display panel, a strip chart and antenna control, and the Megatek Inc. Megraphic 7000 Vector Graphic System. The primary function of the Telemetry Operator’s Station is to perform the general setup and control of the telemetry front end during configuration of the system for use by the flight test engineer. This is accomplished via the operator’s control panel and the Megatek CRT keyboard.

The “Flight Engineer’s Station” consists of an engineer’s control panel, Megraphic 7000, CRT hard copy unit, and strip chart recorders. The control panel is made of 40 function keys, time display, patch panel, and strip chart control. The function keys initiate or stop designated processing routines within the system. The graphic system is interfaced to the Unibus by two RS-232 and one DMA interfaces (see Figure 4). This allows quick release of the screen for hard copy, and both terminals can operate as standard system terminals. The 7000 contains a 21" (diagonal) electromagnetic deflection monitor, organized with the origin (0,0) at the center and a range of -2048 through +2047 for each axis. The X and Y coordinate axes may be redefined in user units, and the origin may be translated under program control by the user. It may have up to 32 sub-pictures, each of any complexity. Each may be individually manipulated or modified. The screen origin and range for each picture may be defined in user units. The hard copy device may be used as a printer/plotter or to obtain a hard copy of either CRT via a function key command. Any discrete output or analog output may be selected via a computer as an input to one of three strip chart recorders. The Flight Engineer’s Station provides the flight engineer with the capability to control all analysis and display results of real-time analysis.

The station has the capability to display any type of data or computer results, but in a working format where speed of the presentation is the most important factor.

OPERATING SYSTEM

The operating system is VAX/VMS (Virtual Address Extension/Virtual Memory System). The function of an operating system is to manage the system's available resources. VAX/VMS is a multi-user, multi-processor operating system. To accommodate multi-processing, main memory must be shared by more than one process. Therefore, memory is a fundamental resource requiring allocation, deallocation, and associated management. The memory management utilized by the VAX operating system is known as virtual memory. Virtual memory refers to the concept that a program's location in main memory is transparent to the process. Additional features of the VAX-11 virtual memory scheme are:

- Only a portion of the program (those pages which are being actively referenced) need reside in main memory during execution.

- Programs (processes) are allowed to exceed the maximum amount of main memory available.

The VAX/VMS provides a complete program development environment. In addition to the native assembly language, it offers the optional high-level programming languages commonly used in developing scientific and commercial applications: Fortran, Cobol, and Basic. It provides the tools necessary to write, assemble or compile, and link programs, as well as to build libraries of source, object, and image modules. The VAX/VMS includes two programming environments:

- The native mode programming environment
- The compatibility mode programming environment

This system utilizes both programming environments,for this application.

SETUP AND APPLICATIONS SOFTWARE

The application software will be primarily written in VAX-11 FORTRAN, with isolated interfaces written in VAX-11 MACRO assembly, for real-time speed and efficiency.

The application software is organized into three software groups - Telemetry Operations, Flight Test Operations, and Mission Utilities.

The Telemetry Operations software provides the operator with full interactive menu and prompting interfaces needed in order to perform initial front-end compilations and setups, calibration and setup files, and to perform front-end checkout with simulated data. In addition the operator will be provided with the capability to initiate telemetry data acquisition and monitor the data being received from the telemetry front-end equipment.

The Flight Test Operations software primarily provides full high-speed interactive service to the Flight Test Engineer's Terminal, as well as monitoring support. The Flight Test Operations software receives data from the calibration file and the Scientific Data Base and allows the test engineer to conversationally edit, or recall, the Project File. When ready, the operator may then execute the mission performing real-time derived parameter calculation, limit and slope checks, all while generating Time History File and outputting Sequential Plot Displays, TAB Data Displays and Headers. Concurrent with the above tasks, computed output may be recorded on the electrostatic printer/plotter, strip chart, command log output (CLOG), and PLOT File.

The Mission Utilities software provides peripheral support to the operations that must be performed before, during, and after a flight test. This includes: Front End Setup File and Calibration File creation and update, Scientific Data Base generation and update, EU Time History File Editor, and EU Time History File Archival.

DATA FLOW OVERVIEW

The Application Software receives instruction from the Telemetry Operator and Flight Test Engineer on how to set up the telemetry front end and, subsequently, how to properly process data. A pictorial overview of the Application Software data flow is presented in Figure 5.

An interactive conversational capability is provided between the system software and the users. The purpose is to provide a Telemetry Operator and Flight Test Engineers with mission-oriented dialog, such that it is not required for the user to be a computer specialist, but instead to be only proficient in his discipline.

Using nested menus (e.g., Flight Test Menu) and answering prompted questions, the Telemetry Operator and Flight Test Engineer establish the Project, Front-End Setup and Calibration Files, and envoke command functions that determine modes of operations and processing.

In operation, front-end data is filtered by EMR front-end hardware, where it is scanned for data pertinent to currently envoked functions and then appropriately processed by the Telemetry Operations, or Flight Test Operations, software.

Input data to the Flight Test Operations software is provided by the front-end hardware data stream, the Scientific Data Base (for comparisons and cross plots) and in a playback mode from the engineering units Time History File.

Output data is provided as displays (of headers, plots, menus, etc.), printer plots (of current displays), strip charts, printer (CLOG), 936 plot tape, and the EU Time History File.

Display Software

There are three primary types of displays for viewing processed data; two each Megatek 7000 Graphic Displays, three eight channel Brush Recorders, and one Printer/Plotter. The graphics software that supports the two Megatek 7000's is a multi-user system. The application program interfaces with the graphics through Fortran subroutine calls.

The Megatek CRT's display the following information simultaneously during a test:

- System Status
- Headers
- Limit or Slope Violations
- Plots

The system presents the following status information to allow both operators to evaluate the state of the system. Information available to operators includes:

- Time: hours, minutes, seconds.
- Mode of operation: playback from disk, simulation, or data (analog or telemetry)
- Disk recording of data.
- Data being written to CVT.
- Maneuver number of the test.
- Setup: in progress, completed, or in error mode.
- Loss of PCM synchronization.

The flight engineer can display up to 10 parameters, measured or derived, in the header portion of his display.

The flight engineer's screen will also include warnings of limitor slope violations. Space is reserved on the screen for 4 violations, after which the plot portion of the screen will be overwritten.

The flight engineer may also obtain either sequential plots or crossplots. Sequential plots involve plotting data against time at a once-per-second rate as the data is obtained. Cross plots are plots of an average of a parameter against time or against another average during a maneuver. Cross plots may be viewed between maneuvers or at the end of a flight.

The software that drives the Brush recorders will take data from the CVT, including derived parameters, reformat the data from floating point, and send the data to the EMR 713 Word Selector. The analog outputs of the word selector are fed to the recorders. This function is used during data acquisition and non-data acquisition modes.

There is an off-line program run by the telemetry operator to calibrate the recorders prior to initiating the applications software to calibrate the recorders via the word selector.

The printer/plotter is used as a hard copy device for the CRT's. The software for hard copy is initiated by a key on the CRT keyboard. This function releases the picture on the screen to be hard copied on the printer/plotter.

The system is modular in design, and flexible enough to allow expansion with minimum cost to the Army. This along with its present processing power assures the Army of being able to meet its requirements in data collection and reduction for years to come.

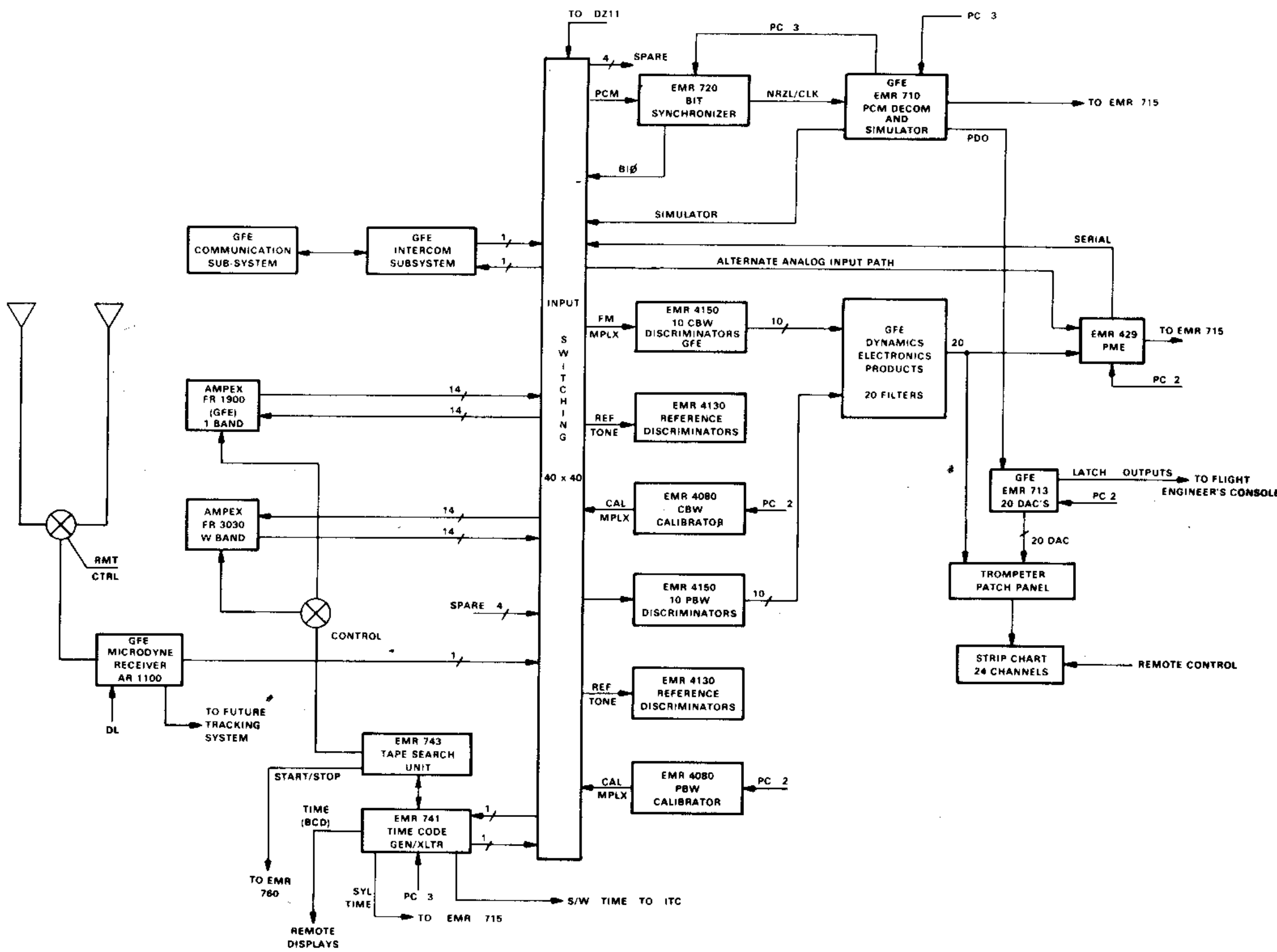

TO DZ11
SPARE
PC 3
EMR 720 BIT SYNCHRONIZER
NRZL/CLK
GFE EMR 710 PCM DECOM AND SIMULATOR
TO EMR 715
PDO
PCM
BIØ
SIMULATOR
SERIAL
ALTERNATE ANALOG INPUT PATH
GFE COMMUNICATION SUB-SYSTEM
GFE INTERCOM SUBSYSTEM
INPUT SWITCHING 40 x 40
FM MPLX
EMR 4150 10 CBW DISCRIMINATORS GFE
GFE DYNAMICS ELECTRONICS PRODUCTS 20 FILTERS
EMR 429 PME
TO EMR 715
PC 2
AMPEX FR 1900 (GFE) 1 BAND
REF TONE
EMR 4130 REFERENCE DISCRIMINATORS
GFE EMR 713 20 DAC'S
LATCH OUTPUTS
TO FLIGHT ENGINEER'S CONSOLE
AMPEX FR 3030 W BAND
CAL MPLX
EMR 4080 CBW CALIBRATOR
20 DAC
RMT CTRL
TROMPETER PATCH PANEL
SPARE
EMR 4150 10 PBW DISCRIMINATORS
CONTROL
STRIP CHART 24 CHANNELS
REMOTE CONTROL
GFE MICRODYNE RECEIVER AR 1100
DL
TO FUTURE TRACKING SYSTEM
EMR 743 TAPE SEARCH UNIT
START/STOP
EMR 4080 PBW CALIBRATOR
TIME (BCD)
EMR 741 TIME CODE GEN/XLTR
TO EMR 760
SYL TIME
TO EMR 715
S/W TIME TO ITC
REMOTE DISPLAYS

FIGURE 1

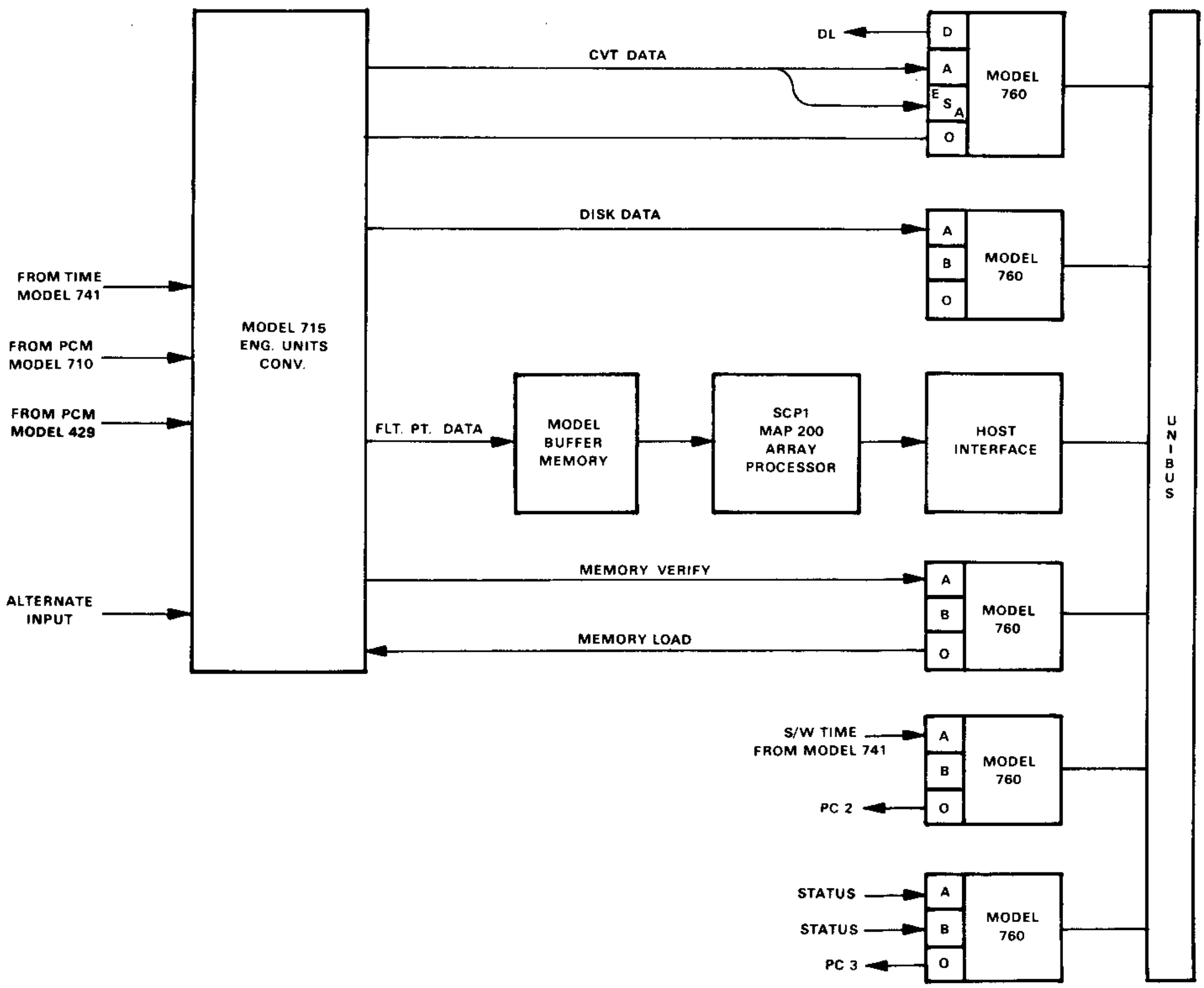

DL
D
A
E S A
O
CVT DATA
MODEL 760
DISK DATA
A
B
O
MODEL 760
FROM TIME MODEL 741
FROM PCM MODEL 710
FROM PCM MODEL 429
MODEL 715 ENG. UNITS CONV.
FLT. PT. DATA
MODEL BUFFER MEMORY
SCP1 MAP 200 ARRAY PROCESSOR
HOST INTERFACE
UNIBUS
MEMORY VERIFY
MEMORY LOAD
ALTERNATE INPUT
A
B
O
MODEL 760
S/W TIME FROM MODEL 741
PC 2
A
B
O
MODEL 760
STATUS
STATUS
PC 3
A
B
O
MODEL 760

FIGURE 2

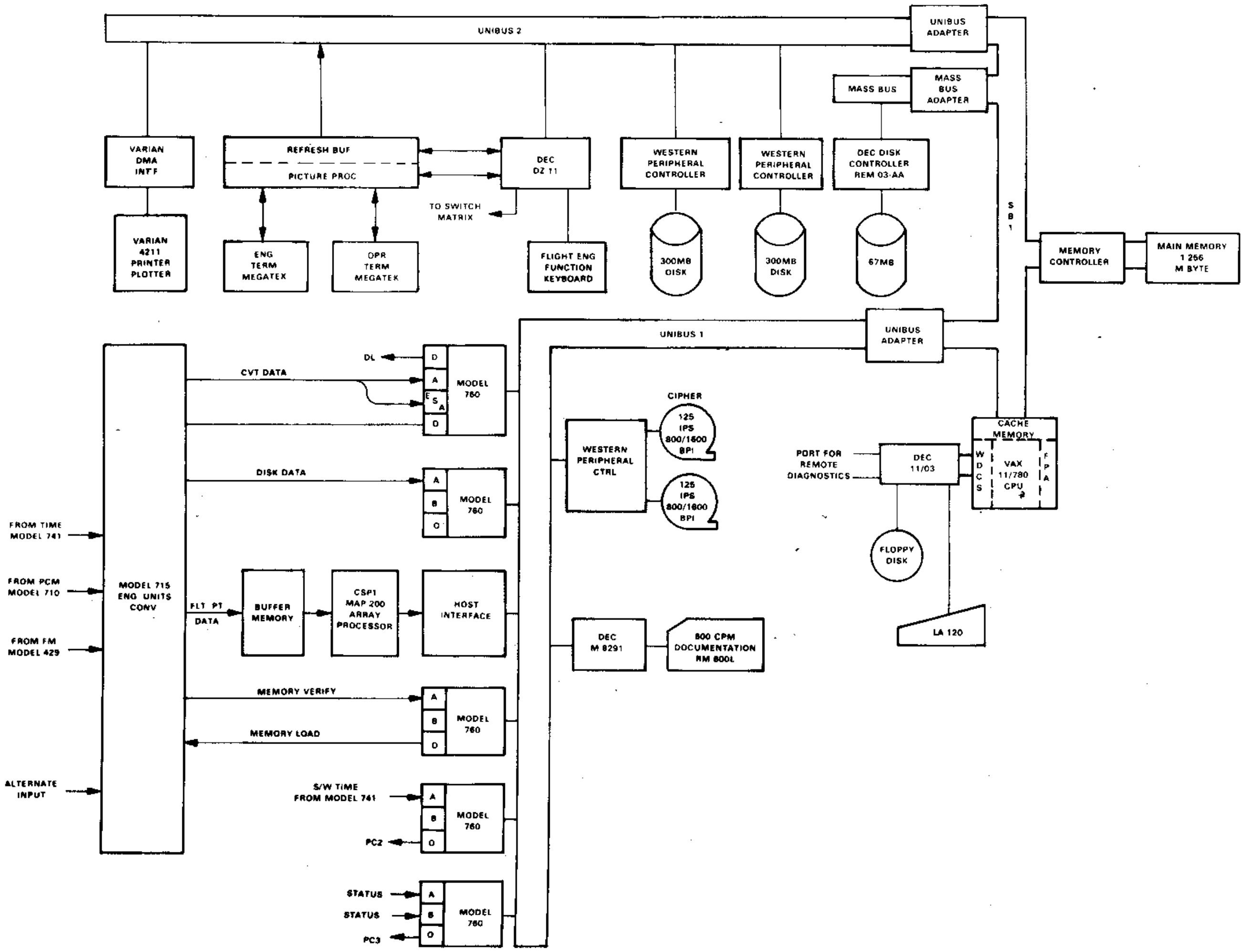
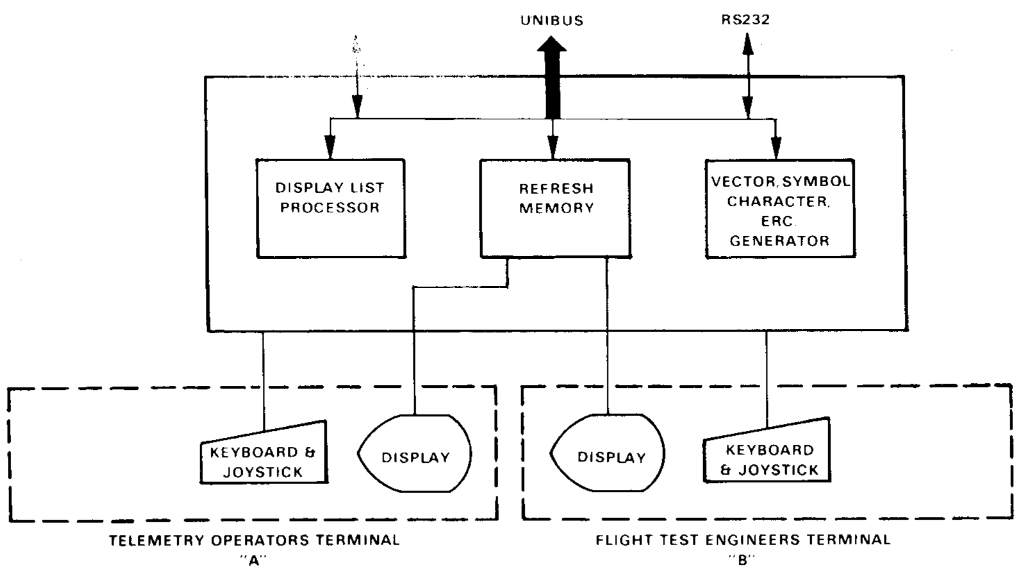


FIGURE 3



TERMINAL SUBSYSTEM BLOCK DIAGRAM

FIGURE 4

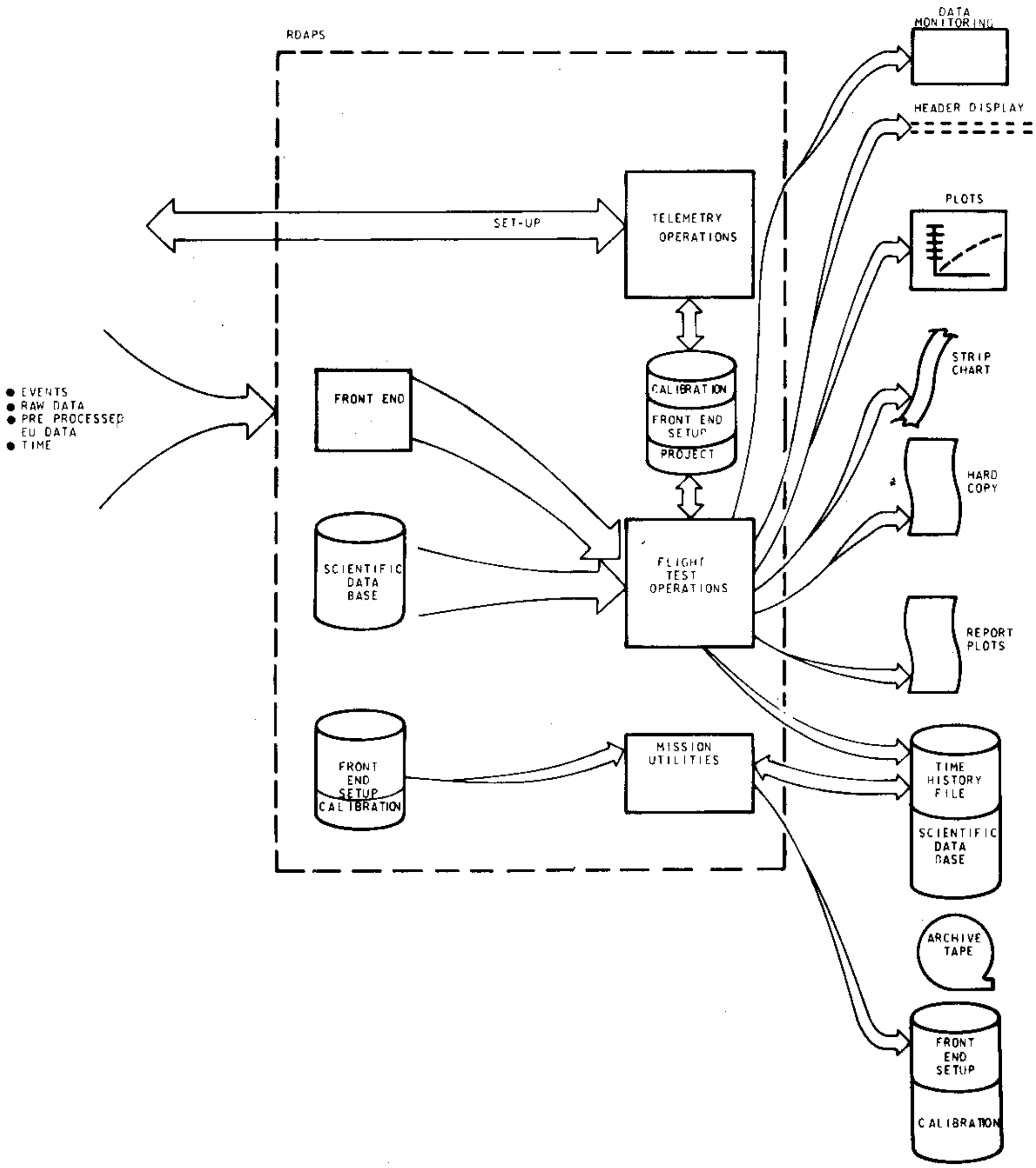

RDAPS
DATA MONITORING
HEADER DISPLAY
PLOTS
STRIP CHART
HARD COPY
REPORT PLOTS
SET-UP
TELEMETRY OPERATIONS
CALIBRATION
FRONT END SETUP
PROJECT
FRONT END
EVENTS
RAW DATA
PRE PROCESSED EU DATA
TIME
SCIENTIFIC DATA BASE
FLIGHT TEST OPERATIONS
FRONT END SETUP
CALIBRATION
MISSION UTILITIES
TIME HISTORY FILE
SCIENTIFIC DATA BASE
ARCHIVE TAPE
FRONT END SETUP
CALIBRATION

FIGURE 5