GDSC AEROSPACE TEST SYSTEM (ATS)

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ABSTRACT

Grumman Data Systems Corporation (GDSC) is presently developing another in a series of computerized realtime systems which accepts, preprocesses, analyzes and displays telemetry and range data. This new Aerospace Test System (ATS) will first be utilized by the Navy at the Pacific Missile Test Center (PMTC). The computerized test system will analyze data, in realtime, being telemetered from missiles, aircrafts and satellities. The system will accept, decommutate/demodulate, preprocess, analyze and display data being transmitted in the forms of PCM, PDM, PAM, and FM.

The system will allow test personnel to continually monitor, in realtime, critical raw and calculated parameters. The answers provided to test personnel, in one phase of the mission, will give them the ability to proceed into the next with a high degree of confidence. The vast amounts of data acceptable by the system, together with its analytical and display capabilities will allow test personnel to accomplish several tests during a single time frame. The system will also allow test personnel to be in complete control of their mission via the data uplink capability. It is a system that support Batch, Time Share, and Remote job entry processing concurrently. Utilized properly, it can greatly reduce the quantity and increase the quality of batch processing.

DESCRIPTION

The ATS is comprised of four major subsystems. One subsystem accepts and processes telemetry data, one subsystem receives and transmits range data, one analyzes data and the fourth displays the answers. The four subsystems are:

- Telemetry Handling Subsystem (THS)
- Range interface Subsystem (RIS)
- TeleSCOPE 350™ Operating System (TS350)
- Display Analysis subsystem (DAS)

The above four subsystems are interconnected by a Communication Subsystem.

Telemetry Handling Subsystem (THS)

The THS is a fully computerized subsystem that will accept and process multiple streams of telemetry data. Each stream of telemetry data can consist of up to nine independent, asynchronous telemetry sources of data. Telemetry data can be either PCM, FM, PDM and/or PAM. The THS can accomodate an aggregate rate of 50,000 samples per second (s/s) and a burst rate of 250,000 s/s for each stream.

The next generation of the ATS will support four streams of telemetry data. The THS is subdivided into three subsystems; the Telemetry Reformatting Subsystem (TRS), the Telemetry Processor Subsystem (TPS), and the Telemetry Setup & Control Subsystem (TSCS). The entire THS will be under computer control with some manual overrides provided. (refer to figure 1)

Telemetry Reformatting Subsystem (TRS)

The TRS accepts data from a realtime telemetry signal, tape playback or a telemetry simulator and reformats the data into a form directly usable by the Telemetry Processing Subsystem (TPS). Inputs consists of FM, PCM, PAM/PDM data and time code information.

The “brain” of the TRS is a large analog input/output switch matrix. Each piece of telemetry hardware in the TRS is attached to this switch matrix. The switch matrix is controlled by a micro computer. The switch matrix is programmed such that only the mission required telemetry hardware is “wired-up” to form a logical data path from the telemetry receivers to the TPS. Because of the various types of telemetry formats that are acceptable to the ATS, all telemetry hardware is programmable for specific mission requirements.

The TRS consists of the standard telemetry hardware (bit synchronizers, frame synchronizers, discrimators, analog to digital converter multiplexor, etc.) and a special piece of telemetry hardware known as the Front End Controller (FEC). The FEC is programmable hardware that will edit any data words in the telemetry wave train. The FEC will edit the unnecessary data words, identify the required data words and transmit them to the TPS. The FEC allows us to pass only the required information through the ATS, not the entire telemetry signal. During a mission this hardware box can be re-configured such that various aspects of the mission can be supported at different time intervals.

Each TSP processes FM, PCM and PAM/PDM data. This subsystem consists of the GDSC TeleSTREAM telemetry processor, capable of processing up to nine independent telemetry data sources and transmitting the processed data to the TeleSCOPE 350™

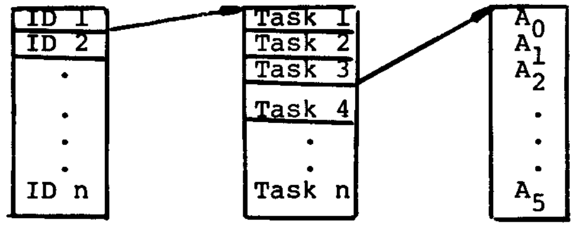
Operating System for analysis and/or other computer peripheral (ie DAC & Strip Chart Recorders). The incoming telemetry data is converted to the appropriate proper number system, calibrated, Engineering Units (E.U.) converted, limit checked and reformatted. The initial TPS System will incorporate the processing features listed in Table 1. Additional processing features such as data compression, and event processing can be easily programmed into the subsystem.

Table 1 TMP Features

Feature	Details
Number System Conversion	From Binary, 1's comp. Sign Mag. Offset Binary To 2's compliment
E.U. Conversion	Up to 5th order polynominal
Calibration	Corrects for Drift in analog system
Limit Checked	High/Low or Delta with Tolerance
Output Devices	CDC Cyber 170 Series computer DAC Recorders Strip Chart Recorders

The TeleSTREAM design is unique in that telemetry data is processed by many parallel independent asychronous mini-computers, rather than in the classical pipeline design. This concept of distributed parallel processing gives Grumman the flexibility of tailoring the TPS to a specific user by adding or deleting mini-computers. The initial TeleSTREAM processor will consist of five parallel minis and accept 50,000 s/s. As the input rate and/or preprocessing requirements vary, so does the number of mini-computers. (Additional computer peripherals, such as a tape recorder, graphic CRT, can be added on as requirements arise) Details of the TPS are given in another paper at this symposium and we shall only give a brief overview of its architecture.

Telemetry data is transmitted from the FEC and/or ADC Multiplexor into a storage area known as the FIFO (first in/first out). Data entering the FIFO is 48 bits wide. The telemetry data is 16 bits, its associated ID tag 16 bits, and it has 16 bits of time. The data remains in the FIFO until one of the mini computers called a Task Oriented Processor (TOP) accesses it. The TOP “cracks” the ID and vectors to a table defining the processing tasks. This table then vectors to other tables that have the required information (ie coefficients, limit checks values etc.) for processing. This procedure is diagrammed below.



Once the telemetry data is processed by the TOP's, it is written into memory shared by another mini-computer. This mini computer, known as the Output Processor (OP) routes the data to the appropriate output devices. The TeleSTREAM processor is programmable based on the mission requirements. As the mission requirements change through various phases, the telemetry processor can be reconfigured with new telemetry processing and routing requirements.

The TSCS is a mini-computer controlled subsystem that sets up, configures, calibrates, and validates the TRS and up to four TPS. After the TRS and TPS have been configured, to the mission's processing and routing requirements by the TSCS, the TSCS will monitor the health of the entire THS. If a unit fails, an operator is notified and a duplicate unit will be "repatched" via the computer control switch matrix. The TSCS allows the telemetry engineer to continually configure the switch matrix, ADC Multiplexor, FEC and telemetry processor to the mission's requirements. The TSCS is in direct communications with all equipment in the TRS and TPS. The TSCS will control up to four telemetry processors. The TSCS utilizes the output files from our Telemetry Compiler to configure the TRS and TPS.

The Telemetry Compiler, known as TELIN, accepts inputs from telemetry users and defines the following:

- test vehicle's telemetry configuration
- transducer's configuration
- telemetry stream definition
- processing and routing requirements

The above four files are input to TELIN and a file, known as the Mission Configuration File (MCF), is generated. The file contains all the information required to configure and load the TRS and TPS for various phases of the ission.

When telemetry data is not being processed in the ATS, the TSCS can go into the Diagnostic mode. Utilizing operational software, operational and special files of data, and the telemetry operators console, the TSCS will diagnose all hardware in the THS. This special diagnostic software executive, executed prior to a mission, will ensure the ATS users of quality data through the THS.

Range Interface Subsystem

The ATS also accepts, besides telemetry data, data being accumulated by various range devices. This subsystem, known as the Range Interface Subsystem (RIS) will initially accept data from eleven NTDS (Naval Tactical Data System) compatible range systems.

The total maximum rate for these eleven range systems is 350,000 bidirectional words/second. Data is accumulated by the RIS and transmitted to the TeleSCOPE 350™ Operating System for analysis. Upon completion of analysis, data is returned via the RIS to command and control range devices (radar, plot boards etc.) The initial RIS has the ability to expand to allow attachment of future devices and to allow inclusion of processors which will allow processing prior to transmission to the Cyber. TeleSCOPE 350™ allows range data to be distributed within the Cyber 175 by a program that is known as the Range Interface Program (RIP).

TeleSCOPE 350™ Operating System

The Grumman developed realtime operating system, known as TeleSCOPE 350™ is a “super set” of the Control Data Corporation’s (CDC) NOS/BE Operating system. TeleSCOPE 350™ is not a system to be loaded only at mission support time, but a system that can support concurrently batch, time share, remote job entry (RJE) and realtime processing of data. (refer to figure 2)

TeleSCOPE 350™, when executing, has four types of processing occurring. They are:

1. Realtime Executive (REX)
2. Range Interface Program (RIP)
3. Peripheral Interface Drivers
4. Real Time Analysis Software

The <u>R</u>eal Time <u>Ex</u>ecutive (REX) is the software program that controls the TeleSCOPE 350™ Operating System. The REX software maintains constant communications with the THS and RIS in order to configure each subsystem for the mission requirements. REX will access the required MCFs and transmit them to the THS for configuration. REX will also access and transmit the Range Configuration File (RCF) so that the RIS can properly configure itself. REX is a batch job, executing at a high priority.

As previously stated, the RIP interfaces with the range data. Data from a range device is received by the RIP and decoded. Information is “cracked’ out of the data stream, processed (ie Kalman filtered) and made available to the real time analysis software.

There are two peripheral interface drivers executing under TeleSCOPE 350™ They are: the Telemetry Interface Driver and the Graphics Interface Driver. The Telemetry Interface Driver (TID) maintains all I/O between the THS and the TeleSCOPE 350™ Operating System. TELIN files, required to configure and re-configure the TRS and TPS, are transmitted using the driver Data being transmitted from the telemetry processor to TeleSCOPE 350™ also utilizes this driver. Commands initiated by REX (start/stop data, reconfigure, termi nate mission etc.) and transmitted to the THS also utilize this driver.

The Graphics Interface Driver (GID) is analogous to the TID. It maintains communications between the DAS and TeleSCOPE 350™.

Once data is transferred into the computer by the TID and RIP it can easily be accessed by the analysis software. Initially, up to ten (10) realtime programs can be executing simultaneously under TeleSCOPE 350™.

The real time programs are written in FORTRAN and perform whatever analyses are required for the mission. These analyses are performed on telemetry data, range data or both types of data. The execution rate and computer resources required are controlled by the user of the system. A scheduling algorithm, will determine if a program entering the input queue, can enter the real time execution mode. The real time analysis software is in constant communications with REX and the test engineer at the graphics console(s). The program can divert data to the computer disk, and later transfer this data to tape or printout.

The number of real time analysis programs executing is a function of memory configuration and processing utilization of each program. With sufficient memory, and well developed analysis software the number of programs executing could easily exceed 10.

Display Analysis Subsystem (DAS)

After telemetry and range data have been analyzed under TeleSCOPE 350™, the answers are transmitted to the Display Analysis Subsystem (DAS). Utilizing GDSC's experience in supporting flight testing of various aircrafts such as the F-14, B-1, F-16, F5E, EF111, etc., we have developed the DAS with the test engineer clearly in mind. Here is the tool required for him to control his test. Via the DAS he has control over the configuration of the THS and RIS. He requests different real time analysis software and controls their execution. He controls the displays and communicates with the other consoles throughout the ATS. From the DAS, the test engineers have control of the mission.

Control of the mission from the DAS is from two levels, mission and test. A test is defined as a phase of the mission. An engineer, operating from an alphanumeric CRT terminal controls the mission. He is in constant communications with REX and is configuring and reconfiguring the THS and RIS for different phases of the mission. Meanwhile, an operator at a graphics CRT console is reviewing answers from the analysis software. Utilizing the latch keys, function keys and keyboard, the test engineer can display various images of data. He can also directly interface with the analysis software executing under TeleSCOPE 350™.

The DAS consists of two CRT's for graphics representation of telemetry and range data, two alphanumeric consoles for mission control, one printer/plotter, two command log printers and one disk for data storage. The ATS will initially support four DASs.

The display is divided into six areas. (see figure 3) One area is designed for subsystem messages. Any errors or problems occurring in the subsystem are displayed here. In addition time of day is displayed. Time of day is synchronized with the TeleSCOPE 350™ system. The next area is reserved for special outputs from the analysis software. These three lines are constants across all displays for a mission. The next area is for displaying data. The DAS has the ability to generate crossplots, time histories, metered plots, as well as tabular displays. Range displays are also displayed. The test engineer can have multiple traces per plot and multiple plots per display. The test engineer can store up to 15 displays per CRT. Table 2 below details the output formats.

Type/Format	Quarter Screen	Half Screen	Full Screen
Time histories			
linear	x	x	x
log	x	x	x
Cross plots			
linear	x	x	x
log log	x	x	x
log linear	x	x	x
Meters	x	x	x
Tabular		x	x
Range display		x	x
Polar Plots	x	x	x

Table 2 Output Display Formats

The fourth area is reserved for out-of-limits parameters. When a parameter exceeds a limit (telemetry processor function) it is flaged and transmitted to the DAS. The parameter name, E.U. value, reason code (high/low or delta) and time are displayed.

Up to twelve limit-checked parameters can be displayed without interfering with the display area. The DAS can display up to 128 limits, but they will be written over the plot area. If the display becomes too cluttered, the test engineer can remove the displays or limit checked parameters. The fifth area is reserved for keyboard input commands. The sixth and final area is the light pen targets for the display page. As previously stated, up to fifteen displays are stored and the test engineer can light pen select any of the fifteen pages. (See figure 3.)

Communications Subsystem

The four subsystems of the ATS are connected via an communication subsystem that gives proper command and control to various operators. Command and control over the ATS is at the test, mission and system level. This hierarchy was based on our direct experience supporting Grumman Aerospace testing of the F-14, EA6B, A6A, EF-111 etc. As stated above the Test Engineer at the graphics console commands and controls the test. The engineer at the alphanumeric console commands and controls the mission. Additionally, at the mission level, a telemetry operator (console off the TSCS) commands and controls telemetry transmission, processing and routing requirements for the mission.

At the systems level, three operators are involved. Two operators, one in the THS and one in the RIS are constantly monitoring telemetry and range data respectively for quality of data inputs. Another operator, known as the System Supervisor, is responsible for allocation/de-allocation of all the ATS resources. He is totally aware of the system’s capabilities and in constant communications with all console operators. The supervisor directly interfaces with REX executing under TeleSCOPE 350™.

SCENARIO

Now that we have a better understanding of the hardware and software supporting the various subsystems of the ATS; we shall attempt to tie it all together via a mission scenario. This scenario is a sample of how the ATS can be utilized and must not be construed as demonstrating its maximum capabilities. The mission scenario will be divided into three logical periods as follows:

- Pre Mission Period
- Mission Period
- Post Mission Period

Pre Mission Period

Prior to supporting a mission, personnel in various organizations must generate the required files of information required to configure the ATS. The Instrumentation Engineer would normally develop the instrumentation file. This file defines the telemetry signal's format (i.e., PCM, 16 bits, 128 words/ frame, odd parity etc.) and where in this format each parameter is located (ie AIRSPEED Mainframe word 6, subframe word 4). While the test vehicle is being "wired-up" by the Instrumentation Engineer, a technician in the calibration lab is developing the calibration file with the latest information regarding the transducers. Calibration information can be in the form of coefficients or a table. Concurrently, Test Engineers defines the processing and routing requirements for each analysis program required to support the mission. When all these processing and routing requirements are gathered, the Test Director should define the telemetry stream definition requirements. Test Engineer will also define his display requirements via a Plot Setup File (PSF). When the above four files are completed, they are input to TELIN and the MCF is generated. While the MCF is being generated by test personnel, another individual, cognizant of the configuration of the range would be defining the Range Configuration File (RCF). The RCF defines the exact configuration of each device and its input channel allocation into the RIS. When these three files (MCF, RCF and PSF) are generated, the mission can be supported.

Mission Period

The System Supervisor will "sign on" to the system via his console. REX will begin execution. The supervisor can then modify the RCF for any last minute updates. REX will, upon command, start execution of RIP. RIP will transmit the RCF to the RIS. The RIS will utilize the RCF to configure itself. The RIS will perform some basic diagnostics and now data can be transmitted to TeleSCOPE 350™.

Concurrently with the RIS configuration the supervisor will inform REX to access the MCF. The MCF will then be transmitted to the TSCS in order to configure, load, calibrate, validate and simulate the telemetry requirements. Upon command from the TSCS, REX will initiate transmission of telemetry data and RIP will initiate range data.

The System Supervisor will direct the real time analytical software outputs to a DAS. Data will flow into the analysis software and out to the graphic CRT. The DAS, previously configured with the PSF, is in constant communication with the analysis software.

Data is now flowing through the THS and RIS into TeleSCOPE 350™ and out to the DAS. During the mission the different operators have control over the mission.

Post Mission Period

After the mission has been successfully supported by the ATS, batch processing can proceed. The batch software routines can now operate off the data disk files generated in realtime. Additional post mission processing can be in the form of tape playback or strip chart recorders.

BENEFITS

The present ATS is the third that GDSC has developed. It is an outgrowth of engineering concepts and systems developed over ten years experience of real time testing. These systems are operational and supporting today's sophisticated telemetry based weapon system tests. One system is at the Grumman Flight Test Center in Calverton, New York supporting F-14 and EF-111 testing. The A6A, EA6B and GII aircrafts were also tested using it. Boeing Vertol fully flight tested its UTTAS helicopter on it. Our software was also utilized to support flight testing of the MRCA for NATO.

Another operational real time system is at Edwards Air Force Base in California. It is currently supporting F-16 testing and was utilized for B-1 testing.

Many benefits will be found by utilizing the ATS. These include:

- Safety of Mission. The ATS will allow test personnel to continually monitor critical parameters, in real time. Critical parameters can be raw telemetry data being checked for high/low or delta failure. In addition, calculated data can be monitored and compared to engineering data.

- Ability to Proceed. The answers provided to the test engineer in one phase of the mission gives him the ability to proceed into the next phase with a high degree of confidence.

- Multi-discipline testing. The vast amounts of data acceptable to the system, together with its analytical and display capabilities, allow test personnel to accomplish several tests during a single time frame. (for example, at mission separation, the test engineer could be monitoring and analyzing separation performance as well as engine performance while still keeping track of the missile.

- Close loop system. The system allows the test engineer to be in complete control of his mission via the data uplink capability of the RIS

- Optimizing Batch. The ATS will never eliminate batch processing but, if utilized properly, it can greatly reduce the quantity and significantly increase the quality of batch data processing.

- Computer Resource Management. The ATS is not a special real time system to “load” prior to a mission. It is a system that supports Batch, Time Share, Remote Job Entry and real time processing concurrently. Management does not have to be concerned with multiple operating systems and could manage their computer resources more efficiently.

CONCLUSION

The systems developed by GDSC have proven themselves beyond their original expectations. They have proved their versatility by supporting the F-14, F-16, B-1 and UTTAS helicopter. They have:

- Shortened test programs
- Extended test periods to 6-7 hours without interruptions
- Accumulated more useful answers/flight
- Saved test vehicles

By accomplishing the above four items, they have made testing of weapon systems less costly and more productive.

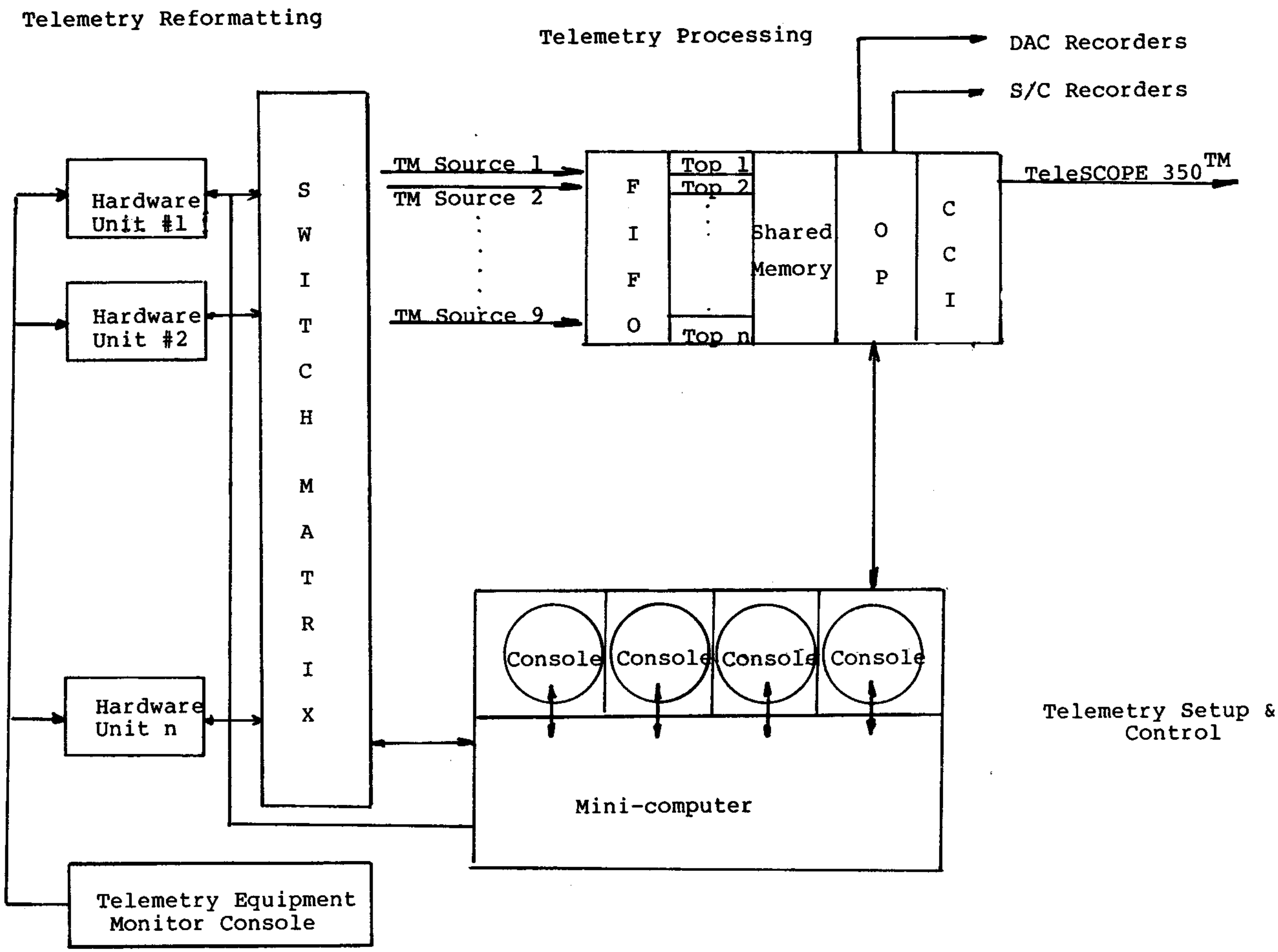


Figure 1 - Telemetry Handling Subsystem

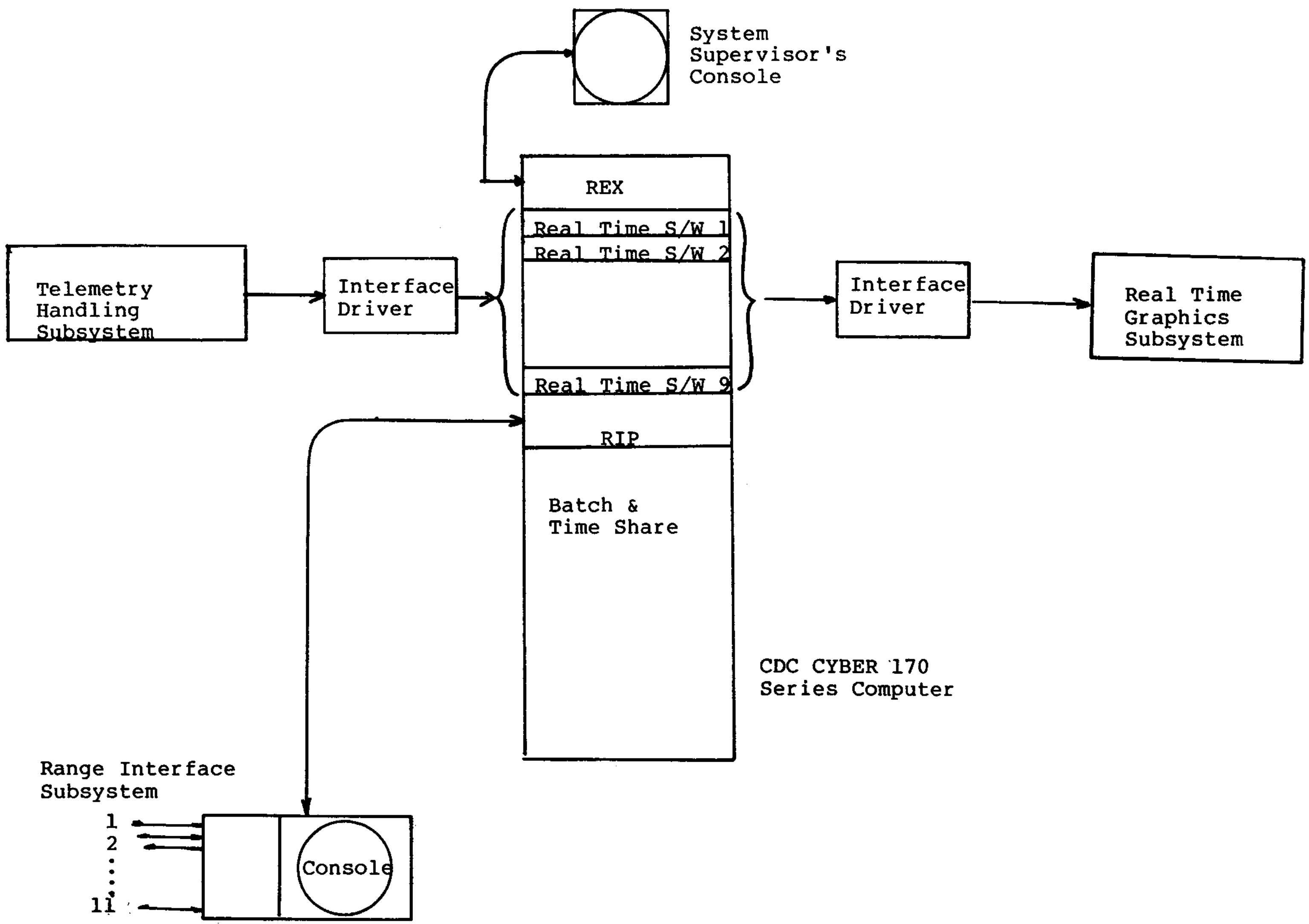


Figure 2 - TeleSCOPE 350™ Operating System

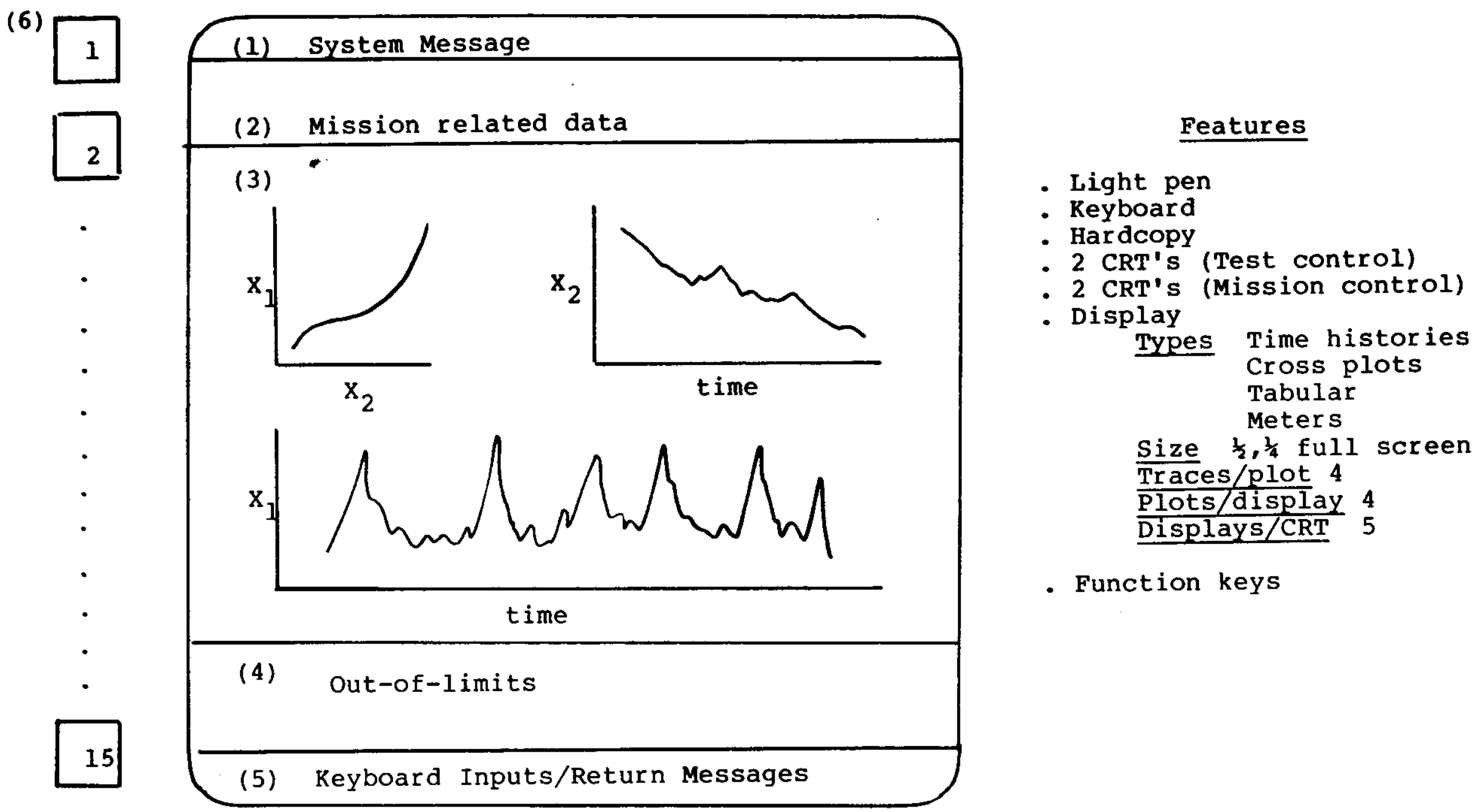


Figure 3 - Real Time Graphics Subsystem