# TIPS—AN INTEGRATED SOLUTION FOR MULTI-MISSION TELEMETRY*

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## SUMMARY

The Air Force Space and Missile Test Center (SAMTEC) must provide concurrent support for a variety of missions requiring real time telemetry data acquisition and processing. An integrated system is presently going operational to replace seven individual complexes presently supporting these missions. The Telemetry Integrated Processing System (TIPS) includes six real-time input streams, a large-scale near-real-time processor, and six interactive display areas. The TIPS facilitates rapid reconfiguration to meet changing operational needs or to continue operation in the face of equipment failures. The cost and lead time required for support of new requirements and also operation and maintenance costs will be substantially reduced. TIPS is the first Air Force data system processed under the Design-to-Cost/Life Cycle Cost (DTC/LCC) philosophy; all design and specification changes are evaluated in terms of operational as well as initial costs. Notable achievements in the TIPS implementation are the Telemetry Compiler and the real-time acquisition and processing subsystems which are described in accompanying papers.

## STATEMENT OF THE PROBLEM

The telemetry data acquisition and processing facilities at Vandenberg AFB have had a growth pattern typical of a number of range systems. The Air Force has had a missile and space launch support requirement at Vandenberg since 1959. As each new program has come into being it has required significant increases in data acquisition and processing capabilities which could only be met by the design, development, and implementation of totally new support systems. The predictable result is that there are now four discrete data centers representing several generations of data processing technology and interfaced to as many generations of data acquisition, display, and storage technology. Most of the equipment is obsolete or obsolescent. Each system requires its own software, its own

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maintenance and operations staff, its own spares, and cannot be used to back up other systems. For missions requiring redundant support, independent investments in new software, hardware modifications, support procedures, etc. are required. This results in excessive cost each time a new support requirement is levied on the range.

In June 1976, SAMTEC signed a contract with System Development Corporation to implement a system to replace all existing telemetry processing equipment and software. The Telemetry Integrated Processing System (TIPS) represents a new era in military range support systems. The system goals are:

1) To provide a single hardware/software base for support of all current and planned telemetry processing missions.

2) To provide plug-in expansion to support unforeseen requirements approximating twice the planned workload growth.

3) To provide a capability to assign any subset of the system resources to a given mission and to support other mission(s) with the remaining resources with no contention, data overlap, or failure impact, between the various concurrently operating missions.

4) To provide for maximum use of general purpose support hardware and software with mission-specific support requirements accommodated by use of table-driven software and easily integrated but separate special purpose software.

5) To provide a large-scale data analysis capability to reduce the need for reliance on data processing facilities remote from the range.

6) To maximize central, automated, system control to reduce operations overhead.

7) To maximize commonality of hardware components to minimize maintenance overhead and permit “instant” reconfiguration in the event of failure of any system component.

8) To provide a system which is so modular in concept and implementation that its components can be used as building blocks to meet other test range support requirements without having to “reinvent the wheel”.

## SYSTEM APPROACH

The TIPS large-scale computation capability is provided by a CDC CYBER 173. Realtime processing is accomplished on a network of seventeen SEL 32/55 midi-computers. Telemetry data ingest is via decommutators and data compressors provided by Aydin Monitor Systems. Real-time data display is provided on plasma/keyboards provided by Interstate Electronics and high-speed electrostatic recorders/printers developed by Gould Inc. System Development Corporation is the prime contractor with system acquisition/integration responsiblity and is providing all software development for the system.

A unique feature of this procurement is that it is the first application of the “Design-to-Cost” procurement philosophy to a data-system development contract. The effect of this approach is to formalize the process of system design changes throughout the development cycle and ensure that each change is evaluated on its merits relative to life-cycle costs to the government rather than concentrating only on implementation cost/ schedule impact. This approach has provided great flexibility to the Air Force and the contractor to optimize the design during the development to meet the system goals enumerated above.

## SYSTEM IMPLEMENTATION - HARDWARE

The TIPS hardware configuration is depicted in figure 1. With the exception of the Near-Real-Time Batch Processor (CYBER 173), which is depicted by a diamond at the top center of the figure, all processors in the system are SEL 32/55 midi-computers. The processors with asterisks within their symbol are not part of the deliverable configuration but represent planned “plug-in” growth capacity.

The circles in figure 1 represent Telemetry Preprocessing (TPP) computers. These receive telemetry data from the Aydin Monitor Systems Telemetry Front Ends (TFE) on four interface parts. The interfaces are “smart” and can be programmed prior to, or during, a mission to select any desired subset of the available data for ingest to TPP memory. Two of these are used to deposit raw data and compressed data in memory for immediate routing to the history files in the Mass Storage Control (MSC) subsystem. The other two telemetry ingest interfaces are used to read selected (programmable) subsets of the compressed data stream into TPP memory for event detection, limit analysis, report preparation, and message formatting. The resulting processed data is forwarded, via the MSC, to assigned Quick-Look Display Area (QLDA) computers) for display.

Each TPP also has programmable control over its associated TFE so that it down-loads the TFE elements prior to a mission and can modify TFE parameters during the mission. There is an alternate path for raw data (decommutated but not compressed) to be routed

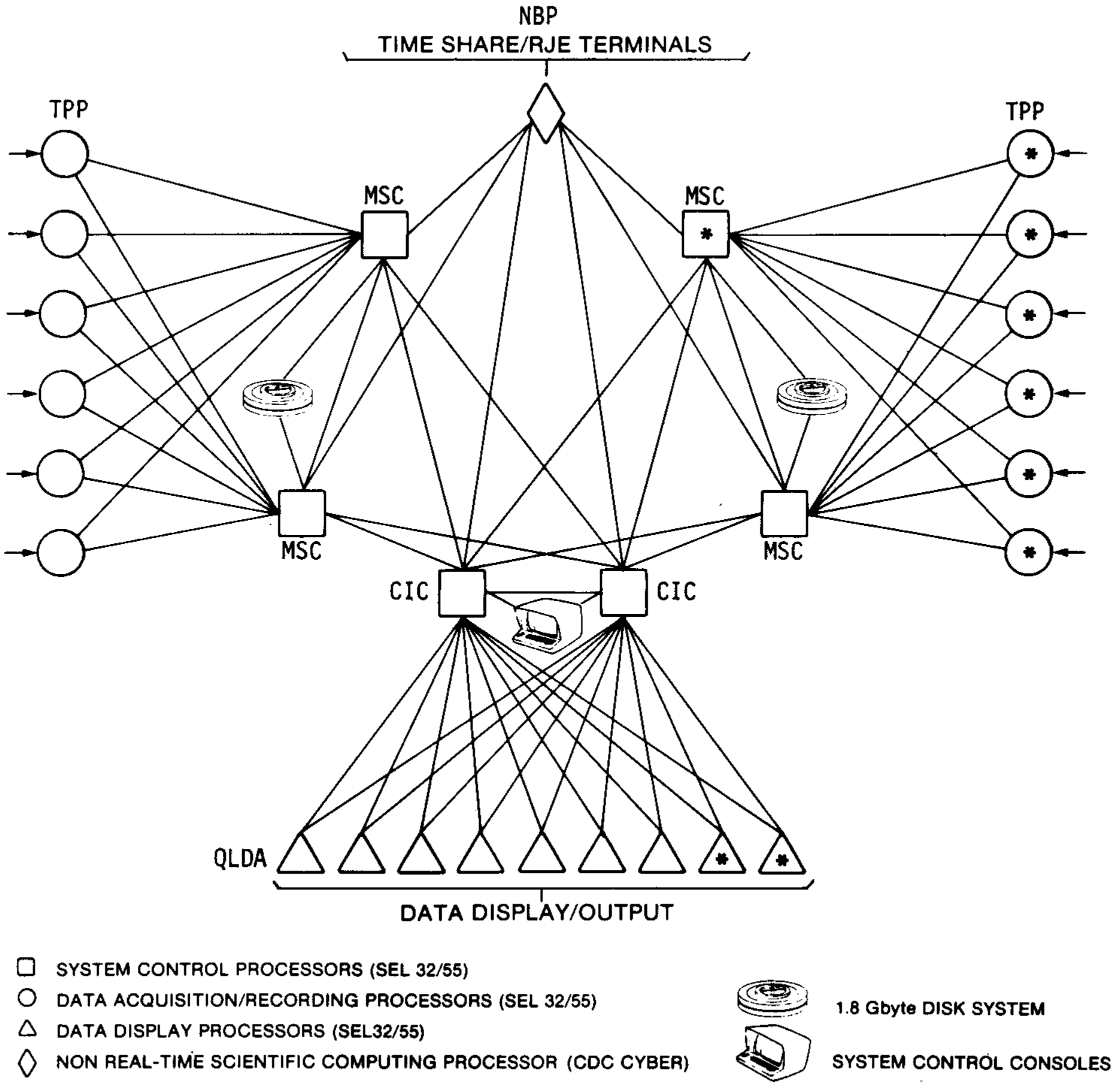


**Figure 1. TIPS Distributed Processing Network**

via a switch matrix from each TFE set to any or all of the QLDA computers. This data is mapped by, “smart” interfaces in each QLDA onto electrostatic strip chart recorders. The entire data path from telemetry data ingest to strip chart is hardware/firmware controlled with no processor support required once initialized. The interface devices handle masking, shifting, and scaling of data samples enroute to the strip chart recorders. The need for manual set-up is eliminated and the total number of display channels needed when using pen/ink recorders with digital-to-analog converters is reduced by the ability to instantaneously reprogram the devices to add, delete, or substitute measurement/channel assignments.

Central control of the system is exercised from consoles attached to two Configuration Inteface Control (CIC) computers. These computers are connected to each of the MSC computers and to each QLDA computer and route messages between processors assigned to the various missions. The CIC computers also host the central pool of peripherals:

tapes, printers, and card devices. This “peripheral pool” is dynamically “assigned” to various missions (JOBS) in the system to provide magnetic tape or hard copy data products or to input data for batch processing support.

Each CIC and MSC computer is also connected to the CYBER computer. The MSC/CYBER interface supports CYBER access, within five seconds of acquisition, to the telemetry history files so that near-real-time data reduction can commence while a mission is in progress. The CYBER can also allocate space on the MSC discs and use it for CYBER “Native” file storage using all the facilities of the CYBER file management system. The CIC/CYBER interfaces are used to spool jobs initiated on the CYBER to the real-time job queue. These jobs may be real-time missions or batch jobs, compilations, etc., to be executed on the TPP computers. At termination of such a job the output is then spooled back to the CYBER or to one of the peripheral pool devices.

As will be seen by close inspection of figure 1, there are a minimum of two paths available for data transfer between any two topologically adjacent processors (in some cases the alternate path must pass through an intermediate processor). This redundancy of data paths, combined with the redundant MSC and CIC computers, contributes to the failsafe nature of the design. If any interface device fails, the alternate data path can be automatically selected. If any processor fails, its functions can be automatically assumed by the remaining processor (MSC or CIC) or can be recovered to an idle processor at system operator discretion (TPP or QLDA).

The telemetry front end equipment and real-time subsystems are described in greater detail in an accompanying paper(1).

## SYSTEM IMPLEMENTATION - SOFTWARE

In addition to the standard vendor-supplied software for the CDC CYBER and SEL 32/55 computers, there are eight categories of software associated with TIPS.

- Distributed Operating System
- NOS Extensions
- Real-Time Applications
- Telemetry Compiler
- Utilities
- Scheduler
- Special Processes
- Non-Real-TiMe Applications

The Distributed Operating System (DOS) provides executive control over the jobs operating in the SEL computers in TIPS. Elements of DOS reside in every processor and provide for multiple independent jobs operating in multiple processors. DOS controls the allocation of system resources, provides the system console interface, handles routing of data/messages/files between tasks in the various processors, manages the history files, performs failure detection, logging and recovery processing, and provides the isolation between concurrently executing jobs (missions) required to ensure mission integrity. DOS is based on the standard SEL-provided Real Time monitor operating system (RTM). All of the features of RTM necessary to support batch operations on the SEL computers have been retained. The additions/modifications to RTM to produce DOS provide for centralized system control, multi-batch, and multi-processing. Also added are the I/O handlers necessary to support the various inter-processor links and special interfaces in the realtime data processing network.

The CYBER operating system used in TIPS is the CDC-provided Network Operating System (NOS). Extensions to NOS have been provided to support the MSC/CYBER and CIC/CYBER interfaces. These permit the spooling of data and jobs back and forth between the CYBER and the SEL systems.

The Real-Time Applications (RTA) software is that body of software directly involved in telemetry data processing and display on the real-time side of TIPS. This software is general purpose in design and is table driven to accomplish the specific processing required for each mission. Thus RTA has the basic structure necessary to process measurements but the measurement-to-algorithm linkage and all algorithm parameters are contained in a Run-Time-File (RTF). RTA includes the logic to generate plasma displays of calibrated data but the RTF defines the specific format of each display and dictates the engineering unit conversion to be applied to each measurement therein. RTA includes the logic necessary to simultaneously process two event sequences of up to 32 events each with up to 16 event conditions per event, but the RTF contains the actual event sequences, measurement names, logical operators, conditions, and result conditions (text display, activation of a task, invocation of a process control directive, change of telemetry decommutation list, etc.) to be invoked upon the detection of the event.

For a given mission, elements of RTA residing in from one to twenty-seven processors may participate. Each processor may support several tasks. The RTF identifies, by logical name, the task(s) with which each task is to communicate. During initialization, DOS determines the physical processors) to be allocated to a mission. Tasks then communicate over logical links, defined in the RTF, and DOS transmits to data to the appropriate physical destinations. Thus, if a processor fails, DOS can recover those tasks to a standby processor and continue the mission without change to the operations in other processors.

Surviving processors “see” only a temporary break in communications and neither know or care that they are now communicating with a different physical processor.

The Run Time Files control the mission processing. They are generated by the TIPS Telemetry Compiler (TTC). The TTC operates on the CYBER and can be used either in batch or interactive mode via timesharing terminals. A special Telemetry Source Language (TSL) has been developed which permits the user to describe the telemetry data, the processing to be performed, the displays and history files to be generated, and the resources to be applied to his mission in terminology which is natural to the telemetry analyst. The compiler then converts the TSL into tables, front end program loads, and SEL program modules and spools the result across the CIC/CYBER interface to be assembled into a Run Time File by one of the utilities on the real-time side. The TTC is described in an accompanying paper(2).

The TIPS Utilities include the Run Time File generator, which converts the TTC output to a DOS/RTA usable form and various RTF modification/update utilities. It also includes accounting routines and other system tools which were not available in the vendor software.

The Scheduler operates on the CYBER and uses batch or interactive schedule information in conjunction with resource requirements spun off by the compiler to construct a support schedule and identify resource conflicts to assist scheduling personnel in the management of the data center.

The Special Processes are mission specific modules which are linked into RTA to perform processing which is outside the scope of the general purpose software. RTA provides a well-defined interface so that special processes can be developed by various agencies and easily integrated into the system to support specific operations. An example is the Range Safety Special Process which receives inertial guidance data from the acquisition module in RTA and generates X, Y, Z and $\dot{X}$, $\dot{Y}$, $\dot{Z}$, data for transmission to the range safety data center at Vandenberg. Other special processes generate statistical summary data or other special report formats in real-time.