PORTABLE TELEMETRY TEST SYSTEM

Ronald DeWaters
Naval Surface Warfare Center
Dahlgren, VA 22448

and

William Anderson
Loral Data Systems
P.O. Box 3041
Sarasota, FL 34230

ABSTRACT

In 1986 the Navy procured Automatic Engineering Read Out (AERO) Telemetry Test Systems to receive, record, process and display telemetry data transmitted from SM-1 and SM-2 STANDARD missiles. AERO systems are self-contained data acquisition systems which are portable for field use, and are capable of receiving missile data, recording the data on analog tape, decommutating data into a computer compatible format, recording data on disk, and displaying processed data on the operator's terminal. The original design was intended to be versatile and to accommodate future telemeters through software programming, signal switching, unit/module substitution, or add-on equipment. Original missile formats included data rates up to 50,000 data words per second. AERO systems have been used to support field testing of Navy missiles since 1987.

In 1989 the AERO system requirements were changed to include support for a new STANDARD missile telemeter which transmits data at much higher rates. The AERO systems have been upgraded to support the new requirement by replacing I/O modules in the host computer, and modifying the control software. The modified system, which is hosted by a low cost DEC MicroVAX computer, records 100 percent of the telemeter data on disk at rates up to 600,000 bytes (300,000 data words) per second, and displays results for quick look review immediately after the missile test.

This paper discusses the requirements for the AERO systems, the design philosophy used to ensure an upgradable path, and the benefits of that philosophy when an upgrade was required. The upgrade itself is significant because a low cost MicroVAX has been adapted to a high performance application.

The AERO systems were designed, developed and upgraded by Loral Data Systems (formerly Fairchild Weston Data Systems) to the specifications of the Naval Surface Warfare Center in Dahlgren, Virginia.

INTRODUCTION

Prior to 1986 the U.S. Navy designed and manufactured its own portable systems for recording and processing data from missiles tested in the field. In accordance with changes in DoD procurement policies, the next generation system was specified so that it could be developed by integrating off-the-shelf equipment into a system that met Navy requirements. AERO is the first system of the new generation. Its capabilities and field results are noteworthy.

SYSTEM REQUIREMENTS

The AERO Telemetry Test System is intended to support research, development, test and training programs on Navy missiles. AERO receives, records and processes test data from Navy telemetered surface missiles.

AFRO must process data in many different formats from many different missiles. It operates where missiles are tested: in environmental labs, at dock side test sites, and at sea. Four systems are in operation.

Production Support Requirement

Missile manufacturers have been the principal users of AERO to support field testing of their missiles. Primary data is recorded on analog tape, and simultaneously decommutated and stored on a computer disk for post test processing. Real time strip charts and computer displays are also available for quick look analysis. Immediately after a test the operator may scan the data for selected conditions, and display requested data in engineering units for detailed examination. AERO also Supports several predefined tabular and graphic data displays for standard reports.

Portability Requirement

AERO is required to be portable and to be configured for use on ships. It is packaged in 11 modular units which can be shipped separately, and assembled and checked out at the test site in about one hour. The modules are stacked and locked to each other during operation, with covers provided for shipping. Power to all critical components is supplied by a UPS to prevent loss of data during power disruptions.

Commercial Product Development

AERO consists of standard commercial products from leading telemetry equipment manufacturers which reduces the initial procurement costs, allows several options for maintenance, and helps ensure availability of spare parts at competitive prices.

System Upgrade Requirement

In 1990 AERO was upgraded to meet the high data rate required by the newly developed AN/DKT-71 telemeter. This telemeter operates at a bit rate of 2.4 Megabits/second, corresponding to a throughput of 300,000 words/second for 100 percent data recording to disk. AERO's original disk recording capability supported formats requiring a maximum continuous rate of 50,000 words/second.

The increased disk record rate was accomplished by installing a high speed input channel, a high performance ESDI (Enhanced Small Device Interface) disk controller, and high speed disk drives. New control software for the input channel was developed and integrated into existing system software. Changes are transparent to the operator.

A second disk requirement, due to security considerations, was for rugged, easily removable disks. Two 167 Megabyte Control Data drives packaged in Trimarchi removable canisters were selected to meet this requirement as well as the speed requirement. The drives in these canisters have high reliability, are shock mounted for rugged environments and can be removed or installed in about one minute.

Additionally, the AN/DKT-71 format contained data not found in previous telemeters. New reports were generated and existing ones modified to meet the data display requirements for the new telemeter.

Several other problems noted during AERO operation were addressed during the upgrade. Graphic display of supercommutated data was modified to give improved time resolution; special post test processing of IRIG B time was added to improve time resolution from 1 msec to 0.1 msec, and provisions to delete selected data during acquisition to disk were integrated into AERO.

Changes were developed and tested on the first system by Loral Data Systems. The remaining systems were upgraded by Navy personnel.

SYSTEM CAPABILITY

The AERO System is housed in stackable, portable enclosures. Each enclosure is used in one of two functional units: the Receive/Record Group or the, Process/Display Group.

Figure 1 is a block diagram of AFRO, showing the primary interconnection between units. Figure 2 is the physical layout of AERO equipment.

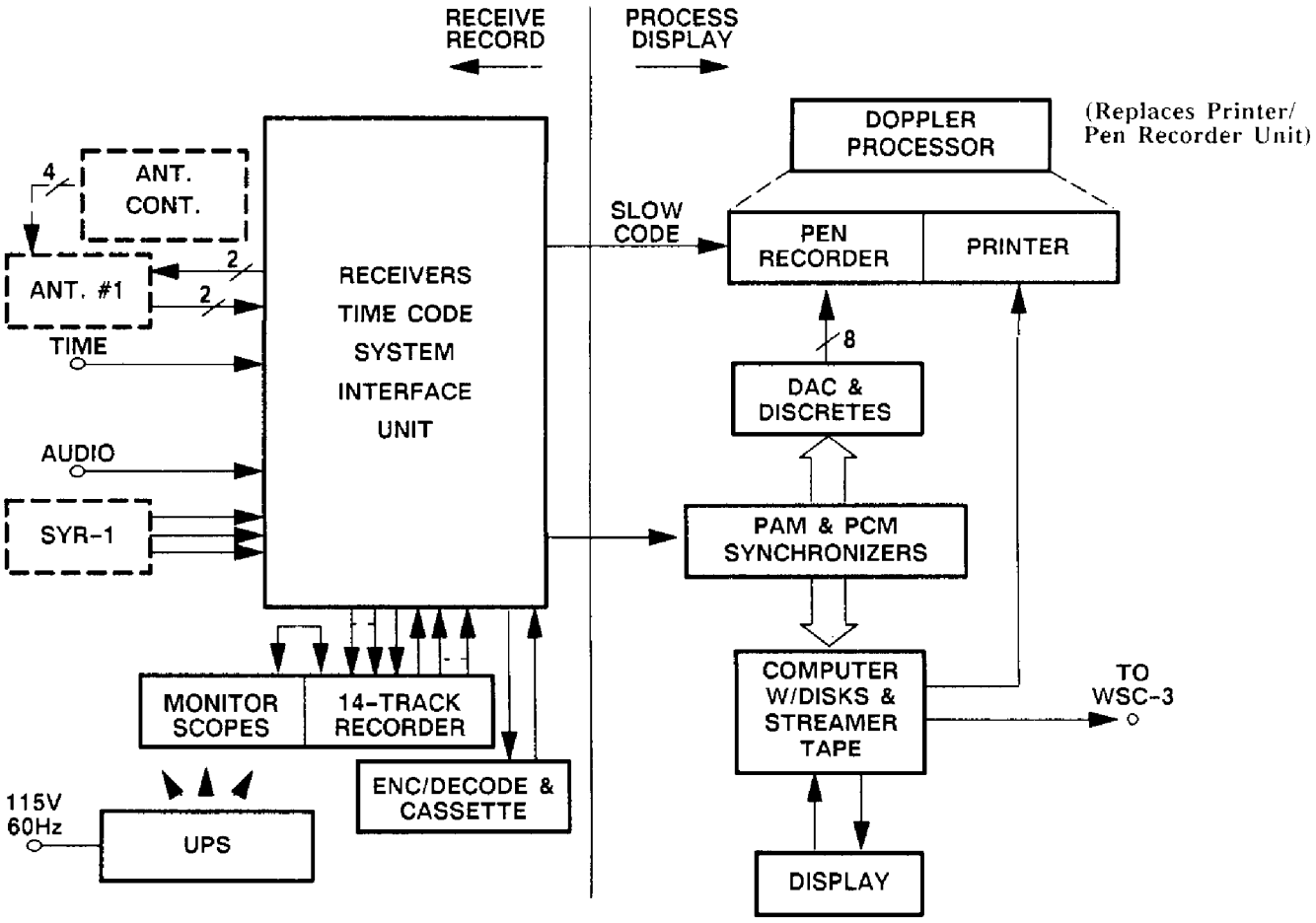

Figure 1 AERO Block Diagram - Data Flow through the System

RECEIVE/RECORD GROUP

The Receive/Record Stack receives telemetry data from a missile and records it on analog tape. The following is a functional description of each unit in the Receive/Record Group.

Video Signal Interface Unit

The Video Signal Interface provides detection/discrimination of the signal from the antenna, translation/ generation of time code, programmable routing of data and time

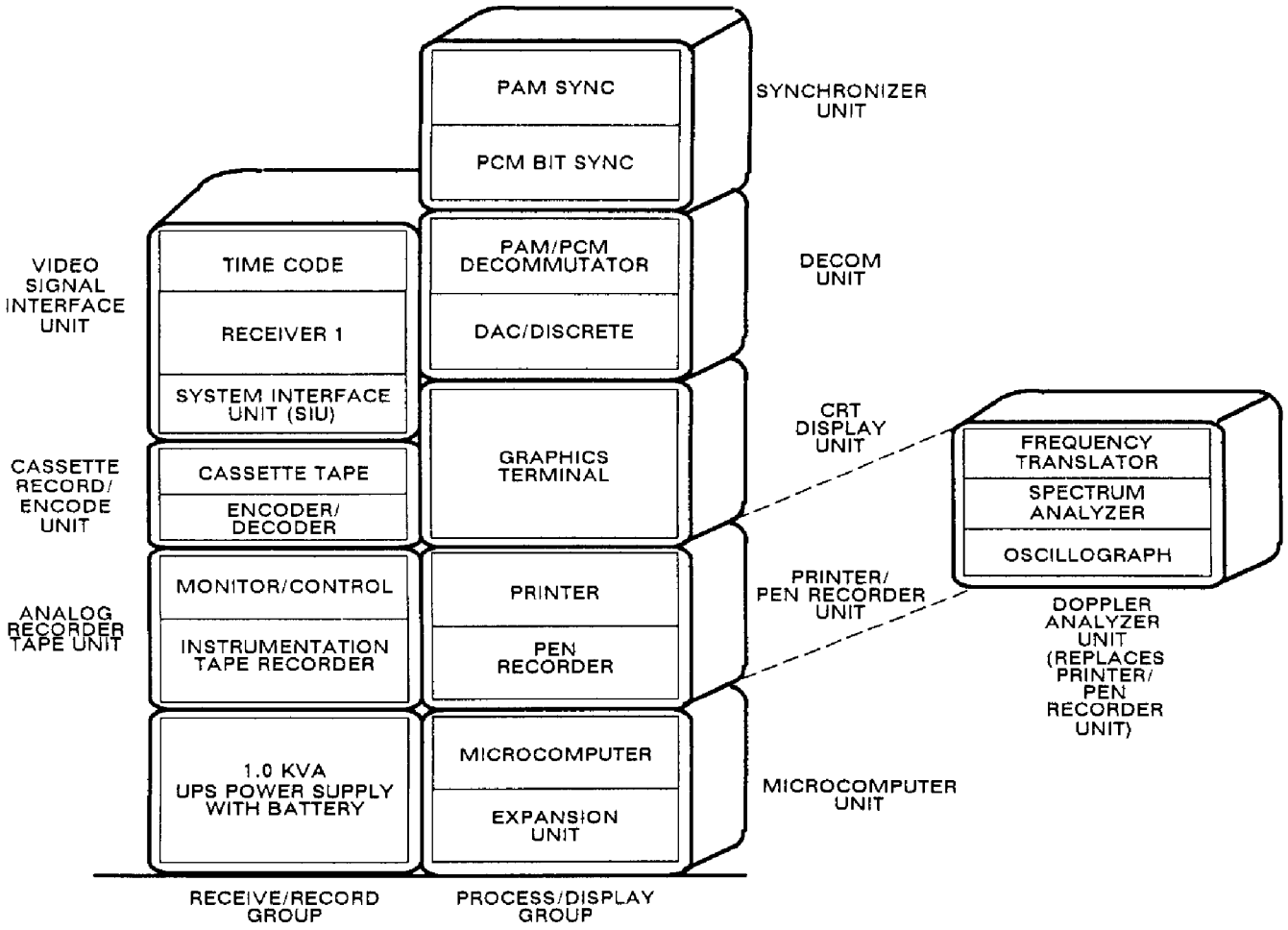

Figure 2 AERO Physical Layout - Outline of Equipment During Operation

between units in the system, and AGC for signals recorded on tape. It contains a Microdyne 2800-RC(W) receiver/combiner, an EMR 1741 Time Code Generator/Translator, a Racal Dana 1250 Matrix Switch, and an EMR System Interface Unit.

Cassette Record/Encode Unit

The Cassette Record/Encoder records and reproduces a selected telemetry signal as well as voice and serial IRIG-B time. The unit includes a Sony DDR-700 Cassette Recorder/Reproducer and a Sony DDA-700 Encoder/Decoder.

Analog Tape Recorder Unit

The Analog Tape Recorder records and reproduces 14 tracks of data. Recorder input and output signals may be monitored on scan scope displays. The unit contains an EMR Model 80 Analog Tape Recorder and a Data Check Model 1800A-2 Scanscope monitor.

Power Supply Units

An Uninterruptable Power Supply provides continuous power to all essential units for five minutes if normal power is interrupted. The unit contains Behlman H-1000 Uninterruptable Power Supply (UPS).

PROCESS/DISPLAY GROUP

The Process/Display Group processes and displays data received by the Receive/Record Group. The following is a functional description of each unit in the Process/Display Group.

Synchronizer Unit

The Synchronizer Unit provides bit synchronization for PCM data and synchronization and decommutation for PAM data. The unit contains an EMR 8320 PCM Bit Synchronizer and an EMR 725 PAM Decommutator.

Decommutator Unit

The Decommutator Unit provides frame and subframe synchronization on data received from the Synchronizer Unit as well as digital to analog conversion of data. Data is distributed to the Micro Computer Unit and Chart Recorder. The unit contains an EMR 8330 PCM Decommutator, and an EMR 8350 D/A Converter.

CRT Display Unit

The CRT Display Unit provides the operator interface to the MicroVAX for equipment setup, data processing, and data display. It contains a DEC VT240 Terminal, and a Black Box RS232/MIL188 Interface Converter for radio transmission of computer data.

Printer/Pen Recorder Unit

This unit provides both printer and plotter hardcopy outputs of selected data. It contains a DEC LA75 Companion Printer and a Western Graphtec WR3101 8-channel strip chart recorder, with event markers and a time channel

Doppler Analyzer Unit

The Doppler Analyzer provides for spectrum analysis of missile Doppler data and for hardcopy display of high frequency data from the Decommutator Unit. It contains a Barry Research Communication 2002N Spectrum Analyzer, a Barry Research Communications

2007A Frequency Translator, and a Honeywell 1858 CRT Visicorder. When used, the Doppler Analyzer unit replaces the Printer/Pen Recorder unit in the system.

Micro Computer Unit

The computer processes data from the Decommutator Unit for recording on disk as well as real-time and disk playback displays on the CRT. It also provides for the setup and control of other Process/Display Group Units. It contains a DEC MicroVAX II, two Control Data removable disks, and a DEC TK50 cartridge tape drive,

SOFTWARE

AERO's most significant improvement over previous portable Navy receiving systems is its software data processing and display capability. AERO is the Navy's first portable system which can display data in engineering units.

The MicroVAX uses standard DEC VMS with no modifications added. The AFRO software is fully menu driven, and includes software for test setup, data acquisition, real time display, post test data examination. and utilities.

When the operator logs onto an AERO user account the main menu, shown in Figure 3, is presented on the CRT display. The operator selects the desired function from the main menu.

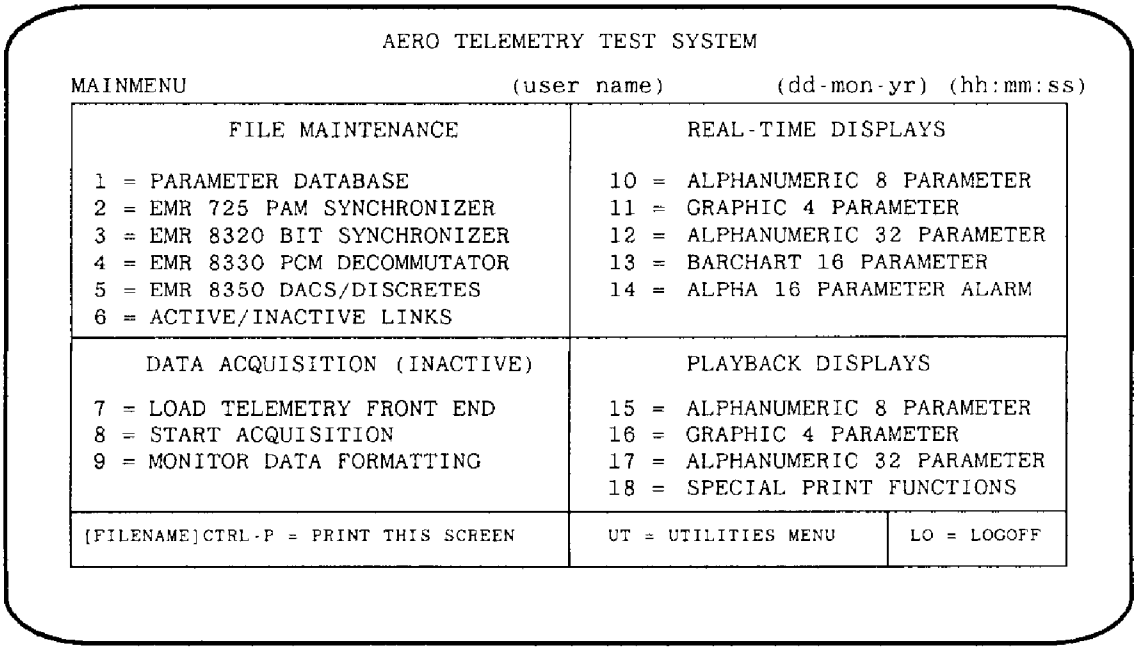

Figure 3 Main Menu

Parameter Data Base Maintenance

Each parameter in the telemetry stream is defined in the parameter data base, including items such as position in the frame, engineering unit conversion information, plot range, and high/low limits. Data types supported include: analog, digital, discrete, derived, fragmented, and time. The parameter data base is created and edited using a comprehensive editor which is an integral part of a system using interactive menus to guide the operator through definition of data in a missile format.

Equipment Setup

All equipment in the Synchronization and Decommutator Units can be set up by the operator via the MicroVAX terminal. The Main Menu allows the operator to request a second menu tailored to the selected equipment. The menu contains separate fields in which each parameter description (such as BIT RATE) and the value currently designed are displayed. The operator may edit any fields of interest and save the result in a disk file for later reference. The saved results are used to set up equipment when data acquisition is to be started. Figure 4 shows the menu for entering bit synchronizer setup information.

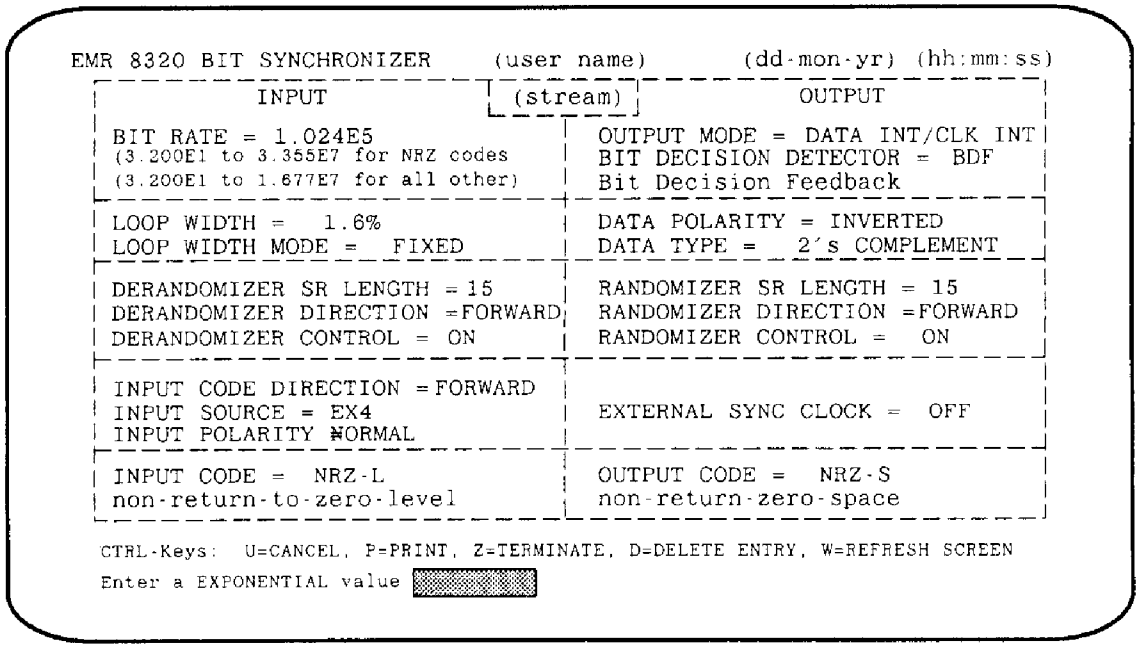

Figure 4 Setup Menu for Bit Synchronizer

Data Acquisition

AERO allows the operator to control data acquisition. Prior to acquisition, the setup files for all equipment must be defined, as described above.

Link Selection - Link selection is a menu which allows the operator to specify whether a PAM or PCM data link will be used, and name the disk file in which data will be stored.

Load Telemetry Front End Equipment - After data links are specified, the operator must load the active equipment. Software reads data from setup files, converts it to the appropriate command formats, and writes it to the selected equipment.

Start/Stop Acquisition - The operator may enable/disable the MicroVAX for receipt of data. With acquisition enabled, data may be recorded on disk and incoming data may be displayed at the operator's terminal.

Real Time Data Monitoring

Real time data may be displayed at the operator's terminal for quick look data monitoring. Each display type consists of two screens: setup menu, and dynamic data display. The setup menu allows the operator to specify names of parameters to be displayed and a display update interval (typically 0.2 to 5.0 seconds). The setup information may be saved in an operator-named file, and later recalled to speed the setup of standard display format. After setup, the operator requests that data be displayed as it is acquired. Formats available for data monitoring are scrolling eight parameter tabular displays, stationary 32 parameter displays, scrolling four parameter graphic displays, and 16 parameter bar chart displays. AERO real time data display capabilities are similar to post test displays, which are described below.

Post Test Data Reports

Post test processing of data recorded on disk includes most display types available for real time display, as well as special reports unique to Navy missile data. Data to be displayed is selected by user defined parameter names, and time interval of interest. Any data displayed on the CRT may be copied to the AERO printer with a single keystroke, Different display types are described below.

Scrolling Tabular Display - The alphanumeric 8 parameter display presents up to nine columns of data which scroll vertically down the screen, Column 1 is always time. Columns 2-9 are numeric data from up to eight operator specified data measurement sources. Each column is headed with the measurement name and the engineering units to

which the data has been scaled. Any value that is out of user defined limits is displayed in reverse video to highlight unusual situations. The 16 most recent values for each parameter are always visible on the screen. The setup menu is shown in Figure 5 (other display setup menus are similar); the data display is shown in Figure 6.

```
                    A N A L Y S I S   M E N U
DISPLAY TITLE =                                          DATE: (dd-mon-yr)

DISPLAY INTERVAL   DISPLAY PARAMETERS  PRINTOUT ONLY
                   1 ------------ 9 ------------
                   2 ------------ 10 -----------
FROM: HH:MM:SS:TTT 3 ------------ 11 -----------      FRAME INTERVAL
TO: HH:MM:SS:TTT   4 ------------ 12 -----------
                   5 ------------ 13 -----------
                   6 ------------ 14 -----------
AVERAGE INTERVAL   7 ------------ 15 -----------      PRINT MODE
                   8 ------------                    80 COLUMNS

SEARCH INTERVAL    SEARCH PARAMETERS  EVENT      VALUE      FOUND AT:
                   1 ------------  --------  --------   HH:MM:SS.TT
                   2 ------------  --------  --------   --------
FROM: HH:MM:SS:TTT 3 ------------  --------  --------   --------
TO HH:MM:SS:TTT:   4 ------------  --------  --------   --------

 CTRL-key Operations
   P=PRINT SCREEN (FILENAME) W=WRITE LIST FILE    G=GO TO ANALYSIS DISPLAY
   B=BEGIN SEARCH (FILENAME) L=RECALL LIST FILE   Z=EXIT
   T=TABULAR PRINT           U=CANCEL OPERATION

 (ENTER HELP IF YOU NEED INSTRUCTIONS)
  A16 INPUT:
```

Figure 5 Scrolling Tabular Display - Setup

```
(user name)                                          (dd-mon-yr) (hh:mm:ss)

                  SAWTOOTH
     TIME           UNITS          SWITCH    COUNT       ---------

  01:46:05:264   0.0000000E+00        0         4
   01:46:05:391   -2.000000           0         5
   01:46:05:516   -4.000000           0         6
   01:46:05:646   -6.000000           0         1
   01:46:05:773   -8.000000           0         2
   01:46:05:900   -10.000000          0         3
   01:46:06:028   -12.000000          0         4
   01:46:06:104   -14.000000          0         5
   01:46:06:283   -16.000000          1         6
   01:46:06:411   -18.000000          1         1
   01:46:06:538   -20.000000          1         2
   01:46:06:666   -22.000000          1         3
   01:46:06:793   -24.000000          1         4
   01:46:06:920   -26.000000          1         5

    CTRL-keys:                                  R=Return to menu
      P=Print screen                            Z=Exit

Vertical ARROW KEYS start/stop scrolling  Number Keys 1-9 control speed
```

Figure 6 Scrolling Tabular Display - Data

Stationary Tabular Display - The alphanumeric 32 parameter display presents up to 32 data values, along with their names and the engineering units to which they are scaled. Each value is updated at the user specified interval, and the most recent value is always displayed. Any value that is out of limits is displayed in reverse video. This display is shown in Figure 7.

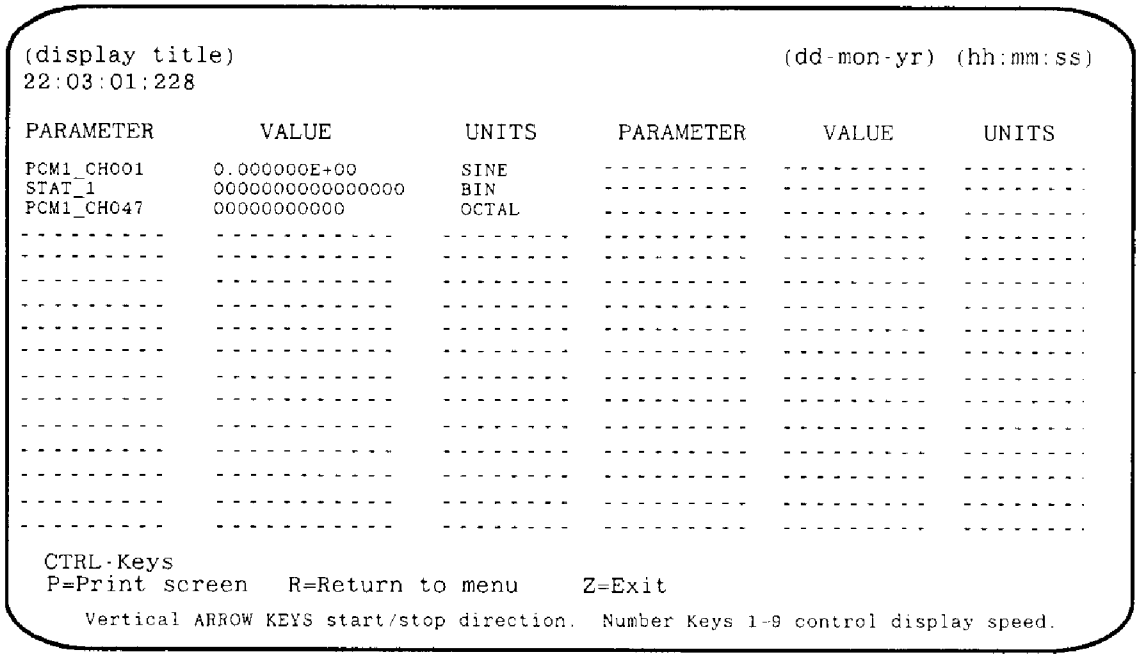

Figure 7 Stationary Tabular Display - Data

Graphic Display - The graphic 4 parameter display allows the operator to specify from one to four parameters to be displayed in a parameter versus time or parameter versus parameter format. The vertical axis plot range is scaled to the engineering units specified in the parameter data base. This data display is shown in Figure 8.

CONCLUSION

The Navy operators have been pleased with the AERO system. Its menu driven software has made it very user friendly. By providing many different forms of data display, AERO allows operators to easily analyze data from missile tests. The AN/DKT-71 upgrade adds increased capability to the field proven system. In short, AERO has proven to be a reliable telemetry receiving system with few shortcomings.

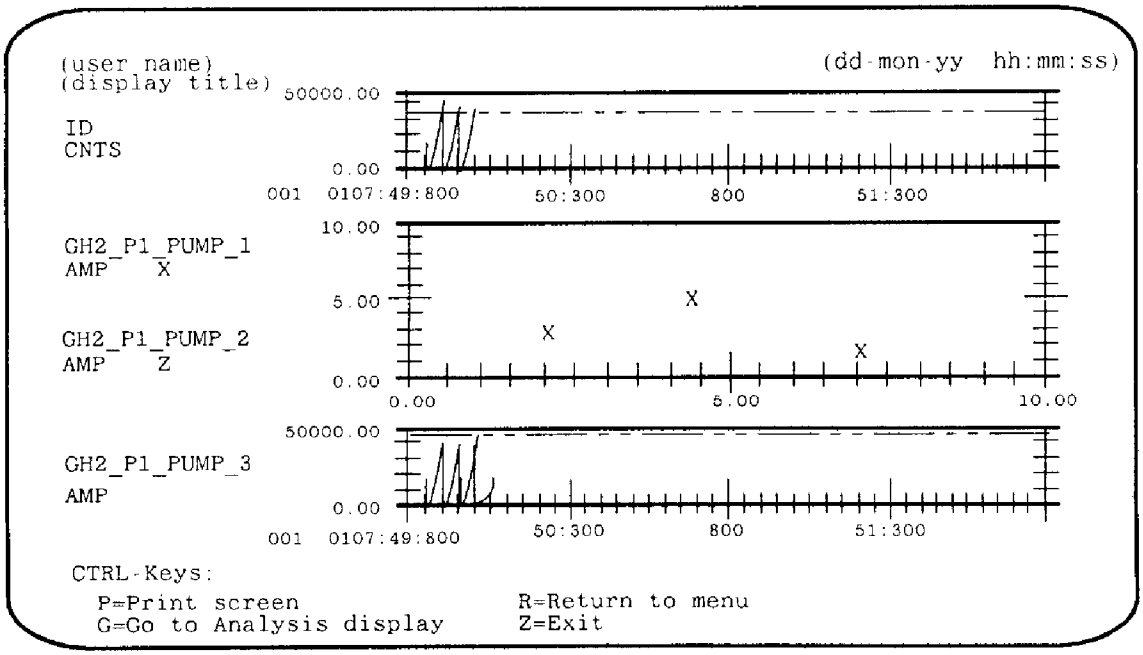

Figure 8 Graphic Display - Data