THE DEVELOPMENT OF APPLICATION SOFTWARE FOR TELEMETRY GROUND STATION REMOTE CONTROL AND ANALYSIS

Dwight M. Peterson PA
10 Telemetry/Telecommunications
Naval Warfare Assessment Division
P.O. Box 5000
Corona, CA 91718-5000
Commercial: (909) 273-5172, DSN: 933-5170

ABSTRACT

Fleet telemetry stations were established in the 1965-1972 time frame to satisfy U.S. Navy requirements for weapons system training support. These stations are currently located at the Atlantic Fleet Weapons Training Facility (AFWTF), Puerto Rico; Naval Air Station (NAS) Oceana, Virginia; the NATO Allied Missile Firing Installation (NAMFI), Crete, Greece; and White Beach, Okinawa, Japan. The mission of these telemetry stations is to collect, record, and process telemetered missile data during exercises involving ships and aircraft. The Naval Warfare Assessment Division uses the data to analyze weapons system performance during missile firing exercises conducted on fleet training ranges associated with these telemetry stations.

Since these stations were originally installed, missile weaponry has advanced in sophistication, complexity, and usage. New weapons and tactics have been developed and introduced into the fleet which have not been matched by corresponding technology enhancements in the existing fleet telemetry stations. As a result, the Program Manager for Tactical Training Ranges (PMA-248) tasked the Naval Warfare Assessment Division to develop a computer-controlled telemetry ground station design capable of meeting current and future fleet training range requirements. This program involved the design, procurement, integration, and testing of telemetry ground station hardware and software required to meet fleet telemetry data collection requirements. Full Operational Capability of the first system, which was installed at AFWTF in Puerto Rico, was achieved in March of 1994.

To date, the new telemetry ground station hardware and software has been used to support complex fleet training exercises, Combat System Ship Qualification Trials, Development Tests, and Operational Tests of U.S. and foreign navies. This paper will

present the hardware and software design principles used to develop a computer-controlled telemetry ground station and the demonstrated performance benefits which have been realized.

INTRODUCTION

1. Mission Description

a. The mission of the fleet training range telemetry stations is to collect, record, and process telemetered missile data during exercises involving ships and aircraft. The Naval Warfare Assessment Division (NWAD) uses the data to analyze weapons system performance during missile firing exercises conducted on the fleet training ranges associated with these telemetry stations.

2. Telemetry Data Collection Process

a. The existing telemetry data collection process is shown in figure (1). This figure illustrates data being collected for air-, surface-, and subsurface-launched telemetered missiles. Telemetered targets are also supported.

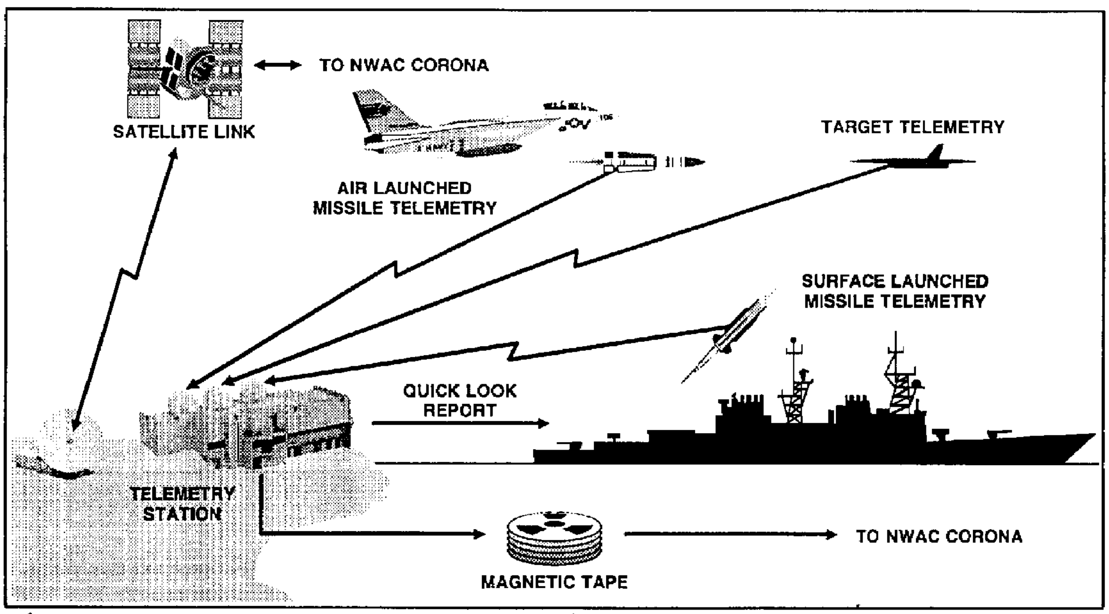

Figure 1 - Telemetry Data Collection Process

3. Navy Training Ranges Supported

Fleet training range locations are shown in table (1).

4. Goals and Objectives

Specific goals and objectives of the fleet training range telemetry stations are identified in table (2).

APPROACH

1. Scope

The paper will discuss the development and application of computer software to (1) remotely control telemetry ground station hardware, (2) analyze telemetry data during fleet on-range exercises and (3) perform reconstruction and analysis of fleet exercises.

2. System Description

In addition to the development of automation software, a new telemetry ground station design was developed to overcome deficiencies in existing equipment and to allow remote computer control of all subsystem hardware. This new hardware design and application software allows automatic station setup and control of all subsystem equipment associated with tracking, receiving, recording, and displaying missile telemetry data. Additionally, it allows rapid station

Training Range	Location
Atlantic Fleet Weapons Training Facility (AFWTF)	Naval Station Roosevelt Roads, Puerto Rico
Pacific Missile Range Facility (PMRF)	Kauai, HI
Naval Air Station (NAS) Oceana	Oceana, VA
NATO Allied Missile Firing Installation (NAMFI)	Souda Bay, Crete, Greece

Table 1 - Fleet Training Range Locations

- Acquire data from every telemetered missile fired at AFWTF, NAS Oceana, NAMFI, WESTPAC, and PMRF
- Provide real-time and post exercise data requested by missile analysts for the generation of ‘quick rep’ message feedback to the fleet
- Satisfy specific fleet requirements for data collection and reduction for individual firings and scenarios to develop final firing reports
- Satisfy fleet and analyst requirements for portable telemetry data acquisition and processing instrumentation
- Provide real-time or re-transmission of acquired telemetry data from AFWTF or PMRF to NWAD to perform in-depth missile or combat system analysis.

Table 2 - Fleet Training Range Telemetry Station Goals and Objectives

reconfiguration between air-, surface-, and sub-surface launched exercise scenarios and reduce training exercise costs accordingly. Telemetry data is interfaced directly to graphics workstations for real time and post exercise data display and analysis.

3. Design

The telemetry station design is made up of one or more subsystems as identified in figure (2). The type and number of each subsystem used at a potential operational site is determined by operational schedules and individual fleet exercise data collection requirements.

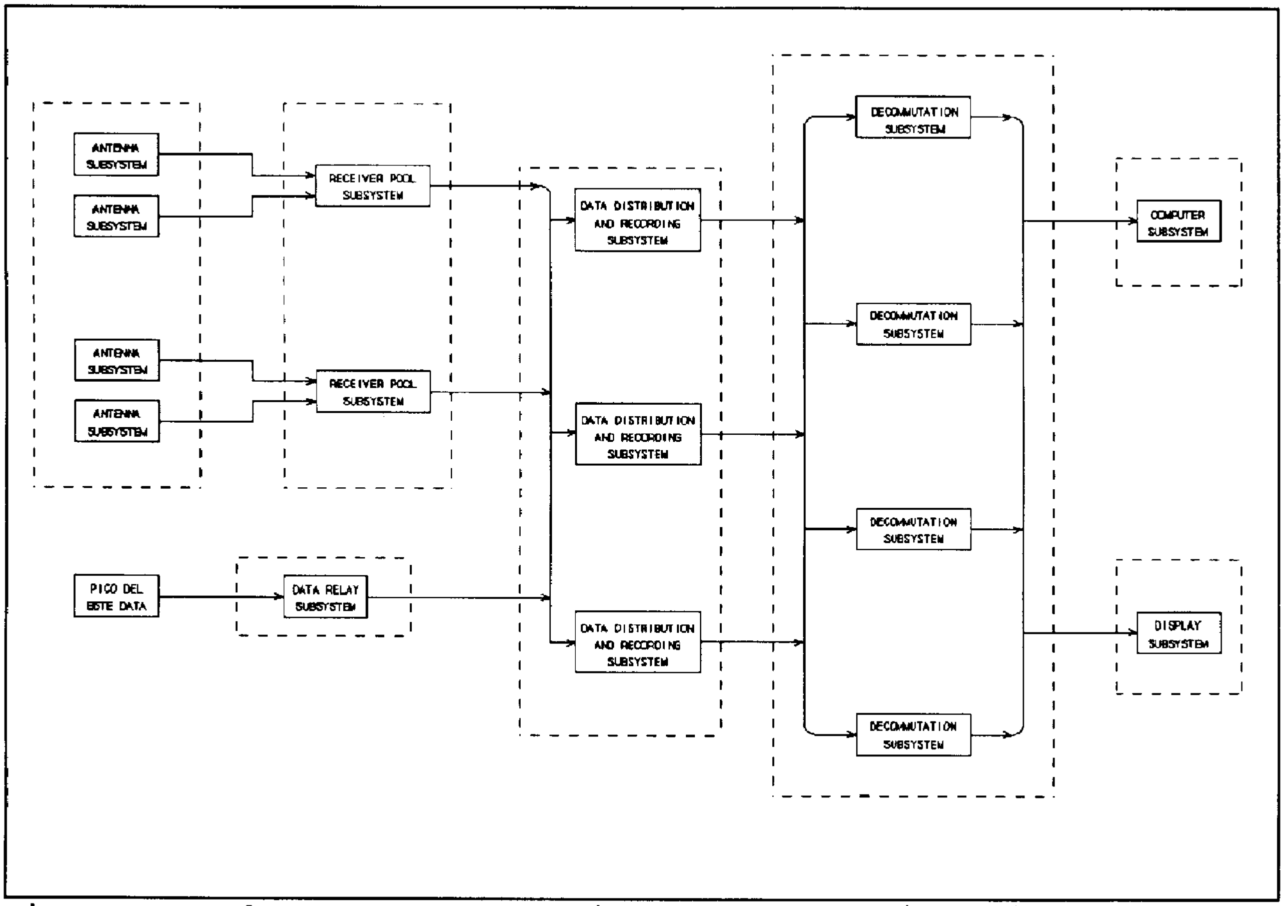

Figure 2 - Telemetry Ground Station Hardware Configuration

4. Computer Resources

All subsystem hardware is made up of non-developmental item (NDI)/commercial off-the-shelf (COTS) computer equipment. All software was developed and documented in accordance with MIL-STD-2167A. The system design includes pre-planned produced improvement (p^3I) features for (1) future growth (e.g., additional telemetered missile/target sources), (2) additional real-time/playback displays, and (3) expandable network, computer, and workstation systems.

5. Compatibility

Compatibility with other Navy, Air Force, and Army telemetry ground stations is required and will be maintained by incorporating Inter-Range Instrumentation Group (IRIG) standards for all hardware/software development efforts.

6. Critical System Characteristics

Critical system characteristics for the missile/telepac types supported, the quick-look analysis feedback requirements, the air-launched to surface-launched reconfiguration time, and the time allowed to complete end-to-end telemetry checks are identified in table (3).

REMOTE CONTROL SOFTWARE

1. Software Operation

Remote computer control of all telemetry ground station hardware subsystems is provided from a main-menu screen on a Vax 3100 workstation. All telemetry ground station hardware is organized into the three sub-menus identified in table (4).

- Antenna System
- Record/Decommutation
- Analyst Workstation.

Table 4 - Telemetry Ground Station Hardware Sub-Menus

Telemeters Supported

Missile	Telepack
HARPOON	DKT-46
PHOENIX	DKT-39, 50(STM)
RAM	DKT-31
SIDEWINDER	DKT-30(V65), 31(V69), DKT-58
SPARROW/ SEASPARROW	DKT-61, 73
STANDARD MISSILE I	DKT-27A/B/C,34A/B/C
STANDARD MISSILE II	DKT-53, 71
VANDAL (target)	DKT-36

Air to Surface Launched Reconfiguration - 5 min

End-to-end Telemetry Checks - 15 min

Table 3 - Critical System Characteristics

a. Antenna System. The antenna system sub-menu provides for the remote control of up to 14 telemetry antennas and up to 80 telemetry receivers. An antenna remote control screen was developed, as shown in figure (3), which duplicates many of the physical antenna control panel signals and displays the current tracking receiver frequencies. All operator front panel antenna controls are duplicated on this screen and can be changed by the workstation operator.

Another screen is provided to allow for display and control of the current antenna coverage superimposed on the top view of a firing range. An example of this screen using the North and South ranges at the Atlantic Fleet Weapons Training Facility (AFWTF) is shown in figure (4).

An additional screen is provided to display and control a matrix switch used to connect twelve independent data receivers to two antenna systems. Individual receiver parameters (i.e. RF frequency, IF bandwidth, etc.) can be setup or a missile can be selected by name when configuring the data receivers. Selecting a missile telepack by name will result in the individual receiver parameters to be setup automatically to reduce the overall setup time. The data receiver screen is shown in figure (5).

b. Record/Decommutation. The record/decommutation sub-menu provides for the remote control of up to 16 analog recorders and four decommutation subsystems. The screen to control the analog recorder inputs is shown in figure (6). This screen allows the workstation operator to select between four pre-configured video and pre-detection signals which originate from the tracking and data receiver outputs.

A screen is also provided to display the status of up to four decommutation subsystems. Each decommutation subsystem is capable of processing two Pulse Code Modulation (PCM), one Pulse Amplitude Modulation (PAM), one FM signal, and one video doppler signal. This screen, which is shown in figure (7), displays how each decommutation subsystem input signal is configured.

Another screen is provided to setup up to four decommutation subsystems as shown in figure (8). As with the receiver screen, the workstation operator can change parameters individually or select from a list of existing missile telemeters.

A screen is also available to display the status of all pen recorder, oscillograph, and 24-inch plotter devices as shown in figure (9). This screen shows the current decommutation subsystem assignments, missile telemetry format, and pen recorder bank configuration for all display devices.

c. Analyst Workstation. The analyst workstation menu provides for the use of the analysis software identified in table (5).

1. Warfare Assessment Model (WAM). In 1991, the Naval Sea Systems Command (NAVSEA) and the Naval Air Systems Command (NAVAIR) formed the Display and Debrief Working Group (DDWG) to investigate the large number of debrief systems in use throughout the Navy. The study group concluded that most of the current debrief systems were of limited application and were

hardware dependent. NAVSEA and NAVAIR endorsed the Naval Warfare Assessment Division's (NWAD) proposal to develop a common debrief system to support operator through Battle Group Commander level feedback for use across all current and future training programs. NWAD began WAM software development in 1992, and introduced it as a fleet debrief tool to support the Chief of Naval Operations' (CNO) Operational readiness Assessment (ORA) program. WAM was used to provide detailed feedback of a live firing exercise conducted at the Naval Air Warfare Center/Weapons Division to the afloat commander within 7 hours after completion of a training exercise. WAM has also been used to brief fleet exercise (FLEETEX) 'hot wash-up' results within 48-hours to second and third fleet commanders on the East and West coasts respectively.

- Warfare Assessment Model (WAM) for fleet battle group exercise reconstruction
- Surface Weapons Interactive Flight Technology (SWIFT) for surface launched missiles
- Multi-Source Interactive Data Analysis System (MIDAS) for AEGIS combat system data
- Advanced Medium Range Air to Air Missile (AMRAAM) Analysis

Table 5 - Workstation Menu Analysis Software

WAM is currently being used as the 'common' display and debrief tool for emerging Navy and joint programs including the Battle Force Tactical Trainer (BFTT), Large Area Tracking Range (LATR), and the Joint Tactical Combat Training System (JTCTS).

The WAM software is UNIX based and can run on any workstation which supports MOTIF (Version 1.1) and X Windows (Version X11 R4). Current capabilities of the WAM software are identified in table (6). Future enhancements of the WAM software are shown in table (7). A typical WAM graphics display is shown in figure (10).

2. Surface Weapons Interactive Flight Technology (SWIFT). NWAD has developed three dimensional graphical analysis software for reconstructing and analyzing combat and weapon system data. This software provides an interactive environment to display three dimensional intercept geometry based on actual telemetered data originating from standard missile firings. Using this software, a flight analyst is able to merge/correlate multiple data sources, generate function versus time plots, perform spectral analysis, reconstruct missile intercept geometries in three dimensions, and model missile warhead performance in three dimensions. A typical SWIFT graphics display is shown in figure (11).

3. Multisource Interactive Data Analysis System (MIDAS). NWAD has developed graphical analysis workstation software to assist with reconstruction,

• DIS compatibility • Direct fleet connectivity through NWAD's Warfare Assessment Laboratory (WAL) central cite telecommunications network to the Navy Tactical Control System, Afloat (NTSCA) • Use of sensor/threat/platform models to give artificial intelligence to simulated platforms for 'what-if' analysis and sensitivity studies.

Table 7 - Future WAM Software Capabilities

analysis, and capability assessment of surface missile system ships. This software provides an interactive environment in which combat system data from AEGIS ship systems and ground truth sources can be organized, manipulated, and viewed for detailed analysis purposes.

MIDAS was developed in conjunction with AEGIS program office (PMS-400) requirements to analyze combat system data during Combat System Sea Qualification Trials (CSSQT), Development Tests (DT), Operational Tests (OT), and fleet training exercises. A typical MIDAS graphics display is shown in figure (12).

• Realistic animated tactical displays in 2D and 3D • Multiple time-synchronized animated display windows • Navy tactical data system (NTDS) symbology and realistic silhouette symbol display • VCR-type control panel for play, reverse, search, etc. • World maps and constructive geography display • Static track display and editor • Data input from multiple sources • Automated performance measures and track correlation algorithm • X vs Y charts (e.g., range separation vs time) • Hard copy graphics output.

Table 6 - Current WAM Software Capabilities

4. <u>Advanced Medium Range Air to Air Missile (AMRAAM) Analysis</u>. NWAD makes use of Dataprobe, Range Doppler Matrix (RDM), and Analysis Software with Expert Reasoning (ANSWER) software packages to analyze AMRAAM telemetry data. The AMRAAM missile telepack contains over 4000 individual functions which are collected from the missile during flight. A graphics workstation and associated software are required to analyze AMRAAM data due to the large number of functions and dependence conditions within the AMRAAM telemetry stream.

Dataprobe is a software package that allows the analysis of large, complicated, multi-source telemetry data sets. Dataprobe has the capability to display data as function versus time, function versus function, spectral plots, histograms, polar plots, interactive labeling, and animated real time displays. Built in mathematical, logical, signal processing, and time series functions are also provided to support in-depth analysis. An example of a dataprobe graphics display is shown in figure (14).

The RDM software package was developed by the Air Force specifically to analyze AMRAAM filter processor data. NWAD uses the RDM software to display two and three dimensional graphics presentations to aid in the analysis of missile filter processor data.

The ANSWER software package was developed by the Mclaughlin Research Corporation as an automated tool to analyze AMRAAM telemetry data. NWAD used the ANSWER software to prepare telemetry data for use on PC-based workstations. The ANSWER software compiles various timelines of significant events and interrogates the behavior of critical missile functions. The analysis results can be imported into commercially available word processing packages such as Microsoft Word, Wordperfect, etc.

CONCLUSION

The remote computer control applications software successfully completed DT-IID technical evaluation testing at AFWTF in December of 1993. Initial Operational Capability (IOC) of this hardware and software was achieved in March of 1994. All performance objectives were met and the system is used to support fleet exercises conducted on the AFWTF range.

The observation and validation of tactical weapons systems in a highly complex analysis process. By continuing to improve the telemetry data collection and analysis process through the use of the hardware and analysis software presented in this paper, NWAD will be able to meet the challenge of providing effective feedback to the Navy and joint forces both now and in the future.

ACKNOWLEDGMENTS

The design, acquisition, integration, installation, and testing of telemetry hardware and software discussed in this paper would not have been possible without the dedicated assistance from individuals of the telemetry/telecommunications engineering (PA 11), Caribbean operations (PA 12), telemetry operations (PA 13) groups within the Naval Warfare Assessment Directorate. A myriad of obstacles were overcome in dealing with the encumbered procurement, military construction, ADP approval, DoD-INST-5000.2M, and SECNAVINST 5000.2A requirements.

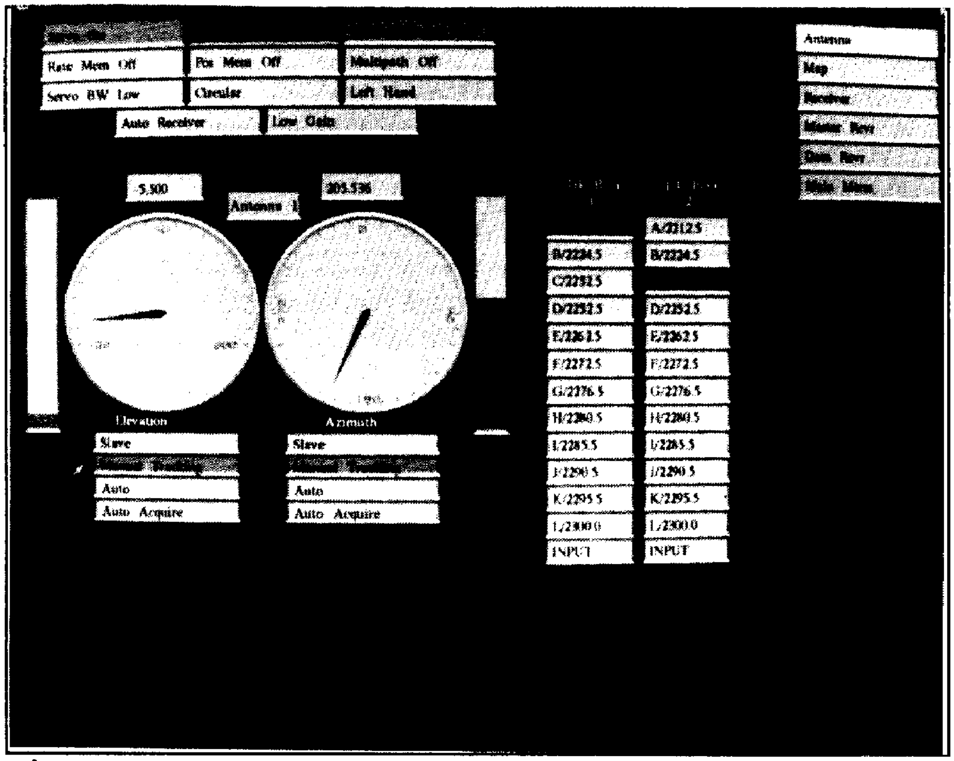

Figure 3 - Antenna Remote Control Screen

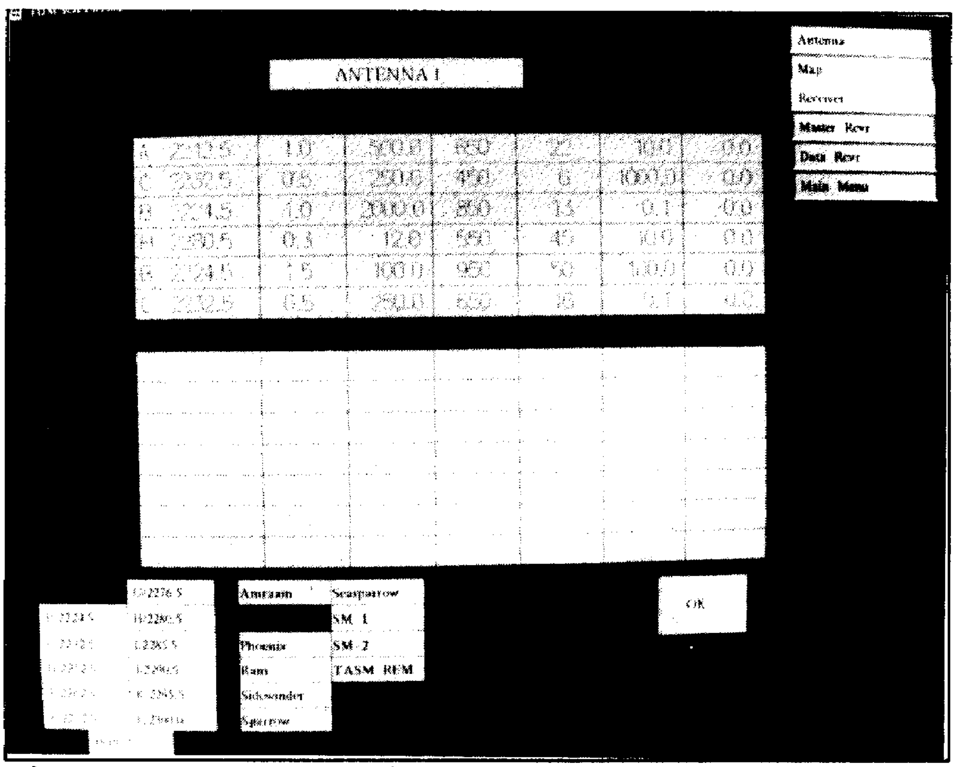

Figure 4 - Data Receiver Selection

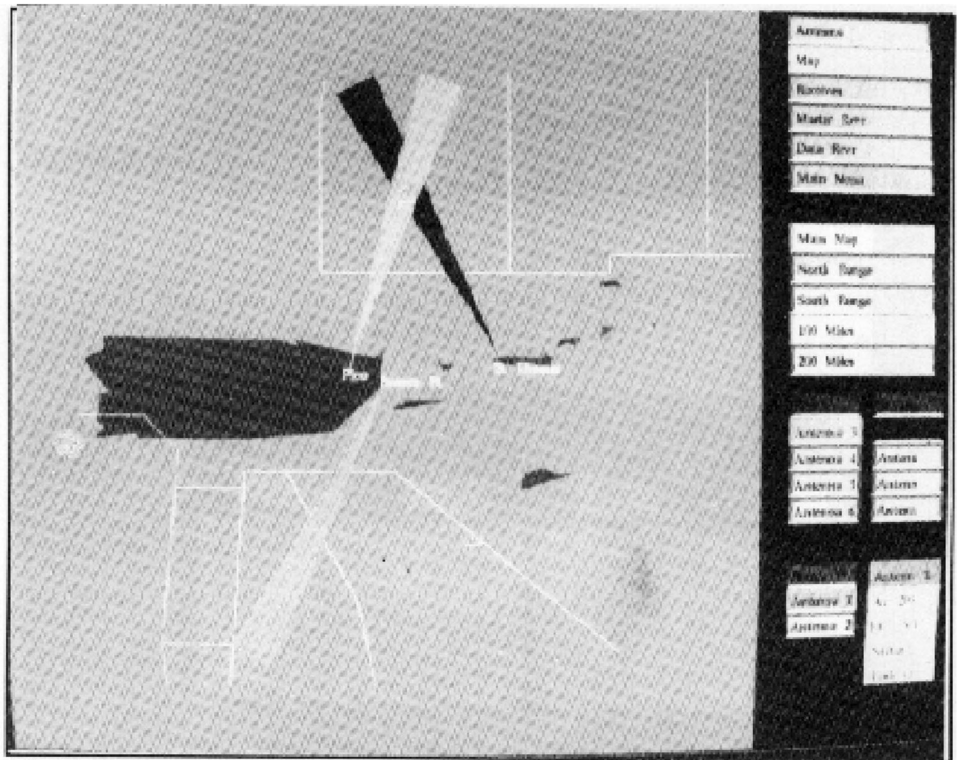

Figure 5 - AFWTF Antenna Coverage

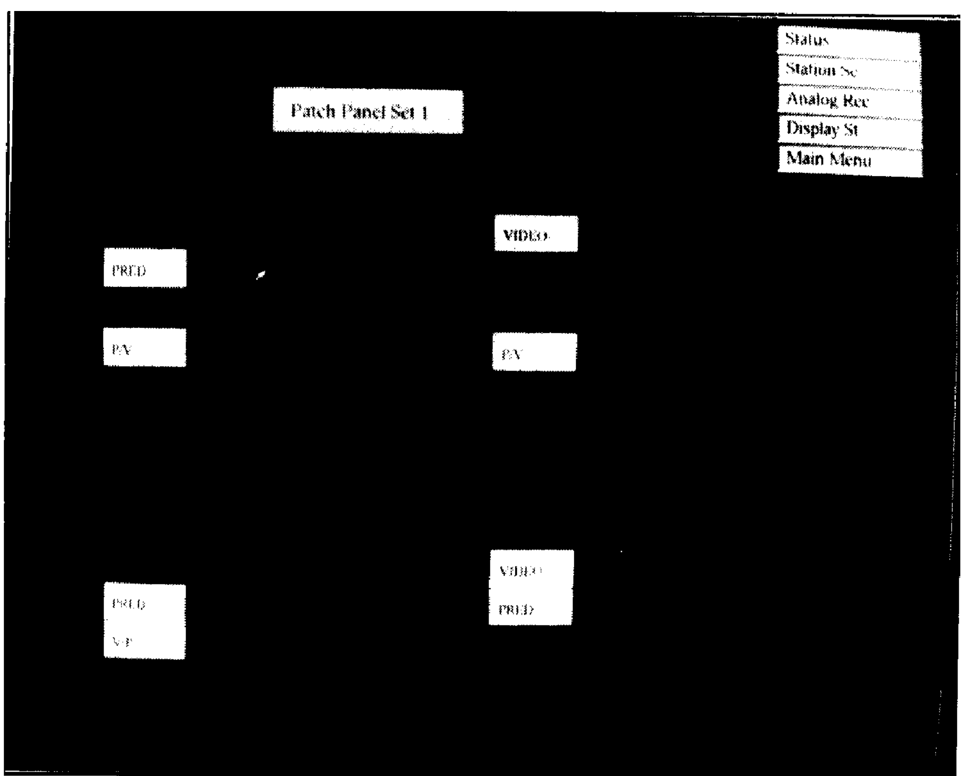

Figure 6 - Analog Recorder Input Control

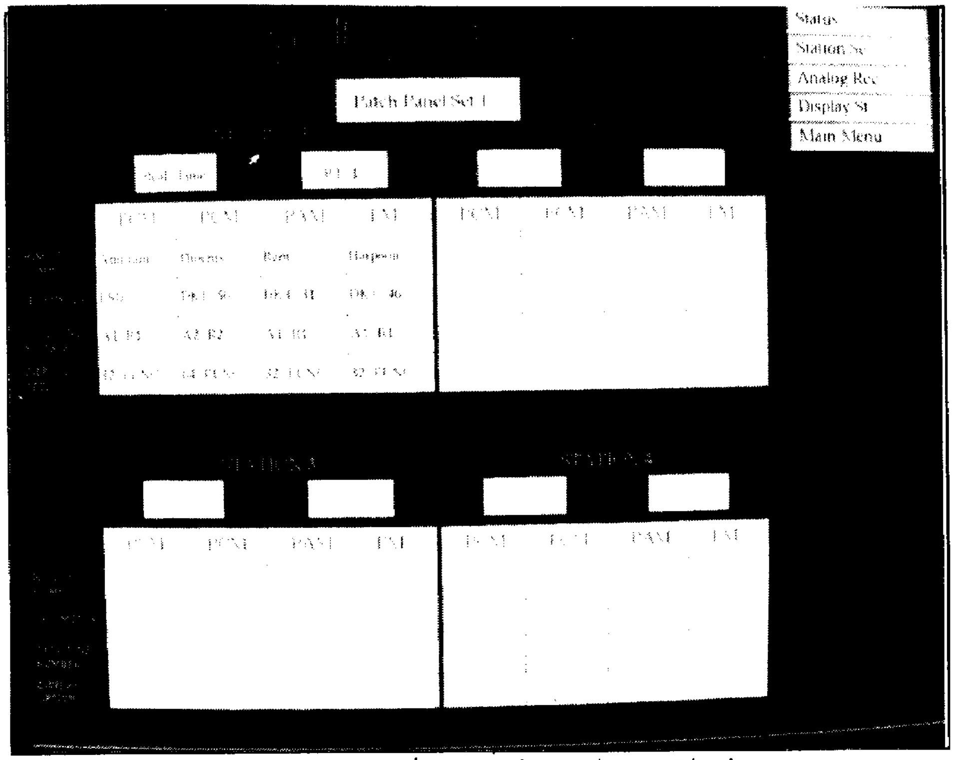

Figure 7 - Decommutation Subsystem Status

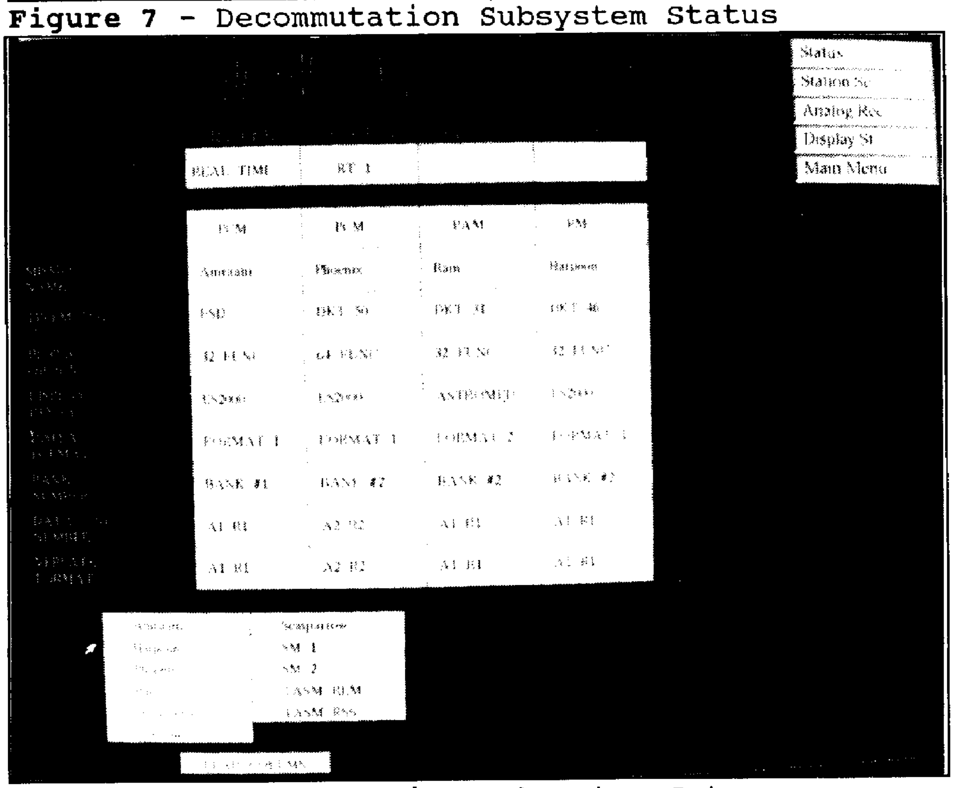

Figure 8 - Decommutation Subsystem Setup

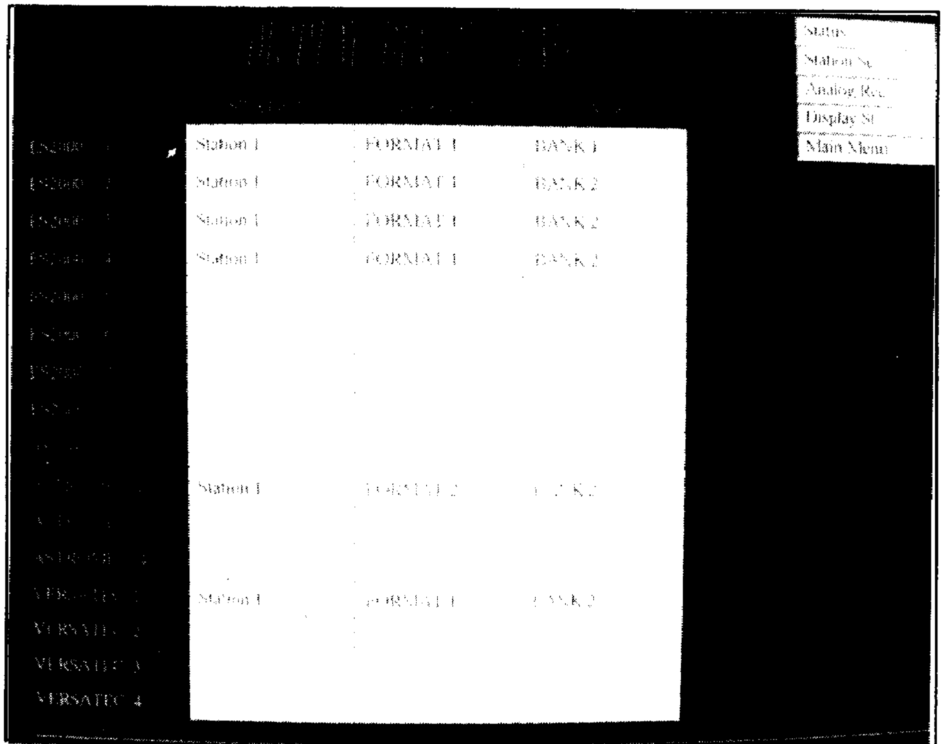

Figure 9 - Display Device Status

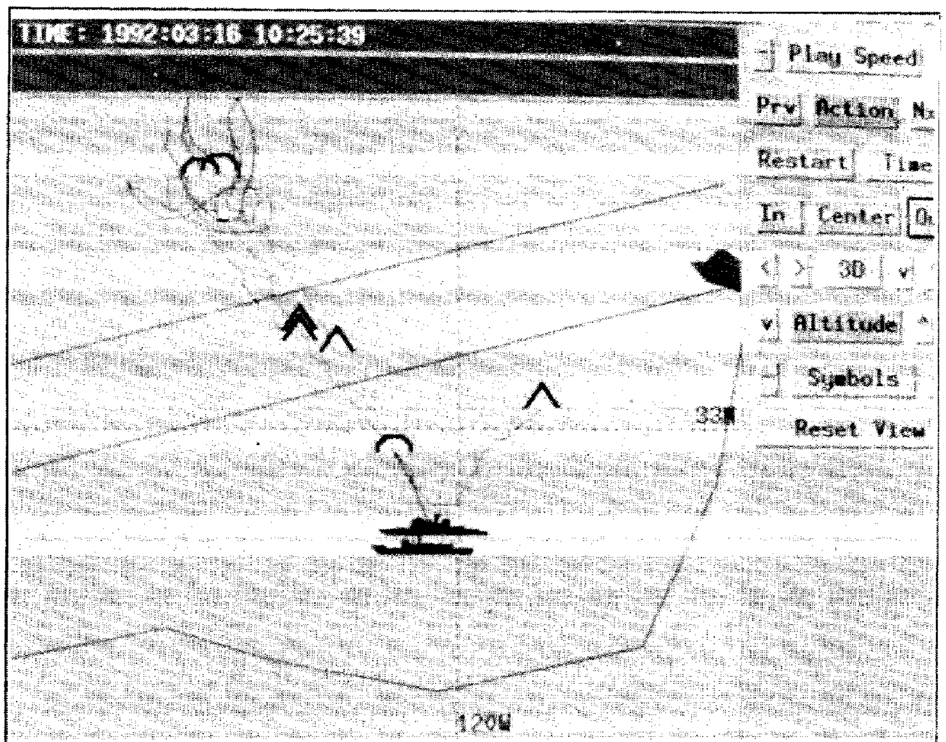

Figure 10 - WAM Graphics Display

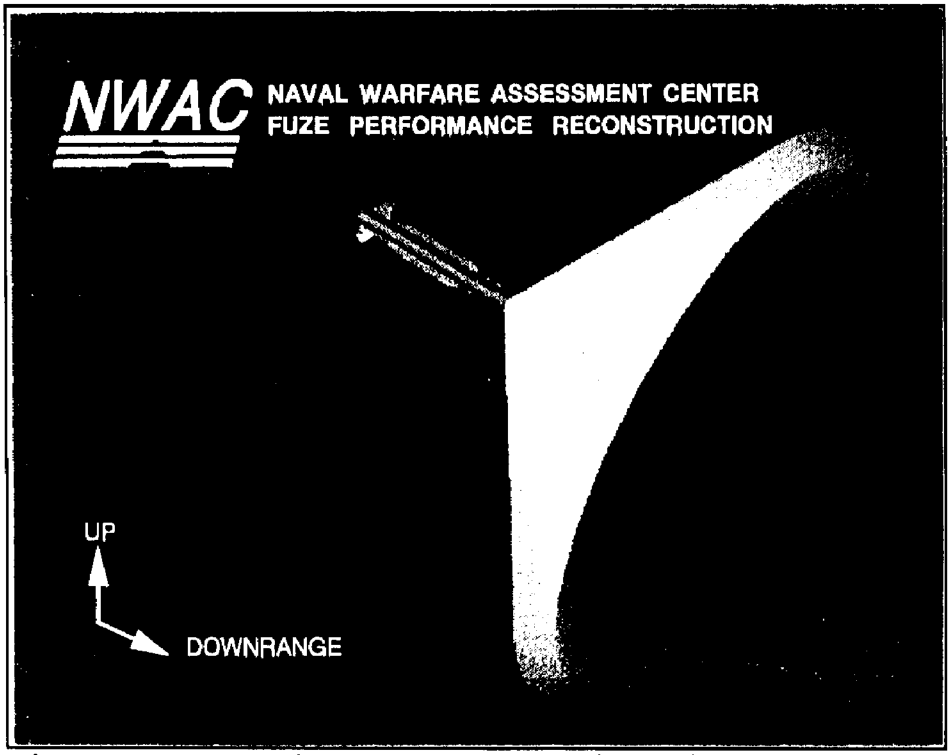

Figure 11 - Typical SWIFT Graphics Display

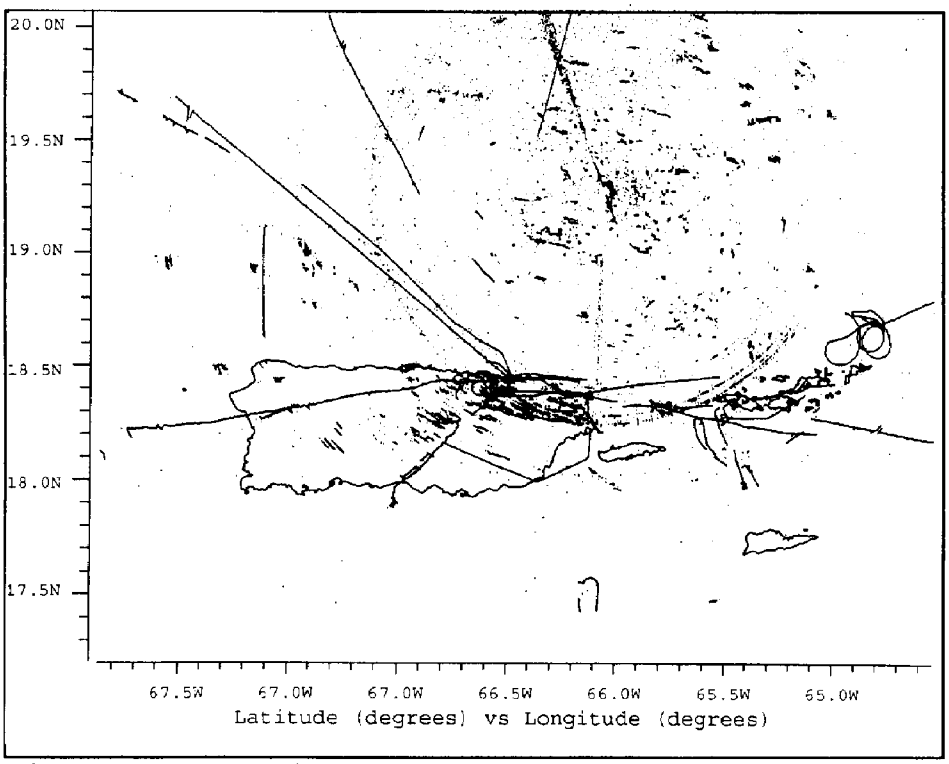

Figure 12 - Typical MIDAS Graphics Display

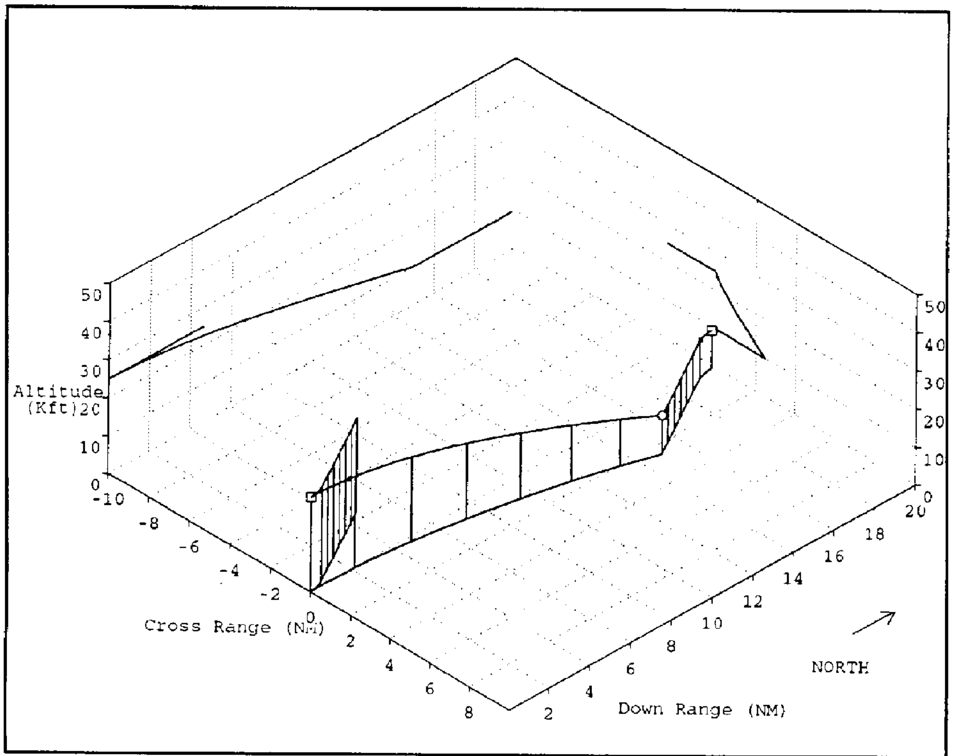

Figure 13 - Typical AMRAAM Graphics Display