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NAVSPASUR Sensor System Digital Signal Processing Receiver

Volume 1 —Hardware and Software Overview

CARL J. MORRIS
CAROLYN F. BRYANT
MARILYN P. EARL
TAMARA A. MYERS

Space Applications Branch
Space Systems Development Department

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Carl J. Morris, Carolyn F. Bryant, Marilyn P. Earl, and Tamara A. Myers

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13. ABSTRACT (*Maximum 200 words*)

This is a system description of the Naval Space Surveillance (NAVSPASUR) Sensor System Digital Signal Processing Receiver (DSPR). The NAVSPASUR system began as an advanced research project in June 1958, was commissioned as an operational Naval command in February 1961, and is operated by the Naval Space Surveillance Center (NSSC) in Dahlgren, Virginia. The DSPR is a real-time radar data acquisition and analysis system. Its function is to detect, with no prior information, all space objects whose orbits cross the continental United States and to compute their subsequent orbits. It provides vital satellite information in support of national defense mission objectives of space intelligence, satellite attack warning, satellite intercept support, and space mission support. This system description was prepared as part of a modernization program that has replaced DSPR hardware for which parts are no longer available.

Volume 1 (NRL/FR/8154--93-9577) describes the DSPR system in terms of current operation and hardware and software environment. Functions of the major subsystems and the relationship between them are discussed.

Volume 2 (NRL/FR/8154--93-9578) discusses the function and capabilities of software and hardware components of the subsystems that provide the digital functions of the DSPR. For each subsystem, individual software modules and hardware components used primarily by that subsystem are described.

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NAVSPASUR SENSOR SYSTEM
DIGITAL SIGNAL PROCESSING RECEIVER

Volume 1
Hardware and Software Overview

1. INTRODUCTION

This is Volume 1 of a four-volume system description of the Naval Space Surveillance (NAVSPASUR) Sensor System Digital Signal Processing Receiver (DSPR) hardware and software. The hardware was developed by the Naval Research Laboratory (NRL) for NAVSPASUR. The original software was designed by NRL and developed jointly by Digital Equipment Corporation (DEC) and NRL. The modernized software described in this volume was designed and developed by NRL.

The NAVSPASUR system began as an advanced research project in June 1958. In October 1960 the project was transferred from the Advanced Research Projects Agency to the Navy, and was subsequently commissioned as an operational Naval command in February 1961. Since then, it has been operated by the Naval Space Surveillance Center (NSSC) in Dahlgren, Virginia. The NSSC is responsible to the Chief of Naval Operations for support to the operating forces of the United States Navy, and is under the operational control of the U.S. Space Command, Colorado Springs, Colorado, for those space object data collection functions that are part of the National Space Detection and Tracking System (SPADATS).

1.1 Purpose and Scope

This volume presents an overview of the hardware and software of the DSPR system. Volume 2 describes the function and capabilities of the individual software and hardware components of each subsystem. Volume 3 describes the operating system functions required by the applications software. Volume 4 discusses hardware interfaces between the major subsystems of the DSPR.

The documentation supports a project that has replaced DSPR hardware for which replacement parts are no longer available. Hardware replaced included the DEC PDP-11/60 minicomputers that served as the central processors for the DSPR system, the Floating Point Systems Array Processors that performed fast Fourier transforms on data from the alert antennas, and various interface hardware. New hardware installed includes DEC VAX 4000 Model 200 (VAX 4200) minicomputers, CSPI MAP 4000 array processors, and updated interface hardware. All new hardware and associated software was required to interface with the rest of the existing system. The new software was required to replicate all the functions of the existing software.

The set of documents describes the DSPR system in terms of its current functionality with modernized hardware and software. It will serve as a baseline description from which future specifications for upgrades to hardware and software may be drawn.

Manuscript approved June 2, 1993.

2. SYSTEM OVERVIEW

The Digital Signal Processing Receiver is a real-time radar data acquisition and analysis system. In the sections that follow, the DSPR is described in terms of current operation, hardware environment, and software environment.

2.1 Current Operation and Purpose

The function of the NAVSPASUR system is to detect, with no prior information, all space objects whose orbits cross the continental United States and to compute their subsequent orbits.

NAVSPASUR is a multistatic continuous-wave radar system operating as a large radio interferometer, with nine stations located along a great-circle path across the southern United States. The inclination of the great circle is 33.57 degrees with respect to the equator.

The system consists of three transmitters and six receivers. The stations are located as follows:

<u>Transmitters</u>:
- Jordan Lake Station, Wetumpka, Alabama
- Lake Kickapoo Station, Archer City, Texas
- Gila River Station, Maricopa, Arizona

<u>Receivers</u>:
- Tattnall Station, Glennville, Georgia
- Hawkinsville Station, Hawkinsville, Georgia (high altitude)
- Silver Lake Station, Hollandale, Mississippi
- Red River Station, Lewisville, Arkansas
- Elephant Butte Station, Truth or Consequences, New Mexico (high altitude)
- San Diego Station, Chula Vista, California

Each transmitting station radiates a continuous wave of radio energy that combines with the other transmitting stations' beams to form the NAVSPASUR "fence." When an object, such as a satellite, enters the fence, a small fraction of the radio energy is reflected to one or more of the receiver sites. The receiving stations use large multiple-array interferometers to detect the reflected signal and to measure its angle of arrival. The transmitter and receiver arrays are cross-polarized to prevent the transmitted energy from reaching the receivers without having been reflected from a space object. Each receiving station transmits phase and amplitude data, along with frequency identifiers, statistical measures, and time stamps to the NAVSPASUR Processing and Operations Center at the NSSC in Dahlgren via a dedicated telephone line, where local direction angles for each object are computed.

The antenna data available at the receiver stations can be processed to produce three types of data: full-Doppler, half-Doppler, and quarter-Doppler. These three types are also referred to as low-altitude, mid-altitude, and high-altitude, respectively. The output of the full-Doppler data is far more important than either the half- or quarter-Doppler data. For this reason, production of the full-Doppler data by the DSPR system takes priority over half- and quarter-Doppler processing. The purpose, then, of each DSPR is to provide a continuous stream of full-Doppler data to the NAVSPASUR Processing and Operations Center.

2.2 DSPR System Philosophy

The DSPR system philosophy stems directly from the system purpose. This system is designed to run continuously, with any single component failure resulting in, at most, a very short (less than a minute) interruption in full-Doppler data processing. For this reason, each DSPR actually consists of two systems that duplicate each other. One of these systems normally handles the full-Doppler data from the antennas and is called the primary system. The other system normally handles the half- and quarter-Doppler data and is called the secondary system. If the primary system malfunctions and is no longer able to process data, the secondary system detects the failure and declares a "primary system failure." The secondary system then reinitializes itself to become a primary system. This reinitialization process occurs only in the secondary system. If, under normal conditions, the secondary system malfunctions, the primary system detects the failure, but does not attempt to process the half- and quarter-Doppler data. This dual system philosophy is embedded into every aspect of the DSPR system.

2.3 DSPR Functional Description

The following sections briefly describe the functions of the major subsystems of the DSPR. Figure 1 diagrams the components. The diagram shows one system; most components are duplicated and occur in both systems. This provides the dual system capability discussed above.

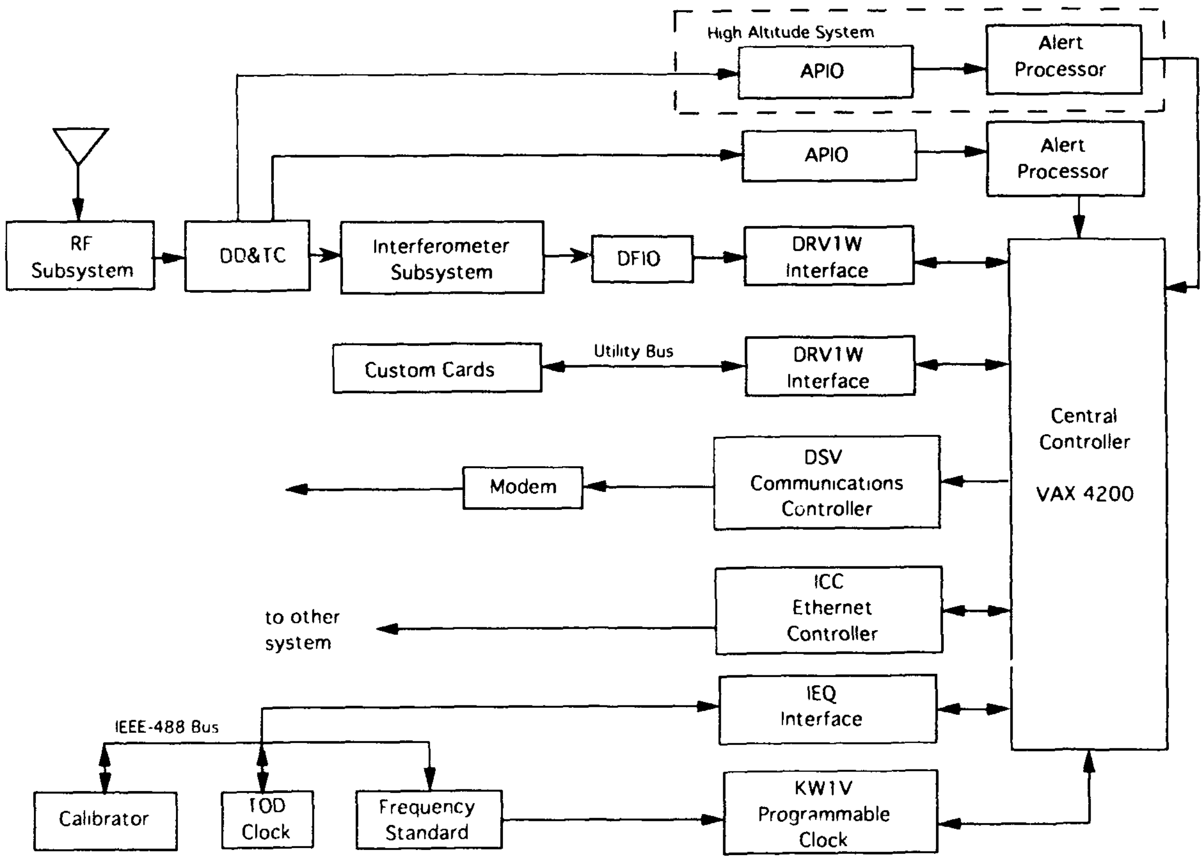

Fig. 1 — NAVSPASUR Digital Signal Processing Receiver block diagram

2.3.1 *Central Controller Subsystem*

The Central Controller Subsystem is responsible for running the software that monitors and coordinates all the actions of the DSPR. This includes controlling all the other subsystems: Target Detection and Selection, Interferometer, Calibration and Diagnostic, Interprocessor Communications, Data Processing, Hardware Control, and Data Line Communications.

2.3.2 *Target Detection and Selection Subsystem*

The Target Detection and Selection Subsystem performs the initial detection of targets that enter the NAVSPASUR fence. It analyzes each target's reflected signal and compiles the data into target lists that identify the signals by frequency and relative signal strength. These lists are passed to the central controller, which then initiates the interferometer data collection tasks.

2.3.3 *Interferometer Subsystem*

Once a list of targets is generated by the Target Detection and Selection Subsystem, up to three targets are selected by each central controller, and the digital filters for that system are tuned to gather data. The accumulated data is provided to the central controller for formatting and transmission to the NSSC.

2.3.4 *Data Processing Subsystem*

Interferometer antenna data is converted to phase and amplitude measurements and formatted for transmission to Dahlgren, Virginia.

2.3.5 *Data Line Communications Subsystem*

The Data Line Communications Subsystem is responsible for interfacing the DSPR system to the communications line to the NSSC. Its function is to transfer data between the DSPR and the NSSC with the necessary communications protocol.

2.3.6 *Interprocessor Communications Subsystem*

The two central controllers communicate with each other via the Interprocessor Communications Subsystem. This subsystem is used by each half of the DSPR to detect failures in the other half and to coordinate operations between the two systems.

2.3.7 *System Timing Subsystem*

The System Timing Subsystem maintains the DSPR system timing accuracy and provides time stamping for data that is sent to the NSSC. The system time has both a hardware and software component. Four hardware clocks are used overall in maintaining precise system time and updating the software clock once per second.

2.3.8 *Calibration and Diagnostic Subsystem*

The Calibration and Diagnostic Subsystem allows the operator to check the status of various hardware components of the system. It also generates calibration constants, used to process interferometer data.

2.3.9 Utilities Control Subsystem

This subsystem is used to configure the customized hardware of the DSPR system. These items include the timing generator, local oscillators, data distribution and test card, array processor input card, and several command and status modules which are connected to the "utility" bus.

2.4 Hardware Overview

This section briefly describes the major hardware components of the DSPR. The description covers the hardware of the primary system. Most of the components are duplicated in the secondary system to provide the redundancy necessary for the dual system approach, in which either the primary or the secondary system can process the essential full-Doppler data.

2.4.1 Central Controller Subsystem

The hardware of the Central Controller Subsystem consists of a DEC VAX 4000 Model 200 (VAX 4200) with attached peripherals and communications components. It runs the operating system VMS version 5.4-3 and uses the Qbus as its communications bus.

Hardware used by the operator's console consists of a cathode-ray tube (CRT) terminal and a hardcopy terminal. The CRT is a DEC VT420, operated at 9600 baud. The CRT on the primary system is the only source for operator input into the DSPR system. The hardcopy terminal is a DEC LA120 operated at 9600 baud; it provides a log of system messages from both primary and secondary systems. No input commands can be entered from the hardcopy terminal.

2.4.2 Target Detection and Selection Subsystem

Hardware used by the Target Detection and Selection Subsystem consists of the alert antenna, the RF subsystem, and an array processor. The alert antennas are a subset of the receiver antennas, whose outputs are combined electrically to provide a usable signal before the interferometer antennas do. The RF subsystem converts the analog outputs from the antennas to digital form.

The array processor is a CSPI MAP 4000, which performs fast Fourier transforms on the data from the alert antenna. The array processor is connected directly to Qbus and a shared memory common is used to transfer data to main memory of the CPU.

2.4.3 Interferometer Subsystem

Hardware used by the Interferometer Subsystem includes the digital filters (DFs). There are three DFs in the primary system and three in the secondary. Each DF is interfaced to the Qbus by a DEC DRV1W 16-bit parallel port.

2.4.4 Data Line Communications Subsystem

Communications to the NAVSPASUR Processing and Operations Center at the NSSC is controlled by a DSV11 synchronous communications controller. Data is transferred by a Codex V.3225 modem through a dedicated line at a rate of 9600 baud.

2.4.5 Interprocessor Communications Subsystem

Hardware used by the Interprocessor Communications Subsystem consists of an Ethernet line that provides communications between the two VAX 4200 CPUs.

2.4.6 System Timing Subsystem

Four types of clocks are used for maintaining system timing accuracy and for time stamping the data that is sent to the NSSC. A Hewlett-Packard 59309A HP-IB digital clock, shared by both systems, provides the time in months, days, hours, minutes, and seconds. The year is read from the central controller's internal clock. Each system's central controller contains a KWV11C programmable real-time clock that refines the timing resolution to 0.1 ms for time stamping all data. A Hewlett-Packard 5061B cesium beam frequency standard provides the precise 5 MHz and 1-pulse-per-second signals for system timing.

2.4.7 Utilities Control Subsystem

Several components provide interfaces between the central controller and the other subsystems, alarm sensors, and the phone line to the NSSC. These include the data distribution and test card, phone relay cards, Command Status Modules (CSMs) and a DRV1W general purpose digital input/output interface.

2.5 Software Overview

The DSPR software is organized in functional modules. The software system runs under the VAX VMS V5.4-3 operating system, which includes full support for the DRV1W general purpose digital input/output interfaces. Also used are the VAX Fortran version 5 optimizing compiler, with its associated run time support routines, and the CSPI MAP 4000 MBFORT Fortran compiler and its scientific subroutine library.

2.5.1 DSPR Software Functions

The DSPR software, which runs in the central controller, monitors and coordinates all the actions of the DSPR. It controls the target detection and selection functions, tunes the interferometer s hat data can be collected, formats the collected target data, and passes the data to the communications subsystem, which then sends it to the NSSC. At the same time, it monitors the central controller in the other half of the DSPR and responds to operator commands. In off-line mode, it performs calibration and diagnostic functions.

2.5.2 Software Organization

There are separate procedures for each function, and the procedures operate as independent processes. The central controller process, SYSMON, is executed as an interactive process by the operator. It, in turn, starts the other processes as "detached" processes. The detached processes are not "attached" to a terminal or a user that is logged onto the system. These processes operate in an asynchronous fashion. That is, activation of a procedure is event driven and does not occur in a regular sequence. For example, the interferometer data collection task becomes active only when a target is detected by the system. The various processes are discussed in Sections 3 through 11.

2.5.3 Interprocess Communications

Three techniques are used for interprocess communications: group global event flags, shared global commons, and mailboxes. Each process has a mailbox, to which the other processes can send "messages," i.e., small packets of data and commands. The processes are also linked to a set of common event flags. Any process can set or clear any of the event flags and any process can read or wait for any of the event flags to be set. There are also several shared common blocks with which the processes are linked.

2.5.4 Shared Common Blocks

The software system uses a database (DSPCOM) that contains static and dynamic parameters used by various components of the software. It also contains variable locations which are used for communications between procedures. The parameters include values describing the characteristics of the receiver station. Since each receiver site has special requirements (such as noise thresholds, biases), each database is unique. Thus the database serves to tailor the DSPR software to individual stations. The database is implemented as a global section to which the various procedures are linked. Appendix A describes the implementation and layout of the database.

There are also three target common blocks which are used to store the data from the digital filters. The individual data collection processes (ADC1, ADC2, and ADC3) are linked to their separate common blocks, while the Data Processing (DP) procedure is linked to all three. A Transport Control Buffer (TCB) common is used to pass data, ready for transmission to the NSSC, from DP to the Data Line Communications process (DLC).

The Target Selection (TRGSEL) process uses a shared memory window to pass data from the MAP 4000 to the VAX 4200. The shared memory window is a piece of MAP memory which is addressable both from the MAP and from the VAX. Therefore, either device can modify locations in the shared memory and the other device can read the same locations. This technique is used to pass parameters to the MAP and by the MAP to pass the target lists.

2.5.5 Operational Goals

The following operational goals apply to all of the software components or relate to their integrated operation.

Full Capability Operation: Each of the software components must have the capability to handle both the primary system (full-Doppler data) and the secondary system (half- and quarter-Doppler data). For example, the alert antenna control component that is loaded at system bootstrap must be able to configure itself for either primary or secondary operation.

Integrat System Throughput Requirements: All DSPR system components must provide meaningful data to Dahlgren in a timely fashion. The requirement is that data from each one-second observation in the full-Doppler region of a target must be sent to Dahlgren less than five seconds after it is first detected by the alert antenna. Secondary throughput times must be comparable to the full-Doppler times once data collection is complete.

3. SYSTEM MONITOR AND CONTROL (SYSMON)

3.1 Description

SYSMON, which is the most complex procedure of the DSPR system, has three major functions: initializing all other procedures, controlling the system operation, and serving as the interface between the operators and the system.

After a DSPR central processor is booted and the system operator logs onto the computer, the operator runs the SYSMON image and DSPR initialization is begun. Initialization is separated into two phases. Phase one occurs only at boot time; phase two occurs both at boot time and when a system reinitializes itself from a secondary to a primary. During initialization, the system monitor first determines whether the other CPU is operating as a receiver. If it is, SYSMON initializes its CPU as a secondary system; otherwise, it initializes it as a primary system. This function is performed by initializing the interprocessor communications subsystem, which attempts to communicate with the other computer over the Ethernet communication line. If no response is received, the other computer is assumed to be not operating.

Any failures detected during initialization are reported on the console subsystem, which consists of a CRT plus a hardcopy terminal.

3.2 Software Interface

The system monitor interfaces to all other components of the DSPR software. Once the system is initialized, error conditions discovered by other software system components are passed to SYSMON to be displayed as error or warning messages on the console subsystem. When one of these messages is displayed, an alarm sounds until the operator acknowledges the message.

The system monitor also interfaces with the system monitor component of the other half of the DSPR. To provide a single unambiguous operator interface to the system, only one console subsystem allows access to the DSPR system. Thus, processing parameters are passed from the primary system to the secondary system; error messages from any component of the secondary system are passed to the primary system for display.

The system has two states: idle and active. In the active state, target data is being collected, processed, and transmitted to the NSSC. In the idle state, the target selection procedure does not send target collection requests to the interferometer data collection tasks.

3.2.1 Operator Interface

The system monitor serves as the operator interface to the DSPR system. The operator commands the system through a multilevel menu-driven interface. The menus and commands are described in Appendix B. Operator commands cover three areas: changing the system state, examining or modifying system parameters, and requesting on-line calibration and diagnostic (C&D) procedures. The operator also receives the results of C&D procedures and other informational messages under software control. Message types and formats are described in Appendix C. All commands, data, and messages are displayed only on the primary system.

3.2.2 Procedure Interface

In the primary system, the system monitor component interfaces to every other component of the DSPR software system and to the system database (DSPCOM). It is also the point from which the operator controls both systems. In this centralized approach, messages to and from other components in either system emanate from or are directed to the system monitor on the primary system.

The system monitor component interfaces are detailed in Appendix D. Briefly, the interfaces are the initialization of the other processes of the DSPR; the operator interface, which is menu driven; control of the other processes through command messages sent to their mailboxes; and reporting status and error conditions sent by the other processes to its mailbox.

In the secondary system, the system monitor has the same interfaces. For reporting status and error conditions, however, the error and status messages are redirected to the system monitor procedure on the primary system, so that only one console and hardcopy device are active at any one time. On detection of a fatal error in the primary system, the operator message handling routine on the secondary system is responsible for shutting down the system, so it can reinitialize itself as the primary system.

3.3 Associated Hardware

3.3.1 VAX 4200 Central Controller

The VAX 4200 is a DEC Qbus based minicomputer. It has 32 MB of central memory, its processing power is 4.8 million instructions per second, and it runs the operating system VMS version 5.4-3.

3.3.2 Console Subsystem CRT Terminal

The CRT is a DEC VT420 operated at 9600 baud. The CRT is used to solicit information from the operator and is the only source for operator input into the DSPR system. All operator input comes from the CRT and goes into the system monitor procedure, which in turn forwards the input to the appropriate subprocedure. Only the CRT on the primary system can be used to enter input.

3.3.3 Console Subsystem Hardcopy Terminal

The hardcopy terminal is a DEC LA120 operated at 9600 baud. It logs any system messages onto a more permanent medium than the CRT screen. The operator cannot enter any input into the system through the LA120. All messages from both the primary and secondary system come to the primary system terminal.

4. TARGET DETECTION AND SELECTION

4.1 Description

The target detection and selection function (also called the alert function) determines the Doppler frequency of targets entering the system and sends that information to the interferometer data collection tasks.

The alert function is divided into two parts: the target detection procedure, which is performed in the MAP 4000 array processor, and the target selection procedure, which resides in the central processor.

The array processor code is a combination of library routines supplied by the manufacturer and user routines written in Fortran language.

4.2 Target Detection

The target detection function performs the initial detection of targets, analyzes each target, and compiles the data into target lists.

4.2.1 Primary Processing

The target detection function uses a fast Fourier transform (FFT) to generate a "comb" of narrowband filters that covers the system spectrum ($\pm$ 15 kHz from center). The signal on the alert antenna is digitized at a 75-kHz rate through the receiver for each antenna onto a multiplexed bus and transferred to the array processor by the custom array processor input/output (APIO) card through the MAP 4000 direct I/O (DIO) interface card. The DIO is programmed to operate in a "double-buffered" mode. Two arrays dimensioned at 2048 16-bit words are allocated. Once the input/output (I/O) starts, the first buffer is filled. After 2048 input samples are collected, the DIO signals that the first buffer is full and starts to fill the second buffer. This process continues in a "flip-flop" fashion as long as the procedure executes.

Once a buffer is marked full, the samples are converted to floating point and placed in memory in front of the last block of data which had been collected in the previous alert cycle. Then the data are windowed using a Blackman-Harris four-point minimum sidelobe window. A real-to-complex 4096-point FFT is performed. The output of the FFT is a complex measurement of the signal in each "bin" or filter. The bin spacing is equal to the sample rate divided by the number of points in the FFT, or 18.3 Hz. The windowing function doubles the bin width to 36.6 Hz.

Under certain atmospheric conditions, the direct energy from the transmitters (feedthrough) is received at the receiver sites. An infinite impulse response stop-band digital filter is used to remove this signal from the FFT outputs in the center of the system spectrum. This filter is designed to remove signals of up to 90 dBm level. Because of FFT filter overlap the stop-band filter must be applied to the center nine bins around zero Doppler. This filter, a six pole 3-Hz wide Butterworth stop-band filter, is designed as three double-pole sections in cascade. Two subroutines are used to perform the notch filter: PRI_NOTCH and FSECT. PRI_NOTCH sets up pointers to the data to be filtered and the filter coefficients for each section in turn. Then FSECT is called to perform the multiplications.

The power for each bin is then calculated by adding the squares of the real and imaginary parts. An exponential low-pass filter is applied to each bin to integrate low-level signals.

Then the spectrum is searched for targets. A constant false alert ratio (CFAR) threshold is determined using another infinite impulse response filter. The energy in each bin is compared to the threshold. When a bin is found with its energy greater than the threshold, the contiguous bin with the highest magnitude is determined. Because of filter overlap, high-magnitude signals will appear in more than one bin. The routine INSERT is called to add the location (Doppler) of these bins to a target list sorted by magnitude (highest first).

4.2.2 Half-Doppler Processing

The half-Doppler processing is performed by the secondary system and operates on the center 15 kHz of the system spectrum ($\pm$7.5 kHz from 0 Doppler). The secondary system functions like the primary.

except that 8096 buffers are used and a 16k-point FFT is performed. Since the output spectrum of the FFT is 37.5 kHz (half the sample rate), only the middle 4k bins are searched for targets. The width of the bins is 9.16 Hz with a bin spacing of 4.58 Hz.

4.2.3 Quarter-Doppler Processing

The output of the secondary FFT is a complex representation (amplitude and phase in rectangular coordinates) of the frequency content at each of 2048 separate locations in the system spectrum with a separation between bins of 4.58 Hz and a bandwidth of 9.16 Hz. Successive outputs of the secondary FFT may be thought of as time samples of the signal at that particular frequency. These samples are used as input data for another discrete Fourier transform (DFT). The complex outputs of the half-Doppler's FFT's center 1310 bins are saved for the quarter-Doppler processing.

Four successive full-Doppler samples for each bin are used in the DFTs. The sample period is 109.2 ms with four samples in the DFT; thus the fundamental frequency is 2.28 Hz. Since the input data are complex, four DFTs, spaced at 2.28-Hz intervals, can be calculated, but the DFTs for $m=2,3$ are redundant since they contain the information for $m=0,1$ in the adjacent bin. Therefore, only the DFTs for $m=0,1$ are performed.

4.2.4 High-Altitude Target Detection

The high-altitude stations differ from the low-altitude stations in two respects: the interferometer antennas are longer, 2400 feet vs 400 feet, and there are two 3600-foot alert antennas. The signals on the two alert antennas are added electronically in quadrature forming two alert beams, an East beam and a West beam. In order to search both beams, there are two MAP 4000 array processors on each half of the system, for a total of four, at the two high-altitude stations. The processing pe formed in each array processor is the same as at the low-altitude stations except that each array processor sends a target list to the VAX 4200. The target selection process merges the two lists before the targets are actually selected.

4.3 Target Selection

The target selection procedure (TRGSEL) is responsible for determining which targets detected by the alert antenna are monitored by the interferometer antennas.

4.3.1 Functionality

TRGSEL coordinates the interaction between the alert antenna and the interferometer antennas. The basic function of this component is to select targets from the lists generated by the array processor and to initiate interferometer data collection tasks with the frequencies of the selected target. The specific operation of the component depends on whether it is running in a primary or secondary system. The inputs to the target selection component are the lists generated by the alert antenna control component. The outputs of this component are the startup commands to the interferometer data collection tasks. These commands contain the frequency word from the target list that can be used to tune the digital filter to the target.

In the full-Doppler (primary) system, TRGSEL simply selects the three strongest target signals for processing by the three digital filters associated with that system. In the half- and quarter-Doppler (secondary) system, the target selection component performs the same functions as in the primary system, but it handles two lists instead of one. As in the primary system, there are three data collection tasks capable of running in parallel. In the secondary system, two of these tasks are devoted to half-Doppler targets, and one is devoted to quarter-Doppler targets.

TRGSEL also maintains elimination lists and notch lists, both of which are used to prevent redundant gathering of data. When a target (frequency) has been selected and data has been successfully collected on the primary system, the frequency is placed on an elimination list that is sent to the secondary system. If data collection has already started on that same target in the secondary system, the data collection task in the secondary system is canceled for that target and that digital filter is released for other data collection efforts. In addition, each system maintains its own notch lists. These are used to disable data collection at a particular frequency for a specified length of time, so that the same target is not collected by more than one digital filter in the system.

4.4 Time Critical Functions

Data from the main data bus is buffered in the MAP 4000 in 16-bit words and processed in blocks of 2048 words. At a 75-kHz sample rate, a buffer is ready for processing every 27.3 ms. Therefore, the array processor must have finished its processing on the previous buffer within this time. It is critical that interferometer data processing be started as soon as possible. Therefore, the target selection process must be completed in the shortest time possible.

4.5 Associated Hardware

4.5.1 CSPI MAP 4000 Array Processor

The MAP 4000 is a 40 megaflop (Mflop) array processor designed to operate as an attached processor for DEC Qbus computers. Its consists of four cards which are designed to plug directly into the Qbus: a host interface card, the CPU card, a main memory card, and a DIO 16-bit parallel interface card for external devices.

4.5.2 APIO Interface Card

The array processor input/output (APIO) card is a custom device designed to select alert antenna data from the main data bus and transfer it into the MAP 4000 through the DIO board.

4.5.3 Main Data Bus

The main data bus is a custom bus designed to handle the digitized outputs of the DSPR RF channels. It is a time multiplexed bus with 16 time slots operating at a 75-kHz rate. It has 16 parallel data lines and contains several control signals.

5. INTERFEROMETER DATA COLLECTION

5.1 Description

In order to improve the signal-to-noise ratio, a narrowband filter must be tuned to the frequency of the target. Once a target is detected and selected, a digital filter (DF) is requested to collect data on the target. Each DF is controlled by a separate procedure ADC'n', where n is the DF number.

Most of the functionality of the ADC task is performed in hardware by the DF. Each interferometer antenna is connected to an RF channel. The data from the RF channels are digitized at a 75-kHz rate and are multiplexed on the main data bus. The DFs perform a series of discrete Fourier transforms on the data from the interferometer antennas.

When TRGSEL has determined that a target is in the system and there is a free DF to collect interferometer data, the ADC procedure controlling that DF is requested to execute. The ADC task first tunes the DF to the frequency of the target and sets its bandwidth. Next, the system time is read to time stamp the interferometer data.

System time is kept in two locations. The year, day, hour, minute, and second are stored in locations in the system database, DSPCOM. The fractional seconds, to a precision of 0.1 ms, are determined from a counter on the KWV11C real-time clock. Module GET_TIME reads both parts of the time and stores them in locations associated with this target for use by the data processing task.

5.2 Time Critical Functions

All functions of these procedures are time critical. Due to the short period of time that a target is in the system, it is vital that data collection be started as soon as possible. It is also vital that the time be accurate. Therefore, the module executes at a software priority of 28 which is the highest priority of the DSPR processes. This prevents another process from interrupting during the read.

5.3 Associated Hardware

5.3.1 KWV11C Programmable Real-time Clock

The KWV11C is a programmable real-time clock used to determine time intervals or to count events. In the DSPR system, a 10-kHz base frequency is used for the input to the counter. Therefore, the counter gives a 0.1 ms resolution referenced to the second.

5.3.2 Digital Filters

The digital filters are custom devices, designed and built at NRL, used to perform discrete Fourier transforms on 14 parallel data channels of sampled data at a 75-kHz rate. Three bandwidths are used in the DSPR system: 36 Hz, 9 Hz, and 2 Hz.

5.3.3 DRV1W Interface

The DRV1W is a general-purpose 16-bit parallel direct memory access (DMA) interface for Qbus systems. There are four DRV1Ws on each VAX 4200, three for the DFs and one for the utility bus interface.

6. DATA PROCESSING (DP)

6.1 Description

The function of the data processing procedure is to format data collected by the Interferometer Subsystem (IS) for transmission to the NSSC. Data from the IS is written to one of three buffers depending on which digital filter collected the data. The data is in the form of the complex signal on up to 14 antennas for 55 time-lines.

When the DP task is not active, it is waiting for an event flag (DCOLEF) to be set by one of the IS tasks. Once the flag is set, DP is asynchronously activated. Using a round robin technique, it determines the next digital filter that has data to be processed. It then initializes its database (DPCOM) with the correct system parameters from the system database (DSPCOM) and reads the time of data collection, which has been stored in TRGCOM. The data, which had been stored in one of three buffers in TRGCOM, is moved into its own buffer. If the spare channel has been selected, the data substitution for the bad channel is made at this time.

The signal strength profile for each channel and an "olympic" average for each time-line are calculated. To save processing time, the magnitude of the signal is calculated by summing the absolute value of the real and imaginary components of the signal instead of taking the square root of the sum of the squares. At this time, the sign of the imaginary part is inverted and the filter bias (3.0) is removed from the data in the buffer. The duration of the observation is determined by finding the location of the latest time-line above threshold starting from the end of the pass.

The data are next checked to determine whether they meet the characteristics of a "feedthrough" signal. Feedthrough signals are of long duration, low Doppler, and low amplitude. These signals are especially prevalent at Hawkinsville and are believed to be caused by airplanes passing through the system. If the target meets the criteria, it is marked no transmit."

An approximation technique is used to determine the phase in 8-bit representation. This process creates 256 possible values for phase with a step size of 1.40625 degrees. The sum of the average voltage for all 55 time-lines is calculated and converted to dBm. Then for each RF channel, the sum of its voltages is calculated in dBm. The differences between the average and each channel, biased by 128, is stored for transmission.

The reduced data are now ready to be packed for transmission. On the primary system, when DP reaches this point, it knows it has "good" data on this target, and thus sends an elimination message to TRGSEL on the secondary system to cancel collection at this Doppler frequency. The primary system data is then packed into a transport control buffer. When secondary system data has been processed, it must be sent via ICC (Interprocessor Communications, formerly Inter-Controller Communications) buffers to the primary system, where it is packed into a TCB by procedure GETSEC.

A TCB is composed of as many 128-byte data transmission packets (DTPs), up to a maximum of six, as it takes to hold all the data in one observation. The first DTP contains a packet header, header control block, signal strength deviation block, and up to 6 phase blocks. All 128 bytes are filled before starting to fill another DTP. (The TCBs and DTPs are defined in Appendix E.) After all the phase blocks in the current observation have been packed into DTPs, the data line communication (DLC) task is notified that one TCB is ready to be transmitted. After primary system data are assigned to a TCB, event flag DLCEF is set to notify the DLC task that it is ready for transmission to the NSSC. Secondary data are assigned to 128-byte ICC buffers, and each buffer is sent to ICC as it is filled, by mailing a send packet containing the buffer number to the ICC procedure.

At this point, DP checks whether notching is enabled. If it is, the current frequency is placed on the notch list. The notch list is used by TRGSEL to disable collection at this frequency for a specified length of time, to avoid having the same target collected by more than one digital filter. The procedure releases the digital filter for new collections, and checks whether more data are ready for processing. If not, it goes back into the wait state.

6.2 Time Critical Functions

Data must be processed within 300 ms, since a maximum of three targets can be collected in 1 second on the primary system.

6.3 Associated Hardware

The DP subsystem has no hardware associated with it. It is entirely software which executes on the VAX 4200.

7. DATA LINE COMMUNICATIONS (DLC)

7.1 Description

This component is responsible for coordinating the flow of data between the central processors in the receiver stations and the NSSC.

The data line to and from the NSSC is controlled by the Data Line Communication procedure. The data line is a leased C1 conditioned line that operates at 9600 baud in asynchronous mode. The DLC procedure uses a DSV11 synchronous line interface, which operates with the SDLC protocol, and a 9600-baud modem. Appendix E defines the data line format.

The basic function of DLC is to complete the formatting of data frames and pass them to the DSV11 for transmission. Skeleton code has been provided to handle data on the return line from the NSSC, but the code has not been tested and the function has not been implemented.

Procedure SYSMON starts DLC during Phase 2 of the system initialization process by executing a create process system service; this causes an initialization send packet to be queued. DLC initializes the DSV11 and checks its status and the status of the modem. It then goes into a data link initialization phase. Since the DSPR system acts as a secondary link, it posts a read QIO from the DSV11 and waits for the read to complete. The primary station, at NSSC, attempts to start the data link by continuously sending a Set Normal Response Mode (SNRM) command. When this is received, an Unsequenced Acknowledgment (UA) message is sent by DLC. The primary then sends a Receiver Ready (RR) command and waits for data to be transmitted.

If the system is operating as a secondary system, initialization tests the communication system's readiness to take over for the primary system in case the primary system fails. Once initialization is complete, DLC hibernates on the secondary system.

On the primary system, DLC suspends itself. The transmit and control functions operate asynchronously; that is, when an asynchronous trap (AST) is executed with DLC as the destination, DLC is awakened at the proper location in the code.

DLC can receive data either directly from the data processing procedure on the primary system or from data processing on the secondary system indirectly through procedures ICC and GETSEC. When the primary data processing component produces a TCB that it wants to send to the NAVSPASUR Operations Center, it first sets the appropriate TCBFLG to the number of packets in the TCB. Then it sets DLCEF to notify DLC that they are all ready for transmission.

GETSEC is a small procedure whose only function is to collect the secondary data processing data from ICC, place them into the fourth Transport Control Buffer, set flag DLCEF to notify DLC that a TCB is ready for transmission, and put the total number of data transmission packets that are in the TCB into TCBFLG(4). When a data packet is received, DLC fills a transmit table with information required by the DSV11, adds the data frame sequence number, and performs a QIO call to the DSV11. At the completion of the transmission, DLC marks the TCB free.

In the course of communications with the NAVSPASUR Operations Center, certain special conditions, such as loss of communications, may be detected. The system monitor is notified of these conditions via an "operator message" packet sent via the SYSMON mailbox.

7.2 Associated Hardware

7.2.1 DSV11 Synchronous Communications Controller

The DSV11 is a dual channel synchronous communications controller for Qbus systems. In the DSPR system the synchronous data line control (SDLC) protocol is used over one line at 9600 baud.

7.2.2 Codex V.3225 9600-baud Modem

The Codex V.3225 modem operates in full duplex at 9600 baud in trellis-coded mode as per recommendation V.32 of the Comité Consultatif Internationale de Télégraphique et Téléphonique (CCITT).

8. INTERPROCESSOR COMMUNICATIONS AND FAILURE DETECTION

The two central processors communicate over a thinwire Ethernet link connecting the two systems. Interprocessor Communications (ICC) is the software procedure which routes messages from subsystems on one computer to subsystems on the other. (In the former PDP-based system, the corresponding procedure was known as Inter-Controller Communications; the abbreviation ICC has been retained.)

8.1 Description

The interprocessor communications procedure exchanges information between both computer systems by performing two basic exchange functions. First, it receives information from the interprocessor communications line (Ethernet) and routes it to other components in the DSPR system. Second, it transmits information from other components, on a demand basis, to the other system using the Ethernet line. The receive and transmit functions are implemented through queued I/O requests (QIOs) to the Ethernet controller. The receive function is implemented by a read QIO and the transmit function uses a write QIO.

8.1.1 Interprocessor Communications Transmit Requests

ICC transmit requests are write requests issued from other components in the DSPR system to ICC. The component allocates an ICC buffer, fills it with its information, and then formats and queues a send packet to ICC's mailbox with the following information:

Word 1 = Source process number
Word 2 = Destination process number (ICC)
Byte 5 = 4 (signifies SEND INTERPROCESSOR MESSAGE type)

Word 4 = ICC buffer number
Word 5 = (optional) event flag to set after message is sent

ICC is notified of the send packet by a write-attention asynchronous trap (AST) mechanism. Since many components can queue a send packet for ICC, receive data ASTs can occur quite sporadically.

8.1.2 ICC Receive Requests

During initialization, ICC posts a read-logical-block QIO to the Ethernet logical unit with the module COM_READ indicated as the code to execute when the read is completed. When data is transmitted by the other computer, the read completes and COM_READ executes. An ICC buffer is allocated and the data in the read buffer is transferred to the ICC buffer. The destination is checked and a send data packet is formatted to inform the destination procedure of the ICC buffer containing the message. Then a new read QIO is posted.

8.2 Failure Detection

After each read of data from the Ethernet, a 10 second timer is set with an AST routine called READ_TMO. If the read QIO completes before the timer expires, the timer is canceled and reset. If the timer completes, it means that no data has been received in 10 seconds and the AST routine READ_TMO is activated. This routine marks the communications link down, sends a failure message to SYSMON, and calls the communications link initialization routine.

8.3 System Status Transfer

After the communications link is initialized, a 2 second timer is started, with an AST routine called WRITE_TMO requested to execute at the completion of the timer. WRITE_TMO sends a message containing its system status to the SYSMON executing on the other computer. This allows both systems to be aware of the other system's status and also ensures that several messages should be received within the failure detection's time-out.

8.4 Associated Hardware

8.4.1 Ethernet controller

The Ethernet controller is embedded on the CPU card of the VAX 4200. It has both standard transceiver and thinwire connectors on the front panel of the CPU module. The DSPR system uses the thinwire connection.

9. SYSTEM TIMING

9.1 Description

Four types of clocks are used for maintaining system timing accuracy and for time stamping the data sent to the NSSC. A Hewlett-Packard 59309A HP-IB digital clock, shared by both systems, provides the time in months, days, hours, minutes, and seconds. The VAX 4200 CPU's internal clock provides the current year. Each system's CPU contains a KWV11C programmable real-time clock that refines the timing resolution to 0.1 ms for time stamping all data. A Hewlett-Packard 5061B cesium beam frequency standard provides the precise 5 MHz and 1-pulse-per-second signals for system timing.

The system time has both a hardware and software component. The process CLOCK controls the timing for the DSPR system. The year, month, day, hour, minute, and second are stored as integer variables in the system database and are updated by the software. This software clock is initialized by reading the HP-IB digital clock and the CPU's internal clock. The clock is updated once per second by the time stamp procedure, which controls the KWV11C programmable real-time clock. The method of obtaining timing information is to set up to read the digital clock, wait for a pulse from the cesium clock to occur, then read the digital clock.

9.2 Time Critical Functions

Procedure CLOCK is assigned the task of keeping system time. At initialization, the software clock must be set by reading the HP-IB digital clock.

9.3 Associated Hardware

9.3.1 Hewlett-Packard 59309A HP-IB Digital Clock

The HP-IB digital clock displays month, day, hour, minute, and second. Upon command, it outputs time via the interface bus.

9.3.2 Hewlett-Packard 5061B Cesium Beam Frequency Standard

The HP 5061B is an atomic resonance device that provides a very high accuracy ($\pm 3 \times 10^{-12}$) primary frequency standard.

9.3.3 KWV11C Programmable Real-time Clock

The KWV11C is described in Section 5.3.1.

10. OPERATIONAL TESTS

The operational tests are on-line confidence tests used to exercise one or more components in the DSPR system. These tests report on the performance of the system or of critical components in the system. They run in conjunction with the DSPR system and are operator selected and initiated. The results of the operational tests and intermediate results are output to CRT and hardcopy devices for operator evaluation.

Four operational tests (OPTESTs) execute as separate tasks in the DSPR system. They are the RF calibration operational test (RFCAL), the digital filter operational test (OPDFT), the alert sensitivity operational test (OPALRT), and the system signal confirmation test (OPSYS). In addition, an Activity Monitor Operational Test is incorporated into the system monitor dynamic activity display.

RFCAL, OPSYS, OPDFT, and OPALRT are all invoked in the same way. The operator selects the test from the OPTEST menu and the parameters for that test from a submenu. The parameters are put into an initialization ICC buffer, and a send packet is mailed to program OPT, which serves as the driver for all the OPTESTs. The ICC buffer contains the ICC buffer number, a message type code of OPINIT, and a subcode, which is the number of the OPTEST that is to be to run. OPT then executes the proper subroutine. Messages indicating that the test has commenced and completed are sent back to SYSMON in embedded text via send packets.

There are two parameters for OPSYS and RFCAL: the signal strength and the Doppler frequency for the calibration signal. For OPALRT, the parameters are the initial signal strength and frequency. The parameters for OPDFT are the number of least significant bits to ignore in the compare and the Doppler frequency for the collection of digital filter data.

At the beginning cf each test, a command is issued to the utility bus procedure, requesting it to turn on the calibration off-air timer on the utility bus to the DSPR system. As the test is running, any intermediate primary or secondary results are sent to SYSMON via ICC buffers. When the test is complete, the calibration off-air timer is turned off.

10.1 RF Calibration Operational Test (RFCAL)

The signal delays through the RF channels are different due to varying electrical path lengths. These differential delays must be removed from the interferometer data before it can be processed. The RF calibration operational test is used to measure the delays, and the results are transmitted to the NSSC in a calibration data frame for use in the data reduction process. This operational test differs somewhat from the others in that it executes automatically at a specified interval (normally 30 minutes). It can be run only on the primary system.

Subroutine RFCAL is responsible for initiating the collection of calibration data. This data is processed and eventually sent to the NSSC. RFCAL does this by allocating a digital filter and requesting the corresponding interferometer data collection task to run by locking DSPCOM and setting an ADC event flag. It then sets the RF signal generator/calibrator on the IEEE bus to the requested amplitude and frequency. After the data are collected, the RF signal is turned off.

10.2 Digital Filter Operational Test (OPDFT)

The Digital Filter Operational Test is used to test the digital filters to ensure that they are operating bitwise consistently. In a manner similar to interferometer data collection, the digital filters under test are tuned to collect data simultaneously. The software collects 55 frames of data from 14 channels, as is done in normal DSPR data collection. Once data collection is complete, each word from each digital filter is compared to see that the value is consistent across all digital filters. A tolerance feature built into the test directs the software to ignore "n" number of least significant bits during the compare. The values of each word from each digital filter must be within tolerance of each other. After all data values are compared, the total number of discrepancies between the digital filters is reported on the CRT and hardcopy device.

If the test has been requested to run on both the primary and secondary systems, the ICC buffer is sent to the secondary system by OPT via ICC; otherwise, the initialization buffer number is deallocated.

OPDFT sends SYSMON its intermediate results via ICC buffers. These consist of the number of discrepancies (errors) between the digital filter pairs (1-2, 2-3, 1-3). Errors are sent directly to SYSMON via a send packet.

OPDFT allocates the digital filters and causes the test digital filters to collect data simultaneously for comparison purposes. OPDFT does not use the ADC'n' processes to control the DFs but sends its own control commands and processes the data itself.

10.3 Alert Sensitivity Operational Test (OPALRT)

The Alert Sensitivity Operational Test calculates and displays statistics on the sensitivity of the alert subsystem. It does this by inputting a calibration signal into the RF subsystem and counting the percent occurrences of the calibration signal on the array processor target lists.

The calibration signal is turned on for a time period and then turned off (4 seconds on the primary system, 64 seconds on the secondary system). When the signal is turned off, the percentage of occurrences of the calibration signal on the array processor target lists is calculated and displayed. Then the calibration signal is adjusted to a weaker value. The step pattern of the signal level is ten 1-dBm signal level decrements. Since the percentage of occurrences of the calibration signal level on the array processor lists is displayed along with the corresponding signal level for each step, the operator can see the alert sensitivity as a function of signal level and evaluate the system's sensitivity. The system's sensitivity is defined as the signal level where the calibration signal occurs on the array processor lists 50 percent of the time.

OPALRT sends SYSMON any intermediate primary or secondary results via ICC buffer. The percent occurrence of the calibration signal on the array processor target lists is sent to SYSMON during the dwell where the calibrator is turned off. The percent occurrence and signal level information are contained in an ICC buffer and a send packet is mailed to SYSMON describing the ICC buffer containing the information.

The target selection procedure is responsible for counting the number of array processor lists generated while the calibrator is on, as well as counting the number of times the calibrator signal appeared on the array processor target lists.

OPALRT is responsible for initiating the collection of calibration data. It does this by allocating a digital filter and requesting the corresponding interferometer data collection task to run. Currently these data are not processed.

OPALRT interfaces to the IEEE bus subsystem through a DEC IEQ11 controller and software driver, both from DEC Computer Special Systems. The IEQ11 interfaces the VAX 4200's Qbus to an IEEE bus with IEEE bus controller logic. The Hewlett-Packard calibrator (signal generator) is interfaced to this bus and can be programmed through it. Through this bus, OPALRT directs the calibrator to output a signal with specific characteristics (signal frequency and strength). The calibrator is set to its lowest signal level during the times when OPALRT cycles through the step where it should be turned off.

At the end of the test, a packet is sent to notify SYSMON that OPALRT has completed. If the test has been requested to run on both the primary and secondary systems, the ICC buffer is sent to the secondary system by OPT via ICC; otherwise, the initialization buffer number is deallocated.

10.4 System Signal Confirmation Test (OPSYS)

The System Signal Confirmation Test exercises the RF subsystem and digital filters to determine and display the relative phase of all channels with respect to the reference channel for all digital filters. It also computes and displays the average signal strength of each channel for all digital filters. In this way OPSYS ensures that each RF channel pair (channel relative to reference channel) has a similar phase across all digital filters and each channel has similar gain with respect to each digital filter and each other.

A weak RF channel can very easily be identified, since it manifests itself with lower signal strength values for each digital filter with respect to the other channels. A malfunctioning digital filter can show up with phase numbers for all channels that differ from the phase numbers from the other digital filters. This test allows the operator to see how well the RF channels and digital filters are performing in terms of similar relative phases and similar signal gain.

The functionality of OPSYS is as follows: The test puts the DSPR system into idle mode and waits for any previous data collections and processing to complete before continuing. Once any previous targets are cleaned out of the system, the calibrator is turned on, outputting a signal into the RF subsystem. Then the data provided by the calibration signal are collected by all the digital filters if possible and processed.

The DSPR system data processing component does not process this data; rather OPSYS itself processes it. (The data collection status variables in DSPCOM are COL'n', where n=1,2,3. These are cleared to prevent the data processing component from processing the data.) There are two calculations performed on the data. The first is the relative phase correction for each channel with respect to the reference channel (channel 4, counting from 0) for all digital filters. The second calculation is the signal strength (gain) on each channel for all digital filters. Thus, there are three phase correction values (one per digital filter) for each of the 14 channels and three signal strength values (one per digital filter) for the 14 channels also. These values are displayed on the CRT and hardcopy devices in columnar format.

The new phase corrections are stored into the system common DSPCOM. The DSPR system is then returned to its initial entry state.

SYSMON is also responsible for displaying the OPSYS commenced, intermediate, and completed messages on the CRT and hardcopy devices. The intermediate message consists of relative phase corrections for each channel pair per digital filter and signal strengths for each channel per digital filter.

OPSYS directs the calibrator to output the specified calibration signal using the IEEE bus. The signal has specified signal strength and frequency characteristics. Then, the ADC processes are requested to perform a data collection.

After data collection is complete, OPSYS calls subroutine PHCALC to compute the average phases relative to antenna 4 and to compute the amplitudes squared and place them in the data array. As indicated previously, the collection status variables are set up so that when data collection completes, the data processing component will not attempt to process the data.

If the test has been requested to run on both the primary and secondary systems, the ICC buffer is sent to the secondary system by SYSMON via ICC; otherwise, the initialization buffer number is deallocated.

10.5 Activity Monitor Operational Test

The Activity Monitor Operational Test, as the name implies, monitors the activity of the DSPR system in terms of targets processed (selected, collected, processed, and transmitted) over some time period. It monitors the extremes of two target activities and alerts the operator when the extremes occur. These extreme activities are zero target activity (i.e., no targets processed) and a saturation condition (i.e., too many targets processed). Each activity extreme indicates a fault in the DSPR system. In the primary system, these conditions are especially serious and should normally never occur.

The primary system monitors zero target activity as well as target saturation activity and the secondary system monitors only zero target activity. By keeping track of the number of targets processed per digital filter over some time period, each of these activities can be monitored. The time period in the primary system is three minutes. If no targets are processed in this time span or too many targets are processed (i.e., more than 90 per digital filter), the operator is alerted to the appropriate condition with a CRT and hardcopy message, in addition to audio and visual alarms. The secondary system, which monitors only zero target activity, has a 20-minute time period. If no targets are processed in this time span, the operator is also alerted with a zero target activity message and audio and visual alarms.

The activity monitor differs from the other OPTESTs in two respects. First, it is not a separate task but rather is incorporated within the SYSMON system activity display program (module DISPLAY on the primary system, module S_DISP on the secondary system). Second, it is not operator selectable but is active any time the DSPR system dynamic activity display is active.

The displays on the primary and secondary systems cycle on 10-second intervals. They display the status of the system, then block their own execution (CALL WAIT) for 10 seconds. The number of targets processed per digital filter is totaled each 10-second interval. After *n* 10-second intervals have expired (18 on the primary system, 120 on the secondary system), a check is made for extreme activity. If it is found (i.e., zero target activity or target saturation on primary, zero target activity on secondary), a CRT and hardcopy message is generated for the operator, along with audio and visual alarms.

10.6 Associated Hardware

10.6.1 Hewlett-Packard 8657A Signal Generator

The HP 8657A is a programmable synthesized signal generator with a frequency range of 0.1 to 1040 MHz and an amplitude range of +13 dBm to -143.5 dBm. It is used by the OPTESTs to inject a signal of known frequency and amplitude into the antenna pre-amps.

10.6.2 IEQ11 IEEE Controller

The IEQ11 is a DEC device that interfaces between the Qbus and the General Purpose Interface Bus (GPIB), which conforms to the IEEE-488 standard. Devices on the GPIB are the HP 8657A signal generator and the HP 59309A digital clock.

11. UTILITY BUS CONTROL

11.1 Description

The utility bus control component (UTIL_BUS) is responsible for directing and supervising activity on the NRL designed and developed utility bus (and related hardware elements). This component gets system dependent hardware configuration information, monitors utility bus activity, and enables or disables utility bus hardware operations.

The functions of UTIL_BUS are similar in the primary and secondary systems. This component executes two basic functions: performing system requests for utility bus operations and monitoring activity on the utility bus.

The system request component is responsible for dispatching system commands to enable/disable or change the various hardware features of devices on the utility bus. These devices (also called cards) were designed and built by NRL. They control the spare channel switching logic, selection of local oscillators, antenna relays, as well as interface to the array processor. There are also miscellaneous function cards and a test/terminator card. UTIL_BUS gets its request information from a send packet. The send packet describes the address of the card whose function is requested and the bit settings, on and off, for that card.

The monitoring component of the utility bus control software notifies the system of any change in the settings of cards on the utility bus. Each card on the bus has its bit setting recorded in local storage for comparison purposes. The utility bus hardware interface, a DEC DRV1W, interrupts when any of its 16 data lines changes state. The service routine gets the card number (address) that caused the interrupt and compares the previous setting of the card to the new state. It then notifies the system of the bit changes, if any. (See Appendix F for information on the send packet.)

The utility bus control component interfaces to the system monitor and to the operational tests. It also interfaces to the I/O page, to manipulate the device registers of the DRV1W. These interfaces are similar in the primary and secondary systems.

The first interface to the system monitor is initiated because the system has to get information from the utility bus during startup, and also must configure the utility bus at system startup. In addition, if the operator chooses to change the utility bus configuration, the system monitor sends the change information to the utility bus control software. This information is contained in a send packet. Also, when the utility bus control software services a hardware interrupt, it consequently sends a status message to the system monitor with a send packet. The packet contains the name of the card that caused the interrupt and information on changes in bit settings. It describes whether no bits changed setting, or if bits changed from zero to one or from one to zero.

The operational tests also send messages to UTIL_BUS, since some of them must alter the utility bus setup for test purposes.

11.2 Associated Hardware

11.2.1 VAX 4200 Central Controller

The VAX 4200 is described in Section 3.3.1.

11.2.2 DRV1W Interface

The DRV1W is described in Section 5.3.3.

Appendix A

DSPR SOFTWARE DATABASE (DSPCOM)

A1. DESCRIPTION

DSPCOM is the system database used by all components of the DSPR system software. It contains parameters used by various components as well as dynamic storage for target information. Some parameter values are established initially (hard coded) and others are established at run-time. Other information in DSPCOM is dynamic and changes constantly, such as the contents of the storage region for array processor target lists, which is updated 40 times per second. Since all of the components in the DSPR system have access to this database, it is the chief means by which critical information is made available to all components simultaneously.

A2. THE ROLE OF DSPCOM IN THE DSPR SYSTEM SOFTWARE

Each of the receiver sites runs DSPR system software that has been specifically tailored to its special requirements (such as noise thresholds, biases). There are, however, only two basic types of DSPR software used by any of the sites. Tattnall, Red River, Silver Lake, and San Diego all run software that has been designated for low-altitude stations. Hawkinsville and Elephant Butte both run the second type of software for high-altitude stations. Thus, all the sites within an altitude type (low or high) use identical run-time software.

The DSPR software is tailored specifically for each particular site through a unique DSPCOM system database. Therefore, there are six DSPCOM system databases, one for each receiver site. Four are for the low-altitude stations and two are for the high-altitude stations. Separate and distinctly valued DSPCOMs are implemented by separate Macro (assembly language) files, as listed below:

DSPCOM.SDO - San Diego
DSPCOM.ELB - Elephant Butte
DSPCOM.RRV - Red River
DSPCOM.SLV - Silver Lake
DSPCOM.HWK - Hawkinsville
DSPCOM.TAT - Tattnall

All of the DSPCOM common blocks for an altitude type (low or high) have identical storage requirements, but differ in parameter values and initial settings that are hard-coded in them. Thus, the software for a particular site is customized for that site by the values of the parameters in DSPCOM common.

This means that the DSPR software is built or rebuilt on an altitude-type basis, in contrast to a per-site basis. When a change or enhancement is added to a low-altitude station, for example, the software needs to be rebuilt only one time and not once per site. The high-altitude software, if changed, needs to be rebuilt only once for both high-altitude stations. NOTE: Each time software is created for a specific site, the corresponding DSPCOM must be referenced during the creation process. The reference to the correct DSPCOM can be assured only by rebuilding the DSPCOM for the particular site for which software is being created.

A3. DSPCOM SYSTEM DATABASE IMPLEMENTATION

When DSPCOM is rebuilt, it creates a file comprised only of data that is loaded into memory and resides there while the DSPR system is operational. Since all components in the DSPR system map to this area of memory, each component has access to the values of parameters in DSPCOM. This means that the DSPCOM system database is implemented as a shared region in memory (also called a global common). Since the database is memory resident, any changes made in it during system operation are temporary. Permanent changes to DSPCOM are made by editing the appropriate DSPCOM file with the new changed value.

In addition to the six DSPCOM Macro files that contain the site specific parameter values, there are two Fortran DSPCOM files (one for low-altitude sites, one for high-altitude sites). These files declare a Fortran common that specifies the exact storage requirements (size and offsets) as the DSPCOM Macro files (per altitude type). Thus, the low-altitude receiver station software has four Macro DSPCOM files and one Fortran DSPCOM file. The high-altitude stations have two DSPCOM Macro files and one Fortran file. The equivalency between Fortran and Macro storage allocation must be maintained.

The Fortran and Macro DSPCOM files, per altitude type, declare the same program section (PSECT), whose name is also "DSPCOM." Both the Fortran and Macro DSPCOM program sections share identical attributes, which are: WRT, RD, NOEXE, SHR, GBL, REL, OVR, NOVEC, and PIC. These attributes allow for a single region of memory to be shared between all the DSPR software components, whether written in Fortran or Macro.

A4. DSPCOM SYSTEM DATABASE DESCRIPTION

The symbolic variables in the DSPCOM system database are described below. The DSPCOM common block sections are listed; then each section is described. The sizes specified are in decimal bytes.

1. System State
2. Hardware Status
3. Array Processor Parameters
4. Data Delay
5. Target Selection Tolerances
6. Data Collection Status
7. Data Processing Parameters
8. Interprocessor Communication Message Buffers
9. Calibration Parameters
10. Task Name Storage
11. Global Event Flags for Data Collection
12. Other Global Event Flags
13. Utility Bus Input Words and Hardware Status
14. Debug Flags
15. Target List Status
16. OPTEST Task Names and Storage
17. Site Designation

18. Filtering Parameters
19. Notching Parameters
20. Delta Time Values
21. Expansion Space

System State

Name	Description	Size	Primary User(s)
MODE	Primary=1, Secondary=2	2	SYSMON
OTHER	Other CPU mode	2	SYSMON, DP, OPTEST
CPUNUM	CPU number	2	SYSMON, DP
RFTIME	System time (yr-mon-day-hr-min-sec)	14	SYSMON, ADCn
AL1CH	Alert channel assignment for AP 1	1	SYSMON
AL2CH	Alert channel assignment for AP 2	1	SYSMON (high altitude)

Hardware Status

The system state and hardware status are position-dependent. These parameters are exchanged between systems to keep track of changes by SYSMON.

Name	Description	Size	Primary User(s)
MAP4000	CSPI array processor	1	SYSMON
DF1	Digital filter #1	1	ADC1
DF2	Digital filter #2	1	ADC2
DF3	Digital filter #3	1	ADC3
COM1	ICC comm. link status	1	ICC
COM2	ICC comm. link status (unused)		
DSV	DSV11 data line controller	1	DLC
DATA_LINE	Data line status	1	ADCn
DR	DRV1W I/O utility interface	1	SYSMON
IEC	IEEE bus interface, IEQ11	1	SYSMON
KWV	KWV11C real-time clock	1	SYSMON
CALST	Calibrator ON/OFF indicator	1	OPTEST, DP
SPARCS	Spare channel status	1	DP
IDLE	DSPR system idle flag	1	TRGSEL
OPTEST	OPTEST flag	2	OPTEST
RTRAN1	ICC retry counter (unused)		
RTRAN2	ICC retry counter (unused)		
NTCH	Notch enable/disable flag	2	TRGSEL, DP
SPWRD	Spare status word	2	SYSMON
KWV_CNT	KWV count	2	SYSMON
KWV_MAX	Maximum KWV count at AST	2	

Array Processor Parameters

Name	Description	Size	Primary User(s)
RFSNR	Signal-to-noise ratio	4	SYSMON, TRGSEL, MAP
RFFDTC	Full-Doppler decay	4	SYSMON, TRGSEL, MAP
RFHDTC	Half-Doppler decay	4	SYSMON, TRGSEL, MAP
RFQDTC	Quarter-Doppler decay	4	SYSMON, TRGSEL, MAP

Name	Description	Size	Primary User(s)
RFFNTC	Full-Doppler noise	4	SYSMON, TRGSEL, MAP
RFHNTC	Half-Doppler noise	4	SYSMON, TRGSEL, MAP
RFQNTC	Quarter-Doppler noise	4	SYSMON, TRGSEL, MAP
APLIST	AP target list	42	TRGSEL
APMAG	AP magnitude list	84	TRGSEL
APBIN	AP base bins	12	DP
APNFFT	AP # points in FFT	12	DP
APBIN_SPA		12	

Data Delay

Name	Description	Size	Primary User(s)
DTIME	Doppler delay time	6	SYSMON
NOROW	Number of rows being used	2	SYSMON
NOCOL	Number of columns being used	2	SYSMON
NSBLKS	Number of subblocks being used	2	SYSMON
NOBAD0	Bad block number on Primary	2	SYSMON
NOBAD1	Bad block number on Secondary	2	SYSMON
GOOD0	No. of good blocks on Secondary	2	SYSMON
GOOD1	No. of bad blocks on Primary	2	SYSMON

Target Selection Tolerances

Name	Description	Size	Primary User(s)
TRFUL	Full-Doppler region bin tolerance	2	TRGSEL
TRHAF	Half-Doppler region bin tolerance	2	TRGSEL
TRQRT	Quarter-Doppler region bin tolerance	2	TRGSEL

Data Collection Status

Name	Description	Size	Primary User(s)
COL1	DF #1 collection status	2	TRGSEL, ADC1, DP
COL2	DF #2 collection status	2	TRGSEL, ADC2, DP
COL3	DF #3 collection status	2	TRGSEL, ADC3, DP
FREQ1	Frequency for target #1	2	TRGSEL, ADC1, DP
FREQ2	Frequency for target #2	2	TRGSEL, ADC2, DP
FREQ3	Frequency for target #3	2	TRGSEL, ADC3, DP
CAFREQ	OPTEST cal freq bin number	2	TRGSEL
BAND1	Bandwidth for target #1	2	TRGSEL, ADC1, DP
BAND2	Bandwidth for target #2	2	TRGSEL, ADC2, DP
BAND3	Bandwidth for target #3	2	TRGSEL, ADC3, DP

Data Processing Parameters

Name	Description	Size	Primary User(s)
RFTH1	Single frame threshold	12	DP
SGBIAS	Signal strength bias	12	DP
RFBIAS	Digital filter biasing constant	4	DP
DBMDWN	DBm down truncation value	4	SYSMON, DP

MINTL	Minimum # of time-lines for transmit	4	SYSMON
AVEOBS	# of time-lines per observation	4	SYSMON, DP
ANTCAL	Antenna calibration numbers	80	DP

Interprocessor Communication (ICC) Message Buffers

Name	Description	Size	Primary User(s)
ICCBUF	ICC buffers	2560	ICC, TRGSEL, SYSMON, DP, OPTEST
IBUFV	ICC buffer vector	20	ICC, TRGSEL, SYSMON, DP,OPTEST
MAXIBF	Maximum ICC buffer allocation	4	SYSMON

Calibration Parameters

Name	Description	Size	Primary User(s)
CADLB	Calibration distribution loss bias	4	OPTESTs
CALIST	# of lists while calibrator on	12	TRGSEL, OPALRT
CAHITS	# of time calibrator freq on list	12	TRGSEL, OPALRT

Task Name Storage

Name	Description	Size	Primary User(s)
NSYSMN	Name of system monitor task	6	OPTEST
NCLK	Name of clock task	6	SYSMON
NICC	Name of ICC task	6	SYSMON
NUBUS	Name of utility bus task	6	SYSMON
NADC1	Name of 1st ADC task	6	SYSMON
NADC2	Name of 2nd ADC task	6	SYSMON
NADC3	Name of 3rd ADC task	6	SYSMON
NOPT	Name of OPTEST task	6	SYSMON
NDLC	Name of DLC task	6	SYSMON
NDP	Name of data processing task	6	SYSMON
NGETSC	Name of get secondary task	6	SYSMON
NTRGSL	Name of target select task	6	SYSMON
NTRACE	Name of trace task	6	SYSMON

Global Event Flags for Data Collection

Name	Description	EFN	Size	Primary User(s)
ADC1EF	Data collected DF 1	67.	4	- all -
ADC2EF	Data collected DF 2	68.	4	- all -
ADC3EF	Data collected DF 3	69.	4	- all -
CDC1EF	Canceled data coll., DF1	70.	4	ADC1, SYSMON, TRGSEL
CDC2EF	Canceled data coll., DF2	71.	4	ADC2, SYSMON, TRGSEL
CDC3EF	Canceled data coll., DF3	72.	4	ADC3, SYSMON, TRGSEL
ADM1EF		73.	4	SYSMON
ADM2EF		74.	4	SYSMON
ADM3EF		75.	4	SYSMON

DF1EF	Event flag for DF1	76.	4	ADC1, OPTEST, DF, OPDFT
DF2EF	Event flag for DF2	77.	4	ADC2, OPTEST, DF, OPDFT
DF3EF	Event flag for DF3	78.	4	ADC3, OPTEST, DF, OPDFT

Other Global Event Flags

Name	Description	EFN	Size	Primary User(s)
LOCKEF	Lock/unlock DSPCOM	80.	4	- all-
DCOLEF	Data collection	81.	4	TRGSEL, ADC1, ADC2, ADC3, DP
SMICEF	SYSMON-ICC synchronization	82.	4	SYSMON, ICC
OPT_MKEF	Calibration interval	83.	4	OPTEST
CADPEF	Calibrator/DP EF	84.	4	OPTESTs, DP
DLCEF	Data line communication	85.	4	DLC, DP, GETSEC
ICCBEF	ICC buffer control	86.	4	ICC
TESTEF	Test completion	88.	4	

Utility Bus Input Words and Hardware Status

Name	Description	Size	Primary User(s)
UB_IN	Utility bus input words	10	UTIL_BUS
	Utility Card #3		
LO240A	240 MHz local oscillator #0	1	UTIL_BUS, SYSMON
LO240B	240 MHz local oscillator #1	1	UTIL_BUS, SYSMON
LO240S	240 MHz local oscillator selected	1	UTIL_BUS, SYSMON
LO23A	23 MHz local oscillator #0	1	UTIL_BUS, SYSMON
LO23B	23 MHz local oscillator #1	1	UTIL_BUS, SYSMON
LO23S	23 MHz local oscillator selected	1	UTIL_BUS, SYSMON
	Utility Card #5		
NACAL	HP calibrator	1	UTIL_BUS
SCRMDR	Screen room door	1	UTIL_BUS
FIRE	Fire detection	1	UTIL_BUS
DEGHI	Temperature sensing	1	UTIL_BUS
PWRS	Power supply	1	UTIL_BUS
DRXXX	Unused	1	UTIL_BUS
COMSWC	Communication switch position	1	UTIL_BUS
DRCPU	Physical unit number	1	UTIL_BUS

Debug Flags

Name	Description	Size	Primary User(s)
DBGGBL	Debug global flag	2	SYSMON, -all-
DEBUG	Debug flags for modules	200	- all-

Target List Status

Name	Description	Size	Primary User(s)
CKHITS	Count hits on/off	2	OPTEST
TARG1	Target count for DF #1	2	DP, SYSMON
TARG2	Target count for DF #2	2	DP, SYSMON
TARG3	Target count for DF #3	2	DP, SYSMON
CANTRG1	Cancel target count for DF #1	2	SYSMON, TRGSEL
CANTRG2	Cancel target count for DF #2	2	SYSMON, TRGSEL
CANTRG3	Cancel target count for DF #3	2	SYSMON, TRGSEL
CPUIDL	Flag to IDLE, this CPU only	2	TRGSEL, OPTESTs

OPTEST Task Names and Storage

Name	Description	Size	Primary User(s)
OPTSK	Task names (position-dependent)	24	SYSMON, OPTESTs
	OPALRT		
	OPSYS		
	RFCAL		
	OPDFT		
OPTPKT	OPTEST send packet	30	OPTESTs
CALTYP	Calibrator type	4	
SECRDY	Sec. TRGSEL ready/not ready	4	SYSMON, DP

Site Designation

Name	Description	Size	Primary User(s)
SITE	Site and software version #	30	SYSMON
STA_CODE	Site number	2	DP

Filtering Parameters

Name	Description	Size	Primary User(s)
ZFEED	Feedthrough enable/disable	2	DP
FDUR	Frame duration value	2	DP
FDOPLR	Lower and upper Doppler limits	12	DP
FLTAMP	Amplitude threshold	2	DP
IDOPLR	Hz equiv. lower Doppler limit	2	SYSMON
IDOPUP	Hz equiv. upper Doppler limit	2	SYSMON

Notching Parameters

Name	Description	Size	Primary User(s)
NLCNT	Notch list count down value	2	TRGSEL
NLARG1	Full-Doppler counter, notch list 1	2	TRGSEL
NOTCH1	Full-Doppler region elements	40	TRGSEL
NLARG2	Half-Doppler counter, notch list 2	2	TRGSEL
NOTCH2	Half-Doppler region elements	40	TRGSEL
NLARG3	Qtr-Doppler counter, notch list 3	2	TRGSEL
NOTCH3	Qtr-Doppler region elements	40	TRGSEL
NLTMP	Temp storage for AP list	21	TRGSEL

Delta Time Values

Name	Description	Size	Primary User(s)
T100MS	Delta time value, 100 ms	8	-all-
TMO01S	Delta time value, 1 s	8	-all-
TMO02S	Delta time value, 2 s	8	-all-
TMO03S	Delta time value, 3 s	8	-all-
TMO04S	Delta time value, 4 s	8	-all-
TMO05S	Delta time value, 5 s	8	-all-
TMO06S	Delta time value, 6 s	8	-all-
TMO10S	Delta time value, 10 s	8	-all-
TMO18S	Delta time value, 18 s	8	-all-
TMO20S	Delta time value, 20 s	8	-all-
TMO30S	Delta time value, 30 s	8	-all-
TMO40S	Delta time value, 40 s	8	-all-
TMO45S	Delta time value, 45 s	8	-all-
TMO60S	Delta time value, 60 s	8	-all-
TMO64S	Delta time value, 64 s	8	-all-
TMO30M	Delta time value, 30 min	8	-all-
TMO05M	Delta time value, 5 min	8	-all-

Expansion Space

Name	Description	Size	Primary User(s)
RSV2	<Reserved for expansion>	52	

Appendix B

SYSTEM MONITOR OPERATOR'S MENU INTERFACE

B1. DESCRIPTION

The primary system's CRT terminal not only displays the dynamic operational characteristics of the DSPR system, but also allows the operator to interact with and control the system. Operators can establish, change, or examine various system parameters. They can request the execution of operational tests, acknowledge the receipt of system messages, turn off any accompanying alarms, and shut down the system(s) if need be. In addition the operator can re-establish the system time, and idle or activate the system.

All of these operator interactions are controlled and driven by menus. There is a single main menu with the basic operator command/action interface to the system. Most of the commands on the main menu have a corresponding submenu to further break down and define that command. Some submenus are additionally broken down.

The main menu and submenu selections (commands) are established by a single alphabetic character typed by the operator. If the main menu initiates a submenu, most submenus in turn require a single alphabetic character to effect that command or initiate a second level submenu. When more than a single character is required for a response, such as a parameter value, the operator must type the value and the carriage return key. The numeric keypad on the VT420 terminal can be used to enter numeric values and the ENTER key on that pad can be used in place of the carriage return key.

The main menus and submenus of the sysiem monitor are illustrated and described in the sections that follow.

B2. DSPR SYSTEM MONITOR MAIN MENU

The DSPR system's main menu is the first menu displayed after the system is booted. Each of the main menu commands is described briefly below. Any commands with submenus are described in subsequent sections.

NAVSPASUR RECEIVER STATION SYSTEM MONITOR

F - FILTER: EXAM/MODIFY FILTERING PARAMETERS
C - CLOCK: UPDATE SYSTEM TIME
D - DISPLAY: PRODUCES DYNAMIC SYSTEM DISPLAY
S - SHUTDOWN: SHUTDOWN SYSTEM
E - EXAMINE: EXAMINE PROCESSING PARAMETERS
M - MODIFY: MODIFY PROCESSING PARAMETERS
O - OPTEST: SELECT OPERATIONAL TEST
A - ACKNOWLEDGE: ACKNOWLEDGE MESSAGE
I - IDLE: IDLE SYSTEM

G - GO: ACTIVATE SYSTEM
COMMAND:

[F]ilter allows the operator to enable/disable, change, or examine parameters used by the data processing and target selection components to determine the conditions for filtering targets from those being selected, processed, and transmitted to the NSSC.

[C]lock allows the operator to re-establish the DSPR system time by rereading the Hewlett-Packard calendar clock on the IEEE bus.

[D]isplay produces the dynamic system activity display on the CRT. This display is the default operational display. Each time a menu or submenu is displayed, the command time-out event flag (CMTOEF) is reset. If the operator does not enter a command in the time-out period (30 seconds), that display times out and returns to the next higher level menu, eventually returning to the dynamic system activity display. Figure 2 illustrates the display.

```
                 NAVSPASUR RECEIVER STATION SYSTEM MONITOR
                       NRL HIGH ALT    PH V   H5.0
  ICC: 19/20 DLC:  4 / 4
      PRIMARY:  CPU #1                      SECONDARY:  CPU #0

      OPERATING MODE:     ACTIVE            OPERATING MODE:     ACTIVE


      DIGITAL FILTER #1:   4    5           DIGITAL FILTER #1:   5    6

      DIGITAL FILTER #2:   2    3           DIGITAL FILTER #2:   1    4

      DIGITAL FILTER #3:   1    3           DIGITAL FILTER #3:   1    7


      COM LINE:     UP                       23 MHZ LO:  #0     UP        IN USE
      DATA LINE:    UP                                   #1     UP

      31-JUL-1993  14:28:53 10000           240 MHZ LO:  #0     UP        IN USE
                                                         #1     UP
      LAST ACTIVATED:
      30-JUL-1993 10:12:03

 P1: 31-JUL-1993 14:27:00 LOG 059 - COMMUNICATIONS SWITCH CONNECTED
```

Fig. 2 — Dynamic system activity display

[S]hutdown initiates the DSPR system shutdown procedure.

[E]xamine and [M]odify allow the operator to examine and modify various system parameters.

[O]PTEST allows the operator to choose an operational test.

[A]cknowledge notifies the system that the operator has received a system message. The command clears the system message from the last (bottom) line of the CRT and turns off any accompanying alarms. There is no submenu associated with this command.

[I]dle idles the DSPR system. All components are left operational, but selection of targets by the TRGSEL is discontinued. Any target collections and target processing in progress are allowed to continue to completion. Thus the system will eventually reach a quiescent state where all software is capable of functioning, but is not since targets are not being selected. This command affects both the primary and secondary systems. There is no submenu associated with this command.

[G]o activates the DSPR system. It reverses the effect of the idle command and allows the target selection component to initiate target selection. When the DSPR system is first booted, the system is in idle mode, therefore the operator must select this command to activate the system (or reactivate it after a system idle).

B2.1 FILTER Submenu

The submenu for the Filter command is illustrated below. The F and D commands enable or disable target filtering. The C command allows the operator to change any or all of the filtering parameter values. The E command displays the current filtering parameters on the CRT and hardcopy terminals.

```
FILTERING PARAMETER COMMANDS ARE:

F   -   ENABLE FILTERING PARAMETERS
D   -   DISABLE FILTERING PARAMETERS
C   -   CHANGE FILTERING PARAMETERS
E   -   EXAMINE PARAMETERS
M   -   EXIT TO MAIN MENU
COMMAND:
```

B2.1.1 Enable/Disable Filtering Second Level Submenu

If the operator chooses to enable or disable filtering, one of the following second level submenu is displayed:

```
FILTERING PARAMETER COMMANDS ARE:

  ENABLE

  F   -   FEEDTHROUGH
  N   -   NOTCHING
  X   -   RETURN TO MAIN FILTER MENU
  COMMAND:


FILTERING PARAMETER COMMANDS ARE:

  DISABLE

  F   -   FEEDTHROUGH
  N   -   NOTCHING
  X   -   RETURN TO MAIN FILTER MENU
  COMMAND:
```

Once enable or disable is selected, the operator can alter one or all the filtering mechanisms (one at a time). The filtering mechanisms are feedthrough filtering (F) and notching (N).

If feedthrough filtering is enabled (ZFEED - logical*2 in DSPCOM and set to TRUE) data processing checks the processed target to see whether it could have been caused by feedthrough conditions and thus should not be forwarded for transmission. There are three conditions usually present in feedthrough: signal amplitude, Doppler, and single frame duration above threshold. Data processing checks to see if the three conditions are met. If they are, then the target is assumed to be a result of feedthrough and is discarded. The notching filtering command is used to enable or disable AP list editing (notching).

B2.1.2 Change Filtering Parameter Second Level Submenu

This submenu allows the operator to change any or all of the values used in the zero duration and feedthrough filtering checks.

CHANGE FILTERING PARAMETER COMMANDS ARE:

```
S  -  SIGNAL STRENGTH
D  -  DOPPLER
F  -  FRAME DURATION
X  -  RETURN TO MENU
COMMAND:
```

B2.1.3 Examine Filtering Parameter Second Level Submenu

If the examine filtering command is chosen, the following filtering parameters are displayed on the CRT and hardcopy terminals. This list incorporates all the values used in the three filtering mechanisms. For example:

```
FILTERING PARAMETERS ARE:

   SIGNAL STRENGTH: 12
   LOWER DOPPLER LIMITS: (HZ) -120
   UPPER DOPPLER LIMITS: (HZ)  120
   FRAME DURATION: 50

   FEEDTHROUGH FILTERING: ENABLED
   NOTCHING: ENABLED COUNT = 20

   PRESS ANY KEY TO RETURN TO MAIN FILTER MENU
```

B2.2 CLOCK Submenu

Commands available in the clock submenu allow the operator to update the DSPR system time. The system time is updated by rereading the Hewlett-Packard HP-IB digital clock interfaced to the IEEE bus. The clock is read, and current time (month, day, hour, minute, second) is returned to DSPCOM array RFTIME. If S or B is selected, a built-in delay allows any secondary collections to complete prior to updating the secondary time. The HP clock does not return the year; that is read from the CPU's internal clock.

READ HP CLOCK

P - UPDATE PRIMARY TIME
S - UPDATE SECONDARY TIME
B - UPDATE PRIMARY AND SECONDARY TIME
M - RETURN TO MAIN MENU
COMMAND:

B2.3 SHUTDOWN Submenu

This submenu permits the operator to shutdown either a single CPU or both CPUs in an orderly manner. If the operator elects to shutdown a CPU or the entire DSPR system an 'ARE YOU SURE Y/N' message is displayed. The operator must answer Y (yes); otherwise the system shutdown will be circumvented by returning to the main menu. If the primary system is shutdown, and the secondary system is up (operational), then the secondary system will attempt to reinitialize as a primary system. If both CPUs are shut down, the secondary system is shutdown first, followed by the primary system.

SYSTEM SHUTDOWN

P - SHUTDOWN PRIMARY
S - SHUTDOWN SECONDARY
B - SHUTDOWN BOTH
M - RETURN TO MAIN MENU
COMMAND:

B2.4 EXAMINE Submenu

This submenu allows an operator to see the values of various system parameters. The parameter values are output to the CRT and hardcopy terminals.

EXAMINE PARAMETER COMMANDS ARE:

A - ANTENNA / ARRAY PROCESSOR
T - TARGET SELECTION
D - DATA PROCESSING
C - CALIBRATION
H - HARDWARE
L - DATA DELAY PARAMETERS
Q - ALL OF THE ABOVE
X - EXIT TO MAIN MENU
COMMAND:

[A]ntenna parameters displayed are the phase corrections for each antenna and the spare channel assignment.

[T]arget select parameters displayed are the target selection tolerances for the full-, half-, and quarter-Doppler regions: TRFUL, TRHAF, TRQRT in DSPCOM common.

Parameters displayed for [D]ata processing are the single frame thresholds, group thresholds, and signal strength biases for each Doppler region (RFTH1, RFTH2, SGBIAS in DSPCOM) and the digital filter bias (RFBIAS in DSPCOM).

[C]alibration displays the value of the calibration distribution line loss bias (CADLB in DSPCOM common).

[H]ardware displays the status of the three primary and three secondary digit filters (DF1, DF2, DF3 in DSPCOM) in terms of whether each one is 'UP' (operational) or 'DOWN' (non-operational).

[L] displays data delay parameters. It is a special setup for sites that have data delay (at present, only Hawkinsville).

B2.5 MODIFY Submenu

This submenu permits an operator to modify the values of various system parameters. Each of these submenu commands, except exit, has a second level submenu associated with it. The parameters modified through this submenu are the ones shown via an EXAMINE command.

MODIFY PARAMETER COMMANDS ARE:

```
H   -   HARDWARE
A   -   ANTENNA
T   -   TARGET SELECTION
D   -   DATA PROCESSING
C   -   CALIBRATION
L   -   DATA DELAY
X   -   EXIT TO MAIN MENU
COMMAND:
```

[H]ardware permits an operator to set or reset the hardware status of the digital filters (DF1, DF2, DF3, in DSPCOM) to operational (+1) or non-operational (-' This is useful if a digital filter has failed (is marked down) and an operator wants to try to exercise the filter again to see if the filter has failed "hard" or is intermittent.

[A]ntenna is used to select a SPARE channel.

[T]arget selection permits the operator to change the values of the target selection tolerances for each of the three Doppler regions (TRFUL, TRHAF, TRQRT in DSPCOM).

[D]ata processing parameters that can be modified include the single frame and group thresholds (RFTH1 in DSPCOM) and the DF or signal amplitude biases (RFBIAS, SGBIAS in DSPCOM).

[C]alibration change allows the operator to choose a new calibration distribution line loss bias (CADLB in DSPCOM).

[L] allows the operator to modify data delay parameters. It is a special setup for stations that have data delay (at present, only Hawkinsville).

B2.6 OPTEST Submenu

If the [O]ptest command is chosen from the main menu, the following submenu is displayed on the CRT console. Each OPTEST queries the operator to get additional parameter values to be used in running the test. If there are no optional parameters for a test, the operator is queried to determine what system to run the test on (primary, secondary, or both).

OPERATIONAL TEST SELECTIONS ARE:

A	-	ALERT TEST	(OPALRT)
S	-	SYSTEM SIGNAL CONFIRMATION	(OPSYS)
R	-	REFERENCE CALIBRATION TEST	(RFCAL)
D	-	DIGITAL FILTER TEST	(OPDFT)
M	-	RETURN TO MAIN MENU	

COMMAND:

The [A]lert sensitivity test assists the operator in determining the sensitivity of the alert subsystem. The optional parameters specify the signal strength and Doppler frequency of the calibrated signal used in this test. These defaults are -150 dBm and -1200 Hz, respectively.

The [S]ystem signal confirmation test is used to test that the RF channels and digital filters are operating consistently with respect to each other in terms of relative signal phases and gain (signal strengths). The optional parameters associated with this test are the signal strength and the Doppler frequency of the calibrator generated RF test signal. The defaults are -120 dBm signal strength and -1200 Hz Doppler, respectively.

The [R]eference calibration test is used to measure the signal delays through the RF channels. The results are transmitted to the Operations Center in a calibration data frame for use in the data reduction process. This test is executed automatically at a specified interval (normally every 30 minutes).

The [D]igital filter OPTEST tests and exercises the DFs to ensure they are operating consistently with respect to each other. Each DF collects calibrated data, and a bitwise comparison between all filters is performed on the data. The two optional parameters are the number of lower order bits to ignore per 16-bit word when comparing data and the Doppler frequency of the calibrated signal. These defaults are 0 bits and -1200 Hz Doppler, respectively.

Appendix C

SYSTEM MONITOR MESSAGE REPORTING

The system monitor controls system message reporting, outputting messages concerning conditions it detects and conditions other components have detected. An error or informational message is displayed on the last line of the CRT terminal. The hardcopy terminal logs the messages as they occur, one message per line. All system messages are identical for both the CRT and hardcopy terminals. The format for system messages is illustrated and explained below.

Cn: DATE TIME severity ### - <up to 42 characters of text>

C - Specifies which system the message originated from:
P for primary, S for secondary

n - Specifies the computer number, either 0 or 1

DATE - Current date, DD-MMM-YY

TIME - Message time stamp, HH:MM:SS

Severity - severity of condition that generated the message

- FATAL, the condition(s) present may shut down the system (turns on both the audio and visual alarms)

- WARNING, the condition(s) could seriously affect the performance of the system (turns on the visual alarm)

- LOG, this is an informational message (no alarms)

e.g.: P1: 22-AUG-92 07:38:46 LOG 004 - SYSTEM INITIALIZATION COMPLETE

Table C1 lists all the system messages defined for the DSPR system and output by the system monitor. These messages are contained in the SYSMON routine FMTMSG.MAR.

Table C1 — DSPR System Messages

SM01,	X,	<OTHER SYSTEM FAILED>	;001
SM02,	L,	<DAHLGREN LINE SWITCHED TO THIS SYSTEM>	;002
SM03,	W,	<TIME STANDARD FAILED>	;003
SM04,	L,	<SYSTEM INITIALIZATION COMPLETE>	;004
SM05,	W,	<DLC INIT FAILED>	;005
SM06,	W,	<INTERPROC COMM INIT FAILED>	;006

```
SM07,  W,  <OPTEST INIT FAILED>                                ;007
SM08,  W,  <ADCX INIT FAILED>, IMBED                           ;008
SM09,  W,  <DATA PROCESSING INIT FAILED>                       ;009
SM10,  W,  <TARGET SELECT / ARRAY PROC INIT FAILED>            ;010
SM11,  W,  <UTIL_BUS INIT FAILED>                              ;011
SM12,  W,  <GETSEC INIT FAILED>                                ;012
SM13,  F,  <SYSTEM SHUTDOWN BY OPERATOR REQUEST>               ;013
SM14,  W,  <HP59309A CLOCK READ FAILED>                        ;014
SM15,  L,  <ALARM ACKNOWLEDGED>                                ;015
SM16,  F,  <ALL DIGITAL FILTERS HAVE FAILED>                   ;016
SM17,  L,  <EXAMINE>                                           ;017
SM18,  L,  <MODIFIED PARAMETERS XX>, IMBED                     ;018
SM19,  L,  <SWITCHED SPARE CHANNEL TO XX>, IMBED               ;019
SM20,  L,  < *** SYSTEM ACTIVATED *** >                        ;020
SM21,  L,  < *** SYSTEM IDLE *** >                             ;021
IC01,  W,  <ICC COM LINE FAILED>                               ;022
IC02,  L,  <ICC COM RECOVERED>                                 ;023
TG01,  F,  <ARRAY PROCESSOR FAILED>                            ;024
TG02,  L,  <TRGSEL ERROR>                                      ;025
DL01,  X,  <DSV FAILURE >                                      ;026
DL02,  W,  <MODEM FAILURE>                                     ;027
DL03,  W,  <DATA LINE FAILURE>                                 ;028
DL04,  F,  <HQ COMMUNICATION FAILURE XX>, IMBED                ;029
DL05,  L,  <DATA LINE FROM HQ RECOVERED>                       ;030
DL06,  L,  <FRAME LATENCY XXXXXXXXXXX >, IMBED                 ;031
AM01,  X,  <ZERO TARGET ACTIVITY>                              ;032
AM02,  X,  <TARGET SATURATION>                                 ;033
TR01,  L,  <TRACE XXXXXX>, IMBED                               ;034
DC01,  W,  <DIGITAL FILTER CHANNEL X FAILED>,IMBED             ;035
DR01,  L,  <240 MHZ LO #0 RECOVERED>                           ;036
DR02,  W,  <240 MHZ LO #0 FAILED>                              ;037
DR03,  L,  <240 MHZ LO #1 RECOVERED>                           ;038
DR04,  W,  <240 MHZ LO #1 FAILED>                              ;039
DR05,  L,  <240 MHZ LO #1 SELECTED>                            ;040
DR06,  L,  <240 MHZ LO #0 SELECTED>                            ;041
DR07,  L,  <23 MHZ LO #0 RECOVERED>                            ;042
DR08,  W,  <23 MHZ LO #0 FAILED>                               ;043
DR09,  L,  <23 MHZ LO #1 RECOVERED>                            ;044
DR10,  W,  <23 MHZ LO #1 FAILED>                               ;045
DR11,  L,  <23 MHZ LO #1 SELECTED>                             ;046
DR12,  L,  <23 MHZ LO #0 SELECTED>                             ;047
DR13,  L,  <PRODUCTION CALIBRATOR OFF>                         ;048
DR14,  L,  <PRODUCTION CALIBRATOR ON>                          ;049
DR15,  L,  <SCREEN ROOM DOOR CLOSED>                           ;050
DR16,  W,  <SCREEN ROOM DOOR OPENED>                           ;051
DR17,  L,  <FIRE DETECTION RESET>                              ;052
DR18,  X,  <FIRE DETECTION ALARM>                              ;053
DR19,  L,  <TEMP SENSOR RESET>                                 ;054
DR20,  X,  <TEMP SENSOR ALARM>                                 ;055
DR21,  L,  <POWER SUPPLY RESET>                                ;056
```

DR22,	X,	<POWER SUPPLY ALARM>	;057
DR23,	F,	<UTILITY INTERFACE FAILURE XXXXXX>,IMBED	;058
DR24,	L,	<COMMUNICATIONS SWITCH CONNECTED>	;059
DR25,	F,	<COMMUNICATIONS SWITCH NOT-CONNECTED>	;060
OP01,	L,	<COMMENCED OPTEST XXXXXX>, IMBED	;061
OP02,	L,	<COMPLETED OPTEST XXXXXX>, IMBED	;062
OP03,	W,	<OPTEST FAILURE X>, IMBED	;063
DP01,	W,	<DP FP ERROR>	;064
CK01,	L,	<COMMENCED CLOCK RESET>	;065
CK02,	L,	<COMPLETED CLOCK RESET>	;066

The general format of a system message from the above message table is:

SSnn, severity, <text XXX >,IMBED, number

SSnn is the symbolic name of the system message. The letters *SS* usually indicate, by an abbreviation, from what component the message originates. The symbolic names are defined in Macro prefix files and Fortran parameter declaration files. Symbolic names for the above system messages below are defined in DSPR-DEF.DCL.

- SM - System monitor message
- IC - ICC message
- DR - Utility bus control message
- NC - DLC (NAVCOM) message
- OP - Operational test message
- TG - Target selection message
- AM - Activity monitor (OPTEST) message
- DC - Data collection (digital filter) message
- DP - Data processing message
- TR - Trace message

The severity code (F, W, or L) generates the severity words FATAL, WARNING, or LOG, respectively. The X severity code is an exception severity code that generates only a warning message, but then turns on both audio and visual alarms.

The text contained within the angle brackets is the text that appears on the CRT and hardcopy terminals.

A message with one or more X's in the text and the designation IMBED, indicates a field that is filled in during run time. The field usually has a value associated with it. For example, the specific digital filter that failed (1, 2, or 3) is put into the DF failed message (DC01, message number 028).

The number field indicates the value of the symbolic name. All symbolic names for system messages must have unique values associated with them.

Appendix D

SYSTEM MONITOR SYSTEM INTERFACES

D1. PRIMARY SYSTEM

In the primary system, the system monitor component (SYSMON) interfaces to every other component of the DSPR software system and to the system database (DSPCOM). It is also the point from which the operator controls both systems. In this centralized approach, messages to and from other components in either system emanate from or are directed to the system monitor on the primary system. The system monitor component interfaces are:

Enable "receive data" and unsolicited character input
Initialize detached process, using request and response packets
Process "report error condition" packet
Control operational test

The first interface allows data to be received by the SYSMON test from other tasks in an asynchronous manner, and allows the operator to enter a console command request without the system's actually having to solicit it. The asynchronous manner of both the receiving data and the unsolicited character input allow the DSPR system to continue without waiting for synchronous events to occur. When information (data or single character) is received by SYSMON, normal operation of SYSMON processing stops, and the asynchronous routine (AST) that has been specified is executed. Upon exit from the AST routine, the system continues where it left off.

The second interface is between SYSMON and the interprocessor communication process (ICC), DRV1W utility bus process (UTIL_BUS), data line communication process (DLC), data processing process (DP), alert and target selection process (TRGSEL), system timing process (CLOCK), and the antenna data collection (ADC'n') processes. Each of these processes is started by SYSMON. The start-task mechanism for each module is to create a mailbox for the task, send an initialization request packet to the mailbox, create a detached process, and start the task running in the process. The task then reads its mailbox to receive the initialization packet (which in some cases tells the task whether it is being started as part of the primary or secondary system), attempts to perform any necessary startup functions, and sends back an initialization response message indicating success or failure in starting. SYSMON waits for the response packet and checks the response code. If the task has started successfully, SYSMON continues; if not, it sends a failure message to the operator.

The third interface is for reporting error conditions. Information is received from the other tasks (and from SYSMON on the secondary system) via the received data with AST as indicated in the discussion of the first interface. Text is always printed on the console CRT and the hardcopy terminal to form a log of events. Based on the information received, the severity of the error (fatal, warning, log, or exception) is determined.

The fourth interface is to all the operational tests which are operator selectable. SYSMON is responsible for getting the operator's choice of test to run, as well as parameters for that OPTEST. This includes which system or systems on which to run the OPTEST. Once this is determined, the OPTEST parameter values are formatted in an ICC buffer. The SYSMON/OPTEST interface on the primary system uses ICC buffers for initialization of OPTESTs and OPTEST intermediate and final results. A data packet is queued for the OPTEST that describes the ICC buffer from which to get its initialization parameters. Then the OPTEST is requested to run.

D2. SECONDARY SYSTEM

In the secondary system, the system monitor interfaces are the same as on the primary except for the following:

In the error reporting interface, error messages directed to SYSMON on the secondary system are re-directed to SYSMON through ICC on the primary system, so that only one console and hardcopy device are active at any one time. Also, on detection of a fatal error in the primary system, the "report error condition" interface on the secondary system has the responsibility to shut down in a known sequence, so it can reinitialize itself to become the primary system.

The operational test interface differs in that the request and parameters for the OPTEST must have originated from the primary system.

Appendix E

DATA LINE FORMAT

E1. TRANSPORT CONTROL BUFFER (TCB)

The Transport Control Buffer contains all the data from one observation at a NAVSPASUR receiver site, and is sent via dedicated telephone lines to the Dahlgren Processing and Operations Center. The TCB transports the data in from one to six 128-byte Data Transmission Packets (DTP). The initial DTP, or packet, for an observation consists of a Packet Control Block (PCB), one Header Control Block (HCB), one Signal Strength Deviation Block (SSD), and one or more (up to seven) Phase Data Blocks (PDBs). Additional packets may be needed if there are more than seven phase data blocks in an observation. The HCB and SSD are not repeated in these additional packets.

The TCB format is the same for both primary data and secondary data, but an extra step is required for secondary data. Since the data transmission lines are connected to the primary system, it must first be put into ICC buffers and sent from the secondary system to the primary system. Then the ICC buffers are formatted into the data transmission packets which make up the TCB.

Table E1 describes the contents of the initial DTP in a TCB.

Table E1 — Transport Control Buffer (Initial Data Transmission Packet)

Bytes Used in Array	Variable Name	Description
		PACKET HEADER
TCBBUF(1,1)	PKTID	Packet ID
TCBBUF(2,1)	SEGCNT(1)	Segmentation number
TCBBUF(3,1)	SEGCNT(2)	Segmentation number
TCBBUF(4,1)	MORE	More flag
		HEADER CONTROL BLOCK
TCBBUF(5,1)	HDRSIZ	Header size
TCBBUF(6,1)	0	Observation number
TCBBUF(7,1)	0	Observation number
TCBBUF(8,1)	CALIB	Data type, obs/calib
TCBBUF(9,1)	0	Software control
TCBBUF(10,1)	HITIM(1)	Time stamp - hours
TCBBUF(11,1)	HITIM(2)	Time stamp - minutes
TCBBUF(12,1)	HITIM(3)	Time stamp - seconds
TCBBUF(13,1)	HITIM(4)	Time stamp - milliseconds
TCBBUF(14,1)	HITIM(5)	Time stamp - milliseconds

TCBBUF(15,1)	CPUNUM	CPU number
TCBBUF(16,1)	INDX	Doppler region
TCBBUF(17,1)	ITRG	Filter number
TCBBUF(18,1)	DPLR(1)	Doppler frequency, Hz
TCBBUF(19,1)	DPLR(2)	Doppler frequency, Hz
TCBBUF(20,1)	MRCTL	Most recent time-line
TCBBUF(21,1)	IDUR	Time-lines sent

SIGNAL STRENGTH DEVIATION BLOCK

TCBBUF(22-33,1)	BDEV(12)	Signal strength deviation

PHASE DATA BLOCKS (Maximum 55)

Block 1

TCBBUF(34-36,1)	TL_SS(1)	Average signal strength
BBUF(1-12)	Phase on each antenna	

.
.
.

Block 55

E2. PACKET CONTROL BLOCK

The PCB contains four bytes that identify the type of packet and segmentation control for the packet. The length of the PCB is fixed. Following are the PCB contents and descriptions of its elements.

Byte	Description
1	Packet identification
2-3	Segmentation number
4	More flag

Packet identification - A one-byte value which identifies the packet as "keep alive" or "TCB (observation) data." All other values are reserved.

1 - Keep alive
2 - TCB data

Segmentation number (SN) - A two-byte value containing a sequence number for related packets. An observation might be segmented into multiple packets for transmission. The first data transmission packet in a TCB for an observation will have a segmentation number of 1. Each additional packet sent, which is associated with the same observation (and TCB), will thereafter be sequentially numbered. Each new observation will restart the sequence.

More flag - A one-byte value that indicates whether there are more DTPs to come after this one, in order to transmit all the data for the current observation.

0 - More packets
1 - Last packet, or "Keep Alive" packet

E3. HEADER CONTROL BLOCK

The HCB for the TCB provides general information about the observation and the circumstances under which the data was collected. It is included only in the initial data transmission packet for the observation. The length of the HCB is fixed at 17 bytes. Following are the HCB contents and description of its elements.

Byte	Description
5	Header size
6-7	Observation number
8	Data type
9	Software control
10-14	Time stamp
15	CPU number
16	Doppler region
17	Filter number
18-19	Doppler frequency
20	Most recent time-line
21	Time-lines sent

Header Size - A one-byte value stating the number of bytes contained in the HCB (17 bytes).

Observation Number - A 16-bit sequence number provided by the receiver site. This number is reset to 0 whenever the receiver system is restarted. It starts at 0 and is incremented by one (modulo 65535) for each new observation reported.

Data Type - A one-byte value to indicate whether the TCB contains observation or calibration data.

0 - Observation data
1 - Calibration data

Software Control - Reserved for future use.

Time Stamp - A five-byte (40-bit) value providing a data time stamp in 1-ms increments. The first three bytes are the hour, minute, and second values. The last 2 bytes are the milliseconds.

CPU Number - A one-byte value indicating the CPU which produced the TCB data.

0 - CPU A
1 - CPU B

Doppler Region - A one-byte value specifying the Doppler region of the TCB data.

1 - Full-Doppler
2 - Half-Doppler
3 - Quarter-Doppler

Filter Number - A one-byte value specifying the filter which collected the TCB data. The DF numbers are:

1 - Digital Filter #1
2 - Digital Filter #2
3 - Digital Filter #3

Doppler Frequency - A two-byte unsigned value representing the measured Doppler in Hz from the carrier frequency to which the DF was tuned to obtain the data. This integer has a bias of 16,000 added to it so that the negative Doppler frequencies can be represented as positive numbers.

Most Recent Time-line - A one-byte value which contains the time-line number of the most recent phase sample which will be transmitted as part of this observation.

Time-lines Sent - A one-byte value specifying the number of phase data blocks sent, which is the same as the number of time-line signal strength values sent.

E4. SIGNAL STRENGTH DEVIATION BLOCK

The signal strength deviation block contains 12 one-byte values that represent the deviations in observed signal strength in dB for each of the 12 phase channels. The SSD is only included in the initial packet of a TCB. The SSD block length is fixed.

Byte	Description
22-33	Signal Strength Deviations

E5. PHASE DATA BLOCK

Each PDB contains a one-byte average signal strength value followed by one time-line consisting of 12 one-byte phases (one phase per channel), making a total of 13 bytes per block. The number of PDBs sent in an observation is variable, and is contained in the HCB value "time-lines sent." The maximum number of PDBs, or time-lines, per observation is 55.

In the initial TCB packet, after all the header blocks are inserted, there are only enough bytes left to hold seven complete PDBs, which are arranged as follows:

Byte	Description
34-46	TL 1 Average Signal Strength and Phase Values
47-59	TL 2 Average Signal Strength and Phase Values
60-72	TL 3 Average Signal Strength and Phase Values
73-85	TL 4 Average Signal Strength and Phase Values
86-98	TL 5 Average Signal Strength and Phase Values
99-111	TL 6 Average Signal Strength and Phase Values
112-124	TL 7 Average Signal Strength and Phase Values
125-128	TL 8 Average Signal Strength and first 3 Phase Values

If more than seven time-lines are in an observation, additional 128-byte data transmission packets must be used until all the phase data blocks for that observation have been sent.

Each additional packet will contain the four-byte packet control block and eight or nine more PDBs. It is therefore possible that up to five additional data transmission packets could be needed, bringing the maximum number of DTPs for one observation to six. Because every byte of a packet is filled, the particular bytes used for each full phase block in each additional packet varies. Unused data bytes at the end of the last packet will be zero-filled. The phase blocks in the second packet would be arranged as follows:

Byte	Description
5-13	TL 8 Phase values for last 9 channels
14-26	TL 9 Average Signal Strength and Phase Values
27-39	TL 10 Average Signal Strength and Phase Values
40-52	TL 11 Average Signal Strength and Phase Values
53-65	TL 12 Average Signal Strength and Phase Values
66-78	TL 13 Average Signal Strength and Phase Values
79-91	TL 14 Average Signal Strength and Phase Values
92-104	TL 15 Average Signal Strength and Phase Values
105-117	TL 16 Average Signal Strength and Phase Values
118-128	TL 17 Average Signal Strength and first ten Phase Values

Appendix F

UTILITY BUS CONTROL FUNCTIONS

The utility bus control component performs two basic functions. It performs utility bus request operations for other components in the DSPR system and it notifies the system monitor whenever a utility card has a change in functionality (bit setting changes). Each of these is further described below.

F1. PACKET AND CARD SPECIFICS

The utility bus control component (UTIL_BUS) takes requests from the other components and reconfigures the NRL-built addressable cards on the utility bus. If a component wants to request a utility bus configuration change, it must send UTIL_BUS a send packet with the following information:

WORD 3 = message type, consists of two bytes
    BYTE 5 = code for message type
    BYTE 6 = SNDUB, specifies SEND UTIL_BUS message type
WORD 4 = address of utility bus card
WORD 5 = setting of bits to turn on (SET)
WORD 6 = setting of bits to turn off (CLEAR).

UTIL_BUS keeps track of the previous settings for each card on the utility bus in array DRO of UTIL_BUS common UBCOM. (DRO is 15 words in length; word one corresponds to the utility bus card with address one, etc.) It uses the previous bit settings in conjunction with the request for bits to SET and CLEAR to form the new card setting. Thus it does not disturb the previous bit settings other than the specifically requested bits. The new value formed replaces the previous card setting in array DRO.

UTIL_BUS's second basic function is to notify the system monitor in the event of change in the utility bus configuration. The DRV1W is configured so that it generates a VAX 4200 interrupt whenever a utility bus card changes its bit settings. Therefore the DRV1W gets asynchronous notification of a change on the utility bus.

If a utility bus with an address greater than five, or with an invalid address (less than zero), interrupts, then a send packet containing an error message (DR23 - UTILITY INTERFACE FAILURE) is queued for SYSMON. If the address of the interrupting card is between one and five inclusive, UTIL_BUS determines the changes from the previous bit settings for that card and sends the change status to SYSMON via a send packet. The previous settings for the utility bus cards are contained in array DRN in system database DSPCOM common (5 words in length). Each bit in the data byte (low byte of DRV1W word) is checked in the previous and new settings. The status of each bit (0-7) change is returned in an eight-byte array indicating its status change (bit 0 = array element 1, etc.), as shown below.

0 = no bit change between old and new value for bit n
1 = old bit value was 0, new value is 1 for bit n
2 = old bit value was 1, new value is 0 for bit n.

Appendix G

INTERPROCESS COMMUNICATIONS

G1. INTRODUCTION

The DSPR software system requires that many processes communicate with each other in an orderly fashion. Three methods are used by these tasks: Event Flags, Intertask Communication Messages, and Common Areas. The following describes how each of these techniques is used by the DSPR software.

G2. EVENT FLAGS

Event flags are a means by which tasks recognize specific events Sixty-four event flags are available to enable tasks to distinguish one event from another. Each event flag has a corresponding unique Event Flag Number (EFN). In the VMS operating system, numbers 0 through 63 form a group of flags that are unique to each task and are set or cleared as a result of the task's operation, with numbers 24 through 31 reserved for the operating system. Numbers 64 through 128 form a second group of event flags that are common to all tasks. Common flags may be set or cleared as a result of any task's operation. The event flags are grouped into four clusters of 32 each. In order to use the group common event flags, the cluster must be created using a $ASCEFC system service.

Since the event flag can only be set (on) or cleared (off), the amount of information transferred is limited. The use is limited to information that has [illegible] values or to signal the occurrence of an event. After the occurrence of an event, appropriate variables may be checked to determine the appropriate action. The following common event flags have been identified in the DSPR software:

Purpose	Mnemonic	EF Number
Set to start ADC1 task to run	ADC1EF	67
Set to start ADC2 task to run	ADC2EF	68
Set to start ADC3 task to run	ADC3EF	69
Cancel ADC1 collection	CDC1EF	70
Cancel ADC2 collection	CDC2EF	71
Cancel ADC3 collection	CDC3EF	72
Task ADC1 DF time out flag	ADM1EF	73
Task ADC2 DF time out flag	ADM2EF	74
Task ADC3 DF time out flag	ADM3EF	75
ADC1 I/O event flag	DF1EF	76
ADC2 I/O event flag	DF2EF	77
ADC3 I/O event flag	DF3EF	78
Lock common database from change (ON - DSPCOM unlocked)	LOCKEF	80
Signal that data collection completed and data are available (ON - Data available)	DCOLEF	81

Signal to system monitor (SYSMON) that interprocessor communication control (ICC) has sent last message	SMICEF	82
Signal to calibration s/w (OPALRT and OPSYS) that mark time expired	OPT_MKEF	83
Signal to calibration s/w (OPALRT) that data processing has finished with calibration data	CADPEF	84
ICC Buffer control flag	ICCBEF	86
Signal that individual diagnostic has completed (used with last send)	TESTEF	88

G3. INTERTASK COMMUNICATION MESSAGES

This section describes the use of intertask communication messages within the DSPR software system. Two general types are used: VMS send/receive packets and interprocessor communication messages.

G3.1 Send/Receive Packets

Both send and receive packets contain 15 words. The first two words of each packet are used for the source and destination process numbers. This leaves only 13 usable data words (WD03 through WD15) in every packet. Therefore, send/receive packets are used when a small amount of data must be transmitted from sender to receiver. These messages generally contain control information rather than the actual data.

Word 3 (WD03) of all packets is the "message type" word. This word characterizes the message and specifies the format of the rest of the data words. It is divided into two bytes, with byte 5 (of the packet) containing a code for a message type and byte 6 containing a subcode. If an ICC buffer is associated with the message type, the buffer number is stored in WD04. The rest of the packet is used for message dependent data.

The message types are divided into three groups: Level 1, Level 2, and Other. Level 1 messages are relatively simple and do not require transfer of much data. Level 2 messages are more complex and normally have an ICC buffer associated with them. OPTEST messages and most ICC type messages are level 2. When a message is received by SYSMON the AST routine RCVAST is invoked and determines the message type. If it is a level 1 message, it is either handled by RCVAST or passed to REC_1. Level 1 messages are numbered 1 through 7. Level 2 messages are passed to RCVAST_2 for processing. Level 2 messages are numbered 20 through 24. Table G1 lists each message. Following the table is a description of each message.

Table G1 — ICC Messages

Code	Value	Description	Subcode
		Level 1 Messages	
INIREQ	1	Initialization request	Mode # (Primary = 1 or Secondary = 2)
INIRSP	2	Initialization response	Success/failure code
OPRMSG	3	Operator message	Msg number (1-69)
UBMSG	4	Message from UTIL_BUS	
STACHG	6	Other CPU status change	
REQREAD	7	Request read of HP clock	
		Other Message Types	
SNDICC	10	Send ICC message	
SECDAT	11	Secondary data	
SNDUB	13	Send message to UTIL_BUS	
		Level 2 Messages	
ICCMSG	20	Message from ICC	
ICCRCV	20	Message from ICC (alternate)	
OPTMSG	21	Message from Primary OPTEST (ASCII)	
SYRSLT	22	Results from OPSYS	
DLYMSG	23	Primary data delay message	
STATMSG	24	Status message	

INIREQ - Initialization Request

Used by SYSMON to tell other tasks in the system how to initialize. Byte 6 (BY06) is "1" for a primary initialization, "2" for a secondary initialization, and "3" for a shutdown. WD04 = ICC buffer number if packet is an OPTEST Initialization.

INIRSP - Initialization Response

Used by various tasks to inform SYSMON of the outcome of SYSMON's initialization request. BY06 is greater than zero for successful initialization, and less than zero for error initialization.

OPRMSG - Operator Message

Used by system tasks to inform SYSMON that a message for the operator is to be displayed. The message code is contained in BY06.

UBMSG - Message from UTIL_BUS

Used by UTIL_BUS to inform various tasks that input information has been received via the DRV1W utility input.

WD04 contains the integer value of the card number.
WD05 contains the change information for bits 0,1.
WD06 contains the change information for bits 2,3.
WD07 contains the change information for bits 4,5.
WD08 contains the change information for bits 6,7.

STACHG - Other CPU Status Change

This message is used to inform SYSMON that a status change has occurred in the other processor. WD04 contains the ICC message buffer number that holds the new status.

REQREAD - Request Read of HP Clock

SNDICC - Send Interprocessor Message

Used by various tasks to inform ICC that an interprocessor communication message is ready to be sent to the other processor. WD04 contains the interprocessor message buffer number. If WD05 is non-zero, it specifies the number of a global event flag that ICC will set when the interprocessor message has been sent. If WD06 is non-zero, it specifies the line over which ICC is required to try to send the interprocessor message.

SECDAT - Secondary data from DP for GETSEC

SNDUB - Send Message to UTIL_BUS

Used by various tasks to inform UTIL_BUS that information is to be placed on the DRV1W utility output.
WD04 contains the integer value of the card number.
WD05 contains the bit pattern to be set on.
WD06 contains the bit pattern to be set off.

ICCMSG - Message from ICC

Used by ICC to inform various tasks that an interprocessor message buffer has been received for the task. WD04 contains the message buffer number.

ICCRCV - Message from ICC

OPTMSG - Message from Primary OPTEST (ASCII message)

Used by various OPTESTs to inform SYSMON that an ASCII message is to be placed on the CRT and/or the hardcopy terminal. The ASCII message is contained in an ICC buffer (see PHASE II ICC message type 04 for details). WD04 contains the integer number of the ICC buffer.

SYRSLT - Results from OPSYS

DLYMSG - Primary Data Delay Message

STATMSG - Status Message

G3.2 Interprocessor Communication Messages

The interprocessor communication (ICC) messages are 128 bytes (64 words) in length. ICC buffers are used to exchange information between computers and also by the OPTESTs to handle initialization and report intermediate results. (Word-length buffer ICCBFW is equivalenced to byte-length buffer ICCBUF.) The information is position dependent as follows:

Word 1	= Destination
Word 2	= Type
Word 3-64	= Type-dependent data

Word	Assigned Value	Description
1	1 = SM_NUM	Procedure SYSMON
	2 = CLK_NUM	Procedure CLOCK
	3 = ICC_NUM	Procedure ICC
	4 = UB_NUM	Procedure UTIL_BUS
	5 = ADC1_NUM	Procedure ADC1
	6 = ADC2_NUM	Procedure ADC2
	7 = ADC3_NUM	Procedure ADC3
	8 = OPT_NUM	Procedure OPTEST
	9 = DLC_NUM	Procedure DLC
	10 = DP_NUM	Procedure DP
	11 = GSEC_NUM	Procedure GETSEC
	12 = TSEL_NUM	Procedure TRGSEL
	13 = TR_NUM	Procedure TRACE
2	1 = SECMSG	Operator message from Secondary
	2 = OPINIT	OPTEST initialization message
	3 = OPASCI	OPTEST ASCII message
	4 = OPRSLT	OPSYS results
	5 = PRIDIR	Directive for Secondary from Primary
	6 = TRGCNT	Digital filter target counts from Secondary
	7 = SECELM	OPTEST elimination frequency for Primary
	8 = DPXFER	Dynamic parameter transfer
	9 = DLYERR	Data delay message
	10 = PRI_ELIM	Primary elimination message (OPTEST)
3-64	Type dependent data	

The system monitor task (SYSMON) uses interprocessor messages to exchange information between the primary SYSMON and the secondary SYSMON. The value contained in WD02 determines the format of the data words (WD03-WD64).

SYSMON Interprocessor Messages

Value Assigned to WD02	Description
1	Message from Secondary (SECMSG) WD03-WD42 = ASCII message text
2	OPTEST initialization message (OPINIT) WD03 = System 1=Primary, 2=Secondary, 3=Both WD04 = OPTEST number (1-6) WD05-WD64 = Test parameters (test dependent)
3	OPTEST ASCII message (OPASCI) WD03-WD42 = ASCII message text
4	OPSYS results (OPRSLT) WD03 = Results set number (1, 2 or 3) WD04 = Not used IF WD03 = 1 or 2 WD05-WD64 = Phase and signal strength data IF WD03 = 3 WD05-WD24 = Phase and signal strength data
5	Primary Directive (PRIDIR): Directive for Secondary from Primary WD03 = 1 = PDSHUT Shutdown directive WD03 = 2 = PDRCLR Zero (clear) ICC retry counters WD03 = 3 = PDDFLT Modify digital filter status WD04 = Digital filter number WD05 = New status WD03 = 4 = PDCLK Read HP clock and update time WD03 = 5 = PDFLTR Store new filtering parameters WD03 = 6 = PDNTCH Notching directive
6	Digital Filter target counts from Secondary (TRGCNT) WD03 = count for DF1 WD04 = count for DF2 WD05 = count for DF3
7	OPTEST elimination frequency for Primary (SECELM) WD03 = Bin number to eliminate
8	Request Parameters (DPXFER) WD03 = 2 = Request system time WD03 = 3 = Send system time WD04-WD09 = RFTIME WD03 = 4 = Request data processing parameters WD03 = 5 = Send data processing parameters WD04 = SPARCS (low byte), CALST (high byte) WD05-WD06 = RFTH1 WD07-WD08 = RFTH2 WD09-WD10 = RFBIAS

WD03 = 6 = Request antenna parameters
WD03 = 7 = Send antenna parameters
    If WD04=1
        WD05 = RFNBP
        WD06 = RFNEW
        WD07 = RFNNS
        WD08-WD47 = RFPAIR
    If WD04=2
        WD05-WD34 = RFBLEW
        WD35-WD44 = RFBLNS

WD03 = 8 = Request phase calibrations
WD03 = 9 = Send phase calibrations
    If WD04=1
        WD05-WD47 = RFCAL
    If WD04=2
        WD05-WD47 = RFSCAL

9 Data Delay Error Message

10 Primary Elimination Message (OPTEST)

G4. COMMON AREAS

The DSPR system uses five common areas (resident commons) for interprocess communication: DSPCOM, TARGET1, TARGET2, TARGET3, and NAVCOM. DSPCOM is the system database. TARGET1, TARGET2, and TARGET3 are the target commons used by the Data Collection procedure (ADCn) and the Data Processing procedure. (Task ADC1 corresponds to TARGET1, etc.) File TRGCOM.CMN contains all three target common descriptions. The target commons contain the storage for the digital filter data, the time stamp, and the calibration on/off status. NAVCOM contains the TCB data, which is formatted for transmission to the NSSC.

ACRONYMS AND ABBREVIATIONS

ADC	Antenna (Interferometer) Data Collection
APIO	Array Processor Input/Output
AST	Asynchronous Trap
C&D	Calibration and Diagnostic
CCITT	Comité Consultatif Internationale de Télégraphique et Téléphonique
CFAR	Constant False Alert Ratio
CLOCK	System Timing Process
CRT	Cathode-ray Tube
CSM	Command Status Module
dBm	Decibels above 1 milliwatt
DEC	Digital Equipment Corporation
DF	Digital Filter
DFT	Discrete Fourier Transform
DIO	Direct Input/Output
DLC	Data Line Communications
DMA	Direct Memory Access
DP	Data Processing
DSPCOM	DSPR system database
DSPR	Digital Signal Processing Receiver
DTP	Data Transmission Packet
EFN	Event Flag Number
FFT	Fast Fourier Transform
GPIB	General Purpose Interface Bus
HCB	Header Control Block
HP	Hewlett-Packard
Hz	Hertz
ICC	Interprocessor Communications (formerly Inter-Controller Communications)
I/O	Input/Output
IS	Interferometer Subsystem
kHz	Kilohertz
MAP	MAP 4000 Array Processor
MB	Megabyte
Mflop	Megaflop
MHz	Megahertz
ms	Millisecond
NAVCOM	Naval Communications
NAVSPASUR	Naval Space Surveillance
NRL	Naval Research Laboratory
NSSC	Naval Space Surveillance Center
OPALRT	Alert sensitivity operational test
OPDFT	Digital Filter operational test
OPSYS	System signal confirmation operational test
OPT	Operational Tests subsystem

OPTEST	Operational Test
PCB	Packet Control Block
PDB	Phase Data Block
QIO	Queued Input/Output
RF	Radio Frequency
RFCAL	RF Calibration operational test
RR	Receiver Ready
SDLC	Synchronous Data Line Control
SN	Segmentation Number
SNRM	Set Normal Response Mode
SPADATS	Space Detection and Tracking System
SSD	Signal Strength Deviation block
SYSMON	System Monitor and Control
TCB	Transport Control Buffer
TRGSEL	Target Selection
UA	Unsequenced Acknowledgment
UTIL_BUS	Utility Bus