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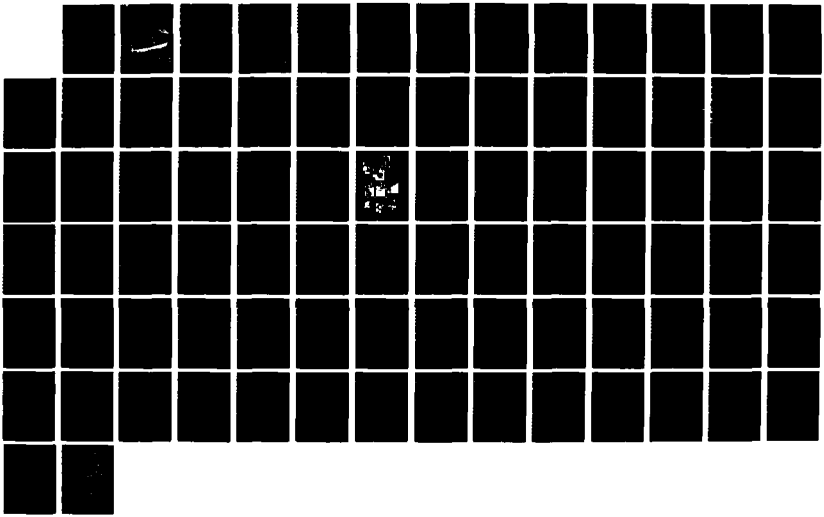

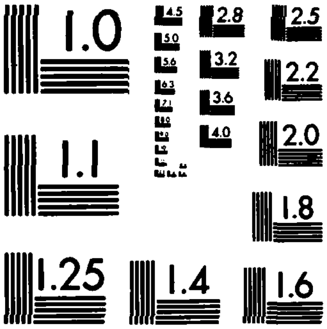
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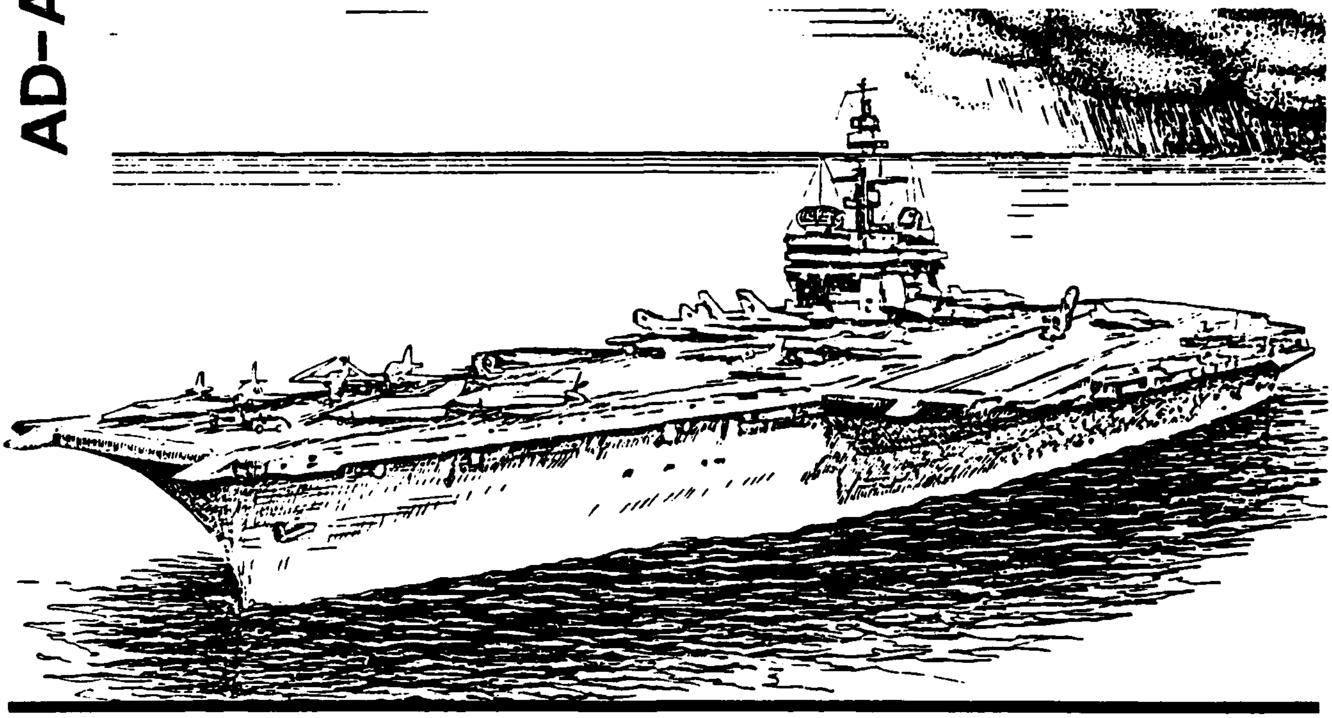
LMSC-HEC-TR-D065300

AD-A189 365

ADVANCED DEVELOPMENT MODEL (ADM) PROGRAM FINAL REPORT FOR THE SHIPBOARD METEOROLOGICAL AND OCEANOGRAPHIC OBSERVING SYSTEM (SMOOS)

20 May 1986

Contract No. N62269-84-C-0309



Prepared for

NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA 18974

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This document describes the design, fabrication and testing of the Shipboard Meteorological and Oceanographic Observing System (SMOOS) Advanced Development Models (ADMs) that was performed under Contract N62269-846-0309. Two smoos systems were successfully tested at sea aboard the USS IOWA (BB61) and the USS KENNEDY (CV68).

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FOREWORD

This final report presents a description of the Shipboard Meteorological and Oceanographic Observing System (SMOOS) Advanced Development Model (ADM). Design, fabrication, and testing were accomplished under Contract N62269-84-C-0309. This document is submitted by Lockheed's Huntsville Engineering Center, Huntsville, Alabama, in fulfillment of Contract Data Requirements List (CDRL) item number A10. Activities conducted under this contract were monitored by Mr. William LaBarge, Naval Air Development Center (NADC), Warminister, Pennsylvania.

Documentation prepared during the course of this contract included quarterly briefings, quarterly progress reports, and reports required by the Contract Data Requirements List (see applicable document section.) The quarterly progress reports and quarterly briefings summarized in-progress results. Formal documentation addresses the following: (1) SMOOS Advanced Development Model (ADM) and Engineering Development Model (EDM) specification; (2) computer program development specification; (3) computer program listings; (4) software program descriptions; (5) an ADM system test plan; (6) acceptance test procedures; (7) acceptance test reports for the three systems produced; and (8) installation briefs for the USS KENNEDY and USS IOWA.

This document presents a summary description of the ADM system.

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1.0 INTRODUCTION

This document describes the system components implemented in the Shipboard Meteorological and Oceanographic Observing System (SMOOS). The contract was conducted to develop an Advanced Development Model (ADM) to demonstrate the SMOOS concept aboard ship. SMOOS consists of a sensor network to acquire surface environmental data, format the data, and disseminate it to displays. Hardware subsystems consist of sensors, data acquisition components, microprocessors, an operator's terminal and remote display units.

Three systems were produced, delivered, and tested during the performance of this contract. One system was used for software development/ check out and to conduct land based shakedown tests. The second and third units, respectively, were installed and tested aboard the USS KENNEDY (CV 67) and USS IOWA (BB 61). This report summarizes the systems produced for the SMOOS advanced development phase.

2.0 APPLICABLE DOCUMENTS

Documents listed below comprise the SMOOS documentation. The list includes both design requirements and documents describing the design and ship installation.

2.1 GOVERNMENT SOURCE DOCUMENTS

1. N62269-84-R-0309 SMOOS Request for Proposal (RFP)
2. N62269-84-C-0309, SMOOS Advanced Development Model (ADM) Contract
3. SA-TS-7833 NAVAIRDEVCEN ADM Specification.

2.2 NON-GOVERNMENT DOCUMENTS

1. LMSC-HREC TR F042602, "Prime Item Development Specification for the Advanced Development Model (ADM) Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

2. LMSC-HREC TR D951786, "Computer Program Development Specification for The System Controller Subsystem of The Shipboard Meteorological and Oceanographic Observing System"

3. LMSC-HREC TR D951782, "Computer Program Development Specification for the Measurement and Control Subsystem (MCS) of the Shipboard Meteorological and Oceanographic Observing System"

4. LMSC-HEC TR F042616, "Measurement and Control Subsystem Software Listing for the Advanced Development Model (ADM) Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

5. LMSC-HEC TR F042620, "System Controller Subsystem Software Listing for the Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

6. LMSC-HEC TR F042619, "Advanced Development Software Package Description for the Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

7. LMSC-HEC TR F042600, "Test and Evaluation Plan for the Advanced Development Model (ADM) Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

8. LMSC-HEC TR F042617, "Acceptance Test Procedures for the Advanced Development Model (ADM) Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

9. LMSC-HEC TR D065301, "Acceptance Test Report for Advanced Development Model (ADM) System 001 Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

10. LMSC-HEC TR F042618-A, "Acceptance Test Report for Advanced Development Model (ADM) System 002 Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

11. LMSC-HEC TR F042618-B, "Acceptance Test Report for Advanced Development Model (ADM) System 003 Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

12. LMSC-HEC TR F042621, "USS KENNEDY Installation Brief for the Advanced Development Model (ADM) System 003 Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

13. LMSC-HEC TR F042622, "USS IOWA Installation Brief for the Advanced Development Model (ADM) System 002 Shipboard Meteorological and Oceanographic Observing System (SMOOS)"

14. LMSC-HEC TR D065302, "Integrated Logistics Support Plan for the Shipboard Meteorological and Oceanographic Observing System (SMOOS)."

3.0 SMOOS DESCRIPTION

This section describes the functions required to satisfy the performance specification delineated in the applicable documents section.

3.1 SMOOS MISSION

The SMOOS mission is to provide meteorological and oceanographic observations, maintain current information for shipboard utilization, and support all naval warfare mission areas. These are: command control and communication; antisubmarine warfare; anti-air warfare; anti-surface ship warfare; amphibious warfare; strike warfare; mine warfare; electronic warfare; intelligence; special warfare; logistics; mobility and fleet support operations. SMOOS is being developed to support these functions aboard the U.S. Navy's major combatants (CV/CVN, AGF, LCC, BB, LHA, LHD, and LPH).

3.2 OPERATIONAL SCENARIO

SMOOS consists of a sensor network to measure specific surface environmental data, and a data acquisition system to acquire, format and disseminate processed data. In operation, the sensor network is periodically interrogated by a data acquisition system and the collected data processed and formatted in preparation for dissemination. The system monitors subsystem performance to detect malfunctions, reports detected errors and stores that data for later use. An interactive terminal permits an operator to interrogate the system for stored data (i.e., historical data, system status information, and current system configuration), perform system configuration changes, view current observations, and view previous observations for the past 15 minutes. Remote data display units at selected locations provide formatted data that are automatically displayed and updated once per minute. The ADM SMOOS provides for manual data entry of the Mini-Rawinsonde (MRS) and the expendable bathythermograph (XBT) data sets. Both data sets are placed in non-volatile storage.

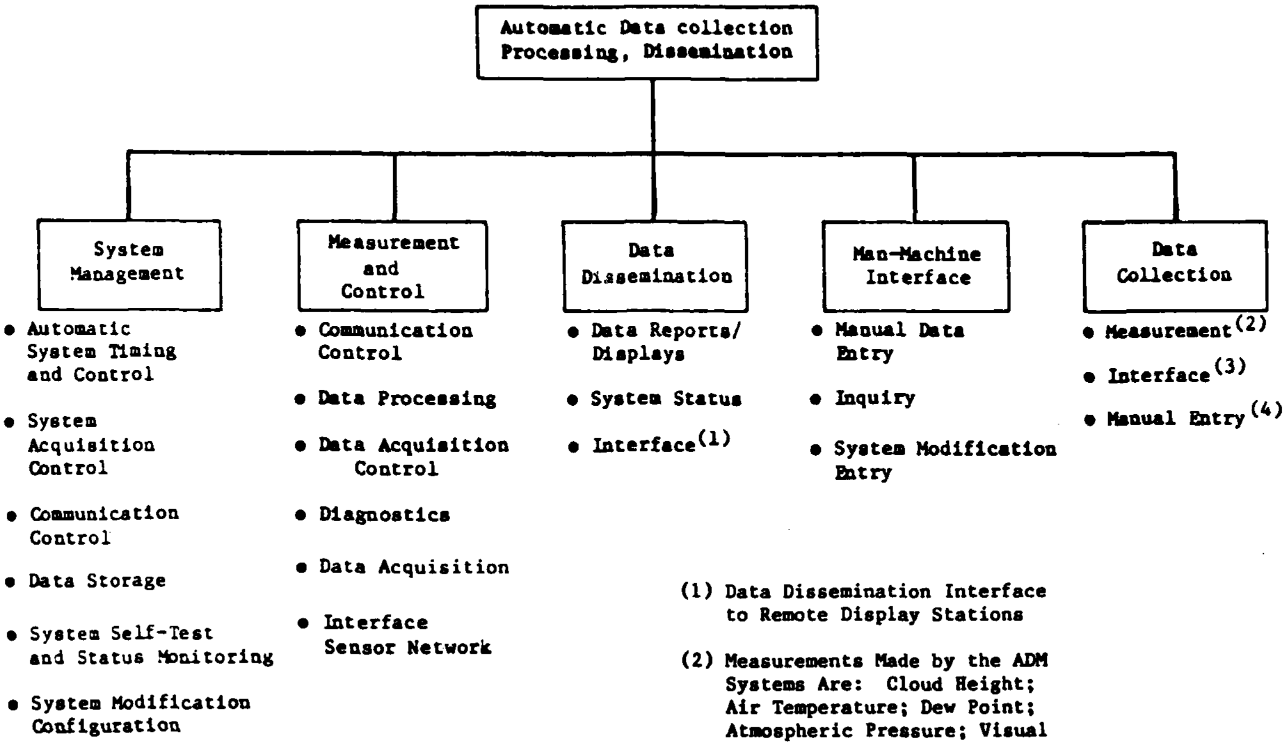
3.3 SYSTEM LEVEL REQUIREMENTS

System level requirements are those derived from the SMOOS operational scenario and the specification requirements delineated in the documents referenced in the applicable documents section. Top level requirements are that the SMOOS system shall be capable of: (1) operating (acquiring and processing) in an automatic, attended or unattended mode; (2) self-test and diagnostics; (3) accepting data from non-SMOOS system elements, i.e., ship's heading and speed, ship's position data and the ship's existing wind sensor system, without disrupting normal system operation; (4) accepting manual inputs to augment the automatically generated observations; and (5) disseminating its products.

3.4 SYSTEM FUNCTIONAL ALLOCATIONS

Five system level functions (Fig. 3.4-1) are required to satisfy the SMOOS system requirements. These are: (1) system management; (2) measurement and control; (3) data dissemination; (4) man-machine interface; and (5) data collection.

The system management function provides overall system control. This is accomplished via automatic system timing and control functions; communication control of data dissemination and of the data acquisition network; system data acquisition control; system configuration control; and self-test and status monitoring. Data processing and acquisition control functions are allocated to both the system management and measurement and control functions. The system management function polls the data acquisition network on a one minute schedule and processes the acquired data for temporary storage and dissemination. Data processing and data acquisition control at the measurement and control level is performed on a repetitive basis and provides data for performing linearization, formatting, and computing specified parameters from the measured data.



(1) Data Dissemination Interface to Remote Display Stations

(2) Measurements Made by the ADM Systems Are: Cloud Height; Air Temperature; Dew Point; Atmospheric Pressure; Visual Range; Sea Water Temperature

(3) Data Collection Interfaces Are for: Relative Wind Data; and Ship's Heading and Speed Data

(4) Manual Entry Provisions Include: Total Cloud Cover; Sea Wave and Swell Wave Data; XBT Data; MRS Data; Present Weather and Remarks

Fig. 3.4-1 SMOOS System Functional Hierarchy

The data collection function acquires data from the sensor network and processes the "raw" data (Section 4.2). This output is in engineering unit formats. The man-machine interface function provides manual data entry capability to the SMOOS system. The data dissemination function permits data reports to be transmitted to remote data displays. Interface functions within SMOOS provide interconnection to the ships wind sensor and the ships heading and speed systems. The data storage function satisfies the operational requirement for temporary information storage.

Subsystem functional allocations are described below.

3.5 SUBSYSTEM FUNCTIONAL ALLOCATIONS

Figure 3.5-1 identifies the SMOOS subsystems and shows the functions allocated to each subsystem. The relationship between the respective subsystems is shown in Fig 3.5-2.

The system controller (SC) performs the system management functions that control data acquisition, system operations and data dissemination. The system controller also provides the interface to the operator's terminal, the remote data displays, and the respective Measurement and Control Subsystem (MCS). Measurement and control functions are accomplished via the respective MCS. Each MCS is identified by a unique address on the network data bus.

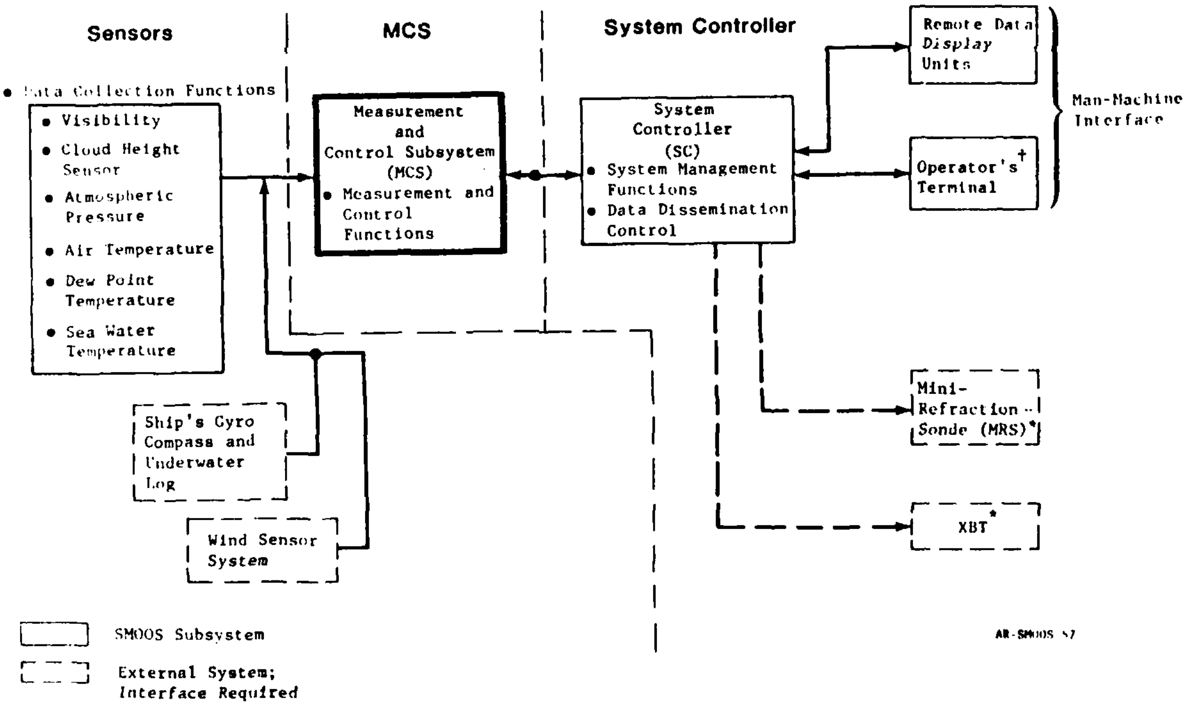
Each MCS is assigned a unique address to which it responds. For the SMOOS ADM system these are zero and one. MCS number zero acquires and processes barometric pressure data, air temperature data, dew point data, and sea water temperature data. MCS number one acquires and processes cloud height data, visual range data and true wind speed and direction. True wind is computed from the apparent wind (speed and direction) and ship's course and speed. Apparent wind is obtained from the ship's existing wind system; ship's course from the ship's gyro and ship's speed from the underwater pit log.

Physical ↓ / Functions →	Data Collection		System Management						Measurement and Control				Data Dissemination				Man-Machine Interface		
	Interface	Measurement	System Timing and Control	System Acquisition Control	Data Processing	Communication Control	Self Test and System Status	System Modification	Communication Control	Data Processing	Data Acquisition Control	Self-Diagnostics	Data Acquisition	Data Reports/Displays	System Status	Interface	Inquiry	Commands Manual Entry	System Modification Entry
Sensors*																			
Cloud Height Sensor		●																	
Visibility		●																	
Atmos. Pressure		●																	
ew Point		●																	
ir Temperature		●																	
Sea Water Temperature		●																	
Sea Swell																		●	
Sea Wave																		●	
XBT																		●	
Radiosonde																		●	
System* Controller	●		●	●	●	●	●	●								●			
MCS*	●								●	●	●	●	●			●			
Operator's Terminal														●	●		●	●	
Remote Display Data														●				●	

* As new sensors are developed or upgrades accomplished its function will be added to the hierarchy

*These subsystems will provide interfaces for SMOOS external systems (i.e., wind, XBT, MRS.

Fig. 3.5-1 Subsystem Functional Allocation Matrix



* MRS, XBT manual input in ADM; automated interface in SMOOS EDM.

† Manual data inputs in ADM include XBT, Radiosonde, sea wave, sea swell information.

Fig. 3.5-2 SMOOS Subsystems

Figure 3.5-3 shows the information and data flow between the SMOOS subsystems and the external systems that interface to SMOOS. The operator's terminal and remote data display subsystems provide the man-machine interface and permit the system to be interrogated. The remote data display(s) are located at selected locations and provide current data for support of shipboard operations. The operator's terminal provides the means whereby the system can be interrogated to retrieve historical data (i.e., system status, previous reports, configuration data, etc.), effect manual data entry, editing, and accomplish system configuration changes. The operator's terminal has the capability to display the same data transmitted to the remote data display(s).

4.0 SMOOS SYSTEM DESCRIPTION

The SMOOS ADM hardware configuration (Fig. 4.0-1) consists of two measurement and control subsystems (MCS); a system controller (SC); sensors to monitor atmospheric pressure, air temperature, dew point, visibility cloud height and sea water temperature; an operator's terminal (display screen and keyboard); and three remote display units (RDU). Apparent wind, ship's direction, and ship's speed are indicated in the block diagram because these data were acquired from existing ship systems. The system parts list, which indicates the part description, vendor, vendor part number and quantity, is included in Appendix A.

4.1 SYSTEM CONTROLLER

The system controller is a microprocessor that operates continuously in a stand-alone mode. It is controlled by software that incorporates a real time operating system and a set of applications programs that implement the required functions.

Ship's Speed & Headings Indicator							Ship's Speed & Data Headings	
	Sea-water Temp						Signal	
		Temp/ Dew Point					Signal	
			Pressure				Signal	
				Visibility			Signal	
					CHI		Signal	
					GFE Sensor	Wind + Sensor System	Synchronous Analog (Apparent Wind) Signal	
					SMOOS Data Collection Package		MCS (Multiple Measurement & Control Functions	
								*MRS Air
							Messages ● Commands ● Scan Req. ● Status Req.	● Ackn Requ ● Surf Data
N/A	Power	Power	Power	Power	Power	N/A	Power	

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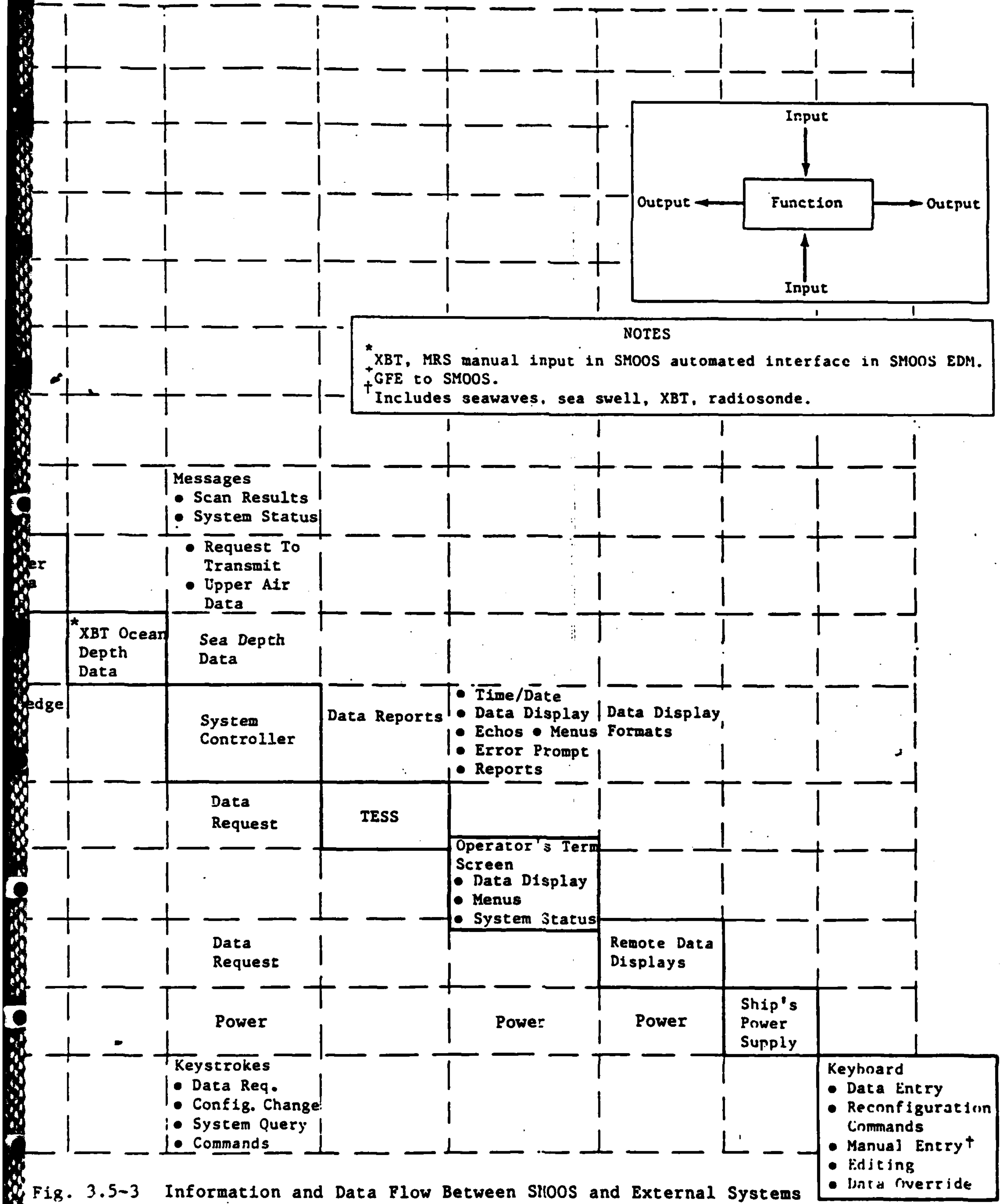


NOTES

*XBT, MRS manual input in SMOOS automated interface in SMOOS EDM.

+GFE to SMOOS.

†Includes seawaves, sea swell, XBT, radiosonde.

Fig. 3.5-3 Information and Data Flow Between SMOOS and External Systems

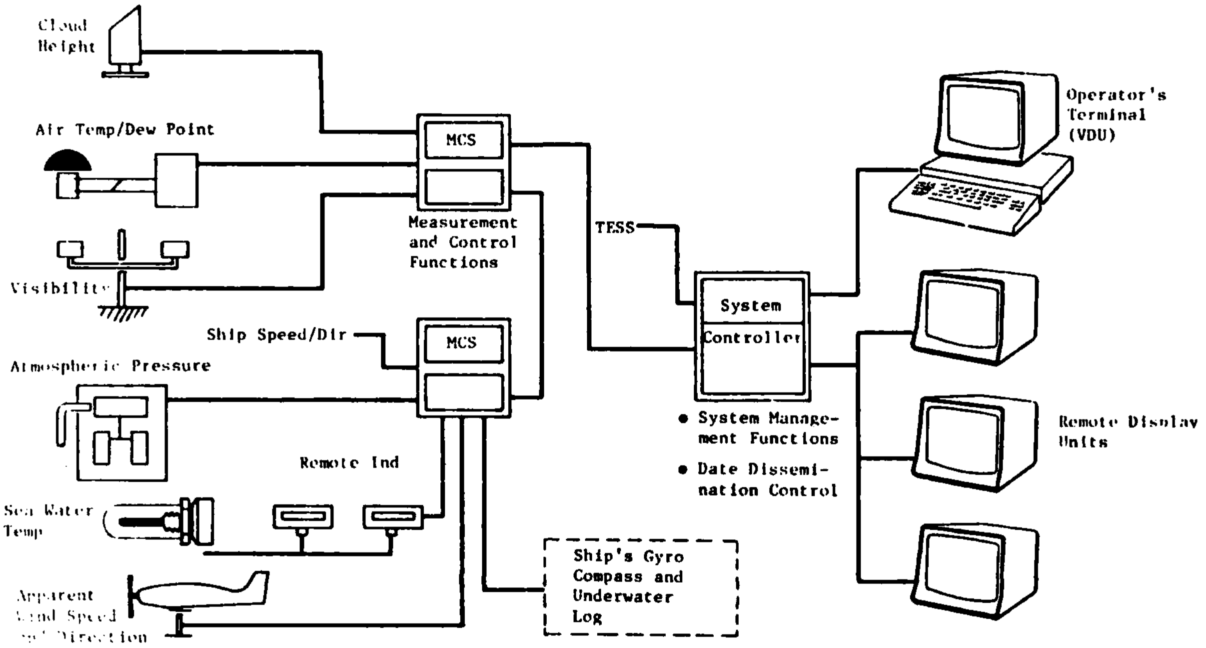


Fig. 4.0-1 ADM System As Installed and Tested Aboard Ship

4.1.1 System Controller Hardware Description

The system controller consists of a multibus oriented electronic card set containing:

1. Central Processing Unit (CPU)
2. 128 K RAM Card
3. Multibus Timing Control Unit
4. Multibus Supervisory Board
5. Math Coprocessor
6. Bubble Memory Card Model BM-128
7. Multiplexer Card.

The respective vendors and model numbers are identified in Appendix A.

These cards reside in a vibration isolated multibus card cage. Both the card cage assembly and a support power supply are installed within a short rack which is integral with an environmental transportation case. A signal manifold provides signal interconnects and transient protection of data and power lines. Filtered air via forced convection cooling is provided by fans and filters mounted on the rear of the system controller. During the shipboard tests the system controller was shock mounted to the deck outside the weather office on the USS IOWA, and the equipment was removed from the short rack and installed in an existing electronic rack aboard the USS KENNEDY.

4.1.2 System Controller Software

The systems controller operating system and applications software are coded in Micro Concurrent Pascal (MCP) high level language. The operating system conducts task management (i.e., system operation is divided into tasks) by monitoring the status, priority and requirements for each task performed by the applications modules. Task management includes process dispatching, queue management, data base management, device polling, and system management.

The applications software is divided into five processes. These are: SCHEDULER PROCESS; OPERATOR'S PROCESS; and three REMOTE DISPLAY UNIT (RDU) processes. Operation of these processes is illustrated in Fig. 4.1-1. This figure indicates the relation between the system controller software and hardware components and shows the data flow between the respective elements.

The SCHEDULER PROCESS controls the acquisition of data from the respective MCSs, formats the data and loads real time data queues for distribution. The OPERATOR'S PROCESS services the operator's terminal. It monitors the keyboard for operator commands and prepares data reports for display on the operator's terminal screen. This process is controlled by a combination of 23 menus and data reports. Menus permit the operator to progressively select lower level menus until a desired data report or manual entry report is displayed. The operator is prompted to enter the appropriate command when a menu is displayed. Menus implemented are:

(1) MASTER MENU

1. Surface Observation Menu
2. Set Time/Date
3. Manual Entry
4. System Monitor
5. MRS Report (Part A)
6. MRS Report (Part B)
7. XBT Report
8. System Configuration Report

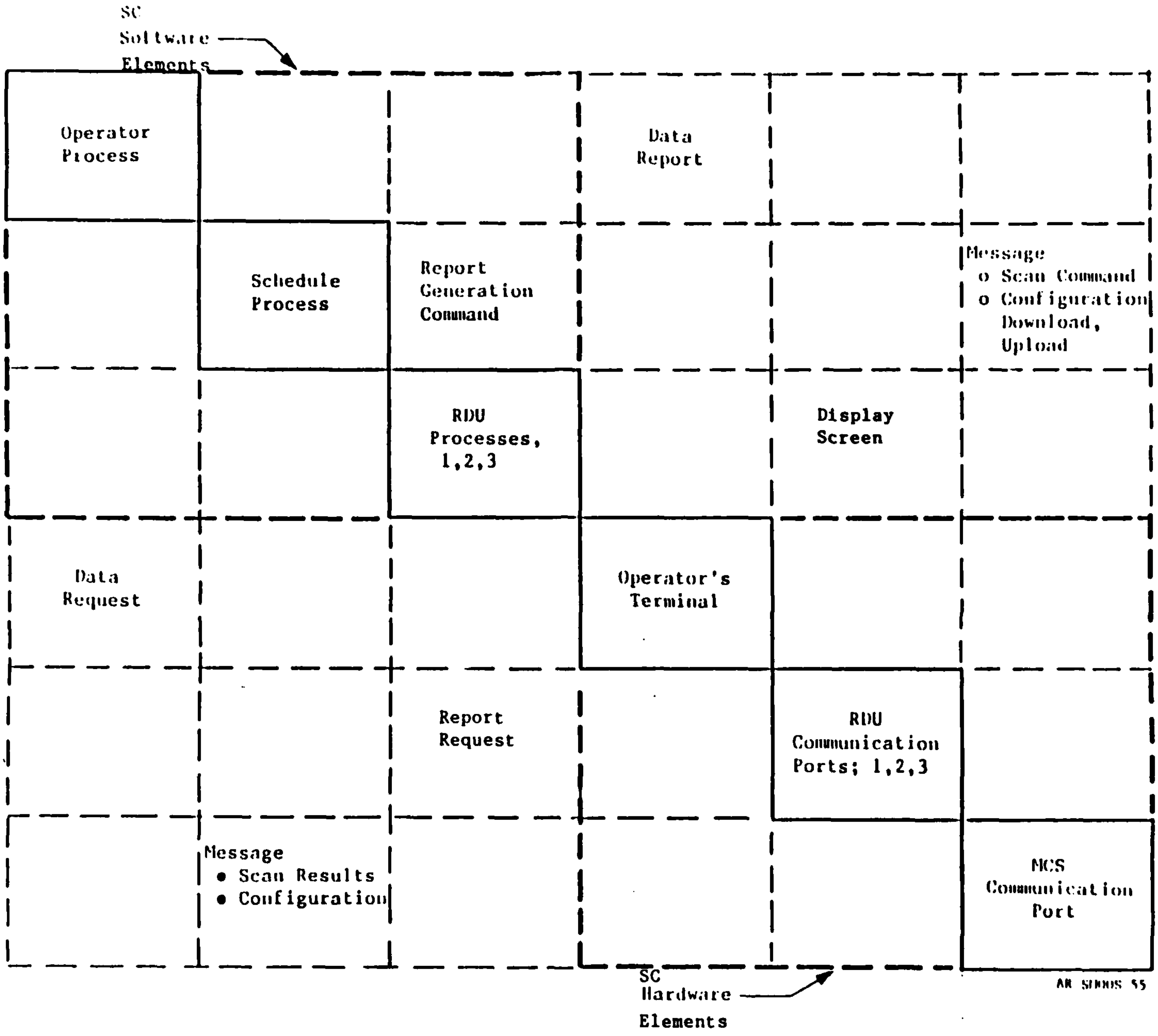


Fig. 4.1-1 System Controller Data Flow Diagram

(2) SURFACE OBSERVATION MENU

1. Surface Weather Observation
2. Previous 15 Minutes Observations
3. Previous 24 Hourly Observations
4. Aviation Weather
5. Miscellaneous Observations

(3) MANUAL ENTRY MENU

1. Manual Observations
2. MRS Entry (Part A)
3. MRS Entry (Part B)
4. XBT Entry
5. System Configuration Entry
6. Alarm Enable/Disable

(4) SYSTEM MONITOR MENU

1. Maintenance Log
2. System Malfunction

Data reports are constructed from a combination of automatically generated products and manual entry observations. Manual entries are effected through the manual entry menu (menu number (3), identified above). Manual observations are weather and obstruction to vision, total cloud cover, obserservation type, sea wave and swell wave data, ships position, observer initials, and special remarks. The Special Remarks is a "free field" that permits the operator to enter text for display at the operator's terminal and the remote display units. The surface weather observation report is a duplicate of Navy Form CNOC 3140/8 that is utilized to record weather observations aboard ship. The previous 15 minutes observations report displays the previous 15 one-minute observations. The format is the same as the surface observation report. The previous 24 hourly observations report is constructed similar to the previous 15 minutes report. Its contents are the hourly observations (i.e., observations taken at 55 minutes past the hour and identified by Type SA) and all special observations recorded during the previous 24 hours. Time reference for this report is midnight Zulu. Aviation Weather is a report designed to support air operations. It contains the following information: observation type, sky condition, visibility, sea level pressure, air temperature, dewpoint temperature, relative humidity, true wind speed and direction, altimeter setting, density altitude, and pressure altitude. The miscellaneous report contains cloud height indicator status (performance information), night time visibility and maximum/minimum temperature recorded during the 24-hour period from midnight Zulu.

When manual data entry is effected the time is recorded and noted on the observation reports. System malfunctions are automatically detected and reported via a status field on the operator's terminal screen. When a malfunction is detected the status field (indicated on the upper left portion of the display) changes from "OK" to "Malfunction" and the diagnostic description is entered into the System Malfunction Report. The operator can then investigate the malfunction by selecting the malfunction report. Malfunction data reported are sensor failure messages, sensor maintenance messages, and MCS status messages.

Each of the three RDU PROCESSES is identical and each services a separate RDU. Three data reports are available for display on each RDU. These are operator selectable at the display unit via a master menu. Reports available to each RDU are the Surface Weather Observation; Aviation Weather, and Special Remarks. Each RDU operates independently of the other two and each is updated once a minute.

Watchdog timer software monitors the system status. If an anomaly is detected that interrupts or stops normal system operation this process causes the controller to effect a system reset. This affects only the controller, which initializes the system and resumes operation.

4.2 MEASUREMENT AND CONTROL SUBSYSTEM (MCS)

The SMOOS ADM system incorporates two Measurement and Control Subsystems to accommodate the baseline sensor network. Each operates independently of the other MCS and of the system controller. Data exchange between each MCS and the controller is accomplished via a handshaking procedure described in the next section. There is no data exchange between the respective MCSs. Data required by a given MCS but not available to it from either its sensors or environmental algorithms, are transmitted to it from the system controller. The system controller transmits air temperature to MCS 1 in this manner. Air temperature is required by the sky condition algorithms.

Each MCS contains the system hardware and firmware to implement the following functions: communication control; data acquisition control; data acquisition; data processing; and self diagnostics.

4.2.1 MCS Hardware

Each MCS consisted of the following modular subassemblies (MSA):

1. Computer Bay MSA
2. Electronics 1 Bay MSA
3. Electronics 2 Bay MSA (Space only)
4. Power Control Bay MSA.

In addition, an interconnect bay was incorporated to facilitate signal routing and transient protection. All of the above bays were installed in a Hoffman enclosure with EMI and environmental gasketing.

The data acquisition system used in the MCS design is a microMac 5000 microprocessor that was procured from Analog Devices.

The Electronics 1 bay houses the electronic components that signal condition the analog (synchro) signals from the wind speed and direction and the ship course and speed systems. Synchro-to-linear voltage converters procured from Analog Devices Inc., were used in this bay to accomplish the analog format conversions.

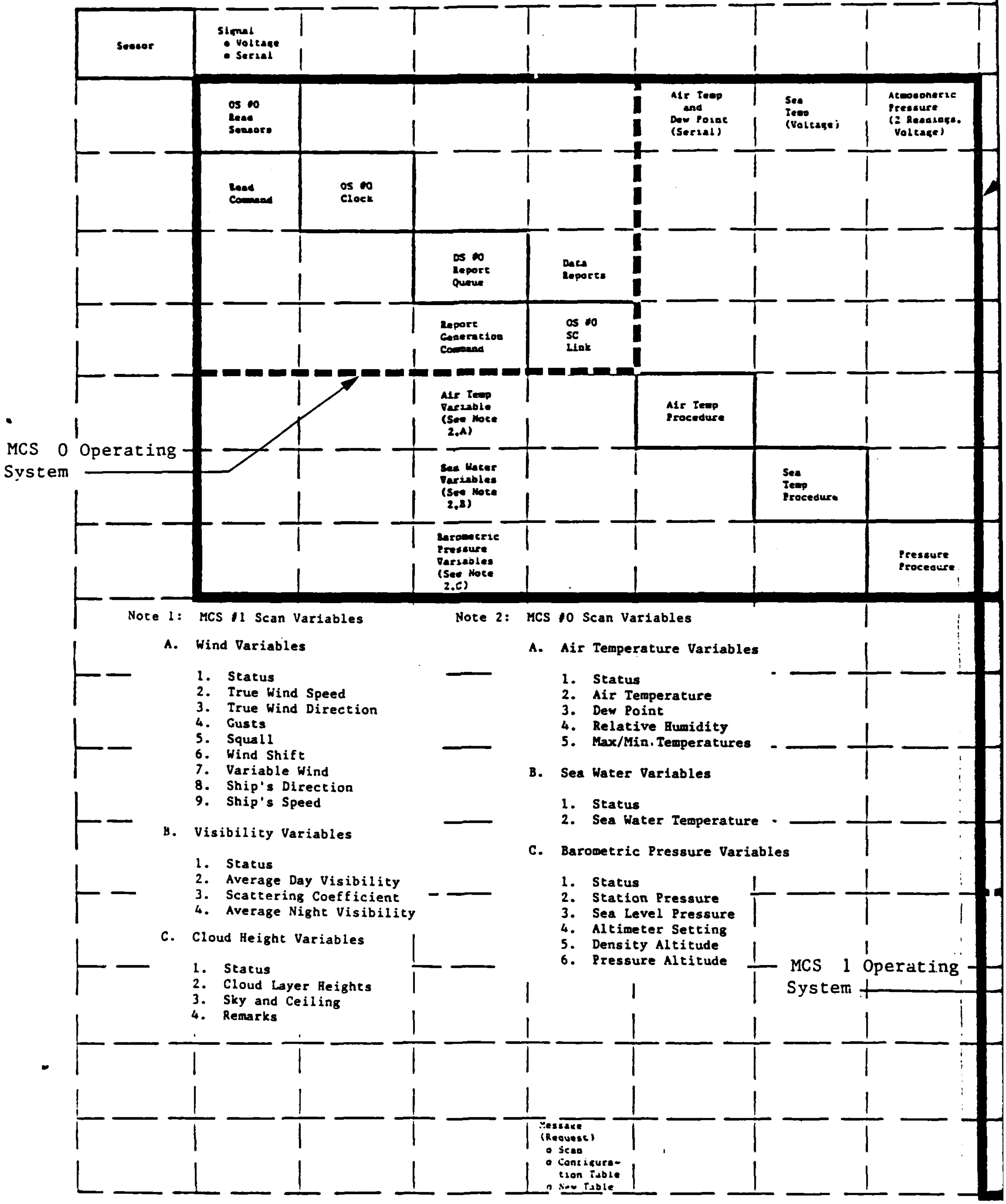
4.2.2 MCS Software

Functions allocated to the MCS are collectively accomplished by the real time operating system and the applications programs identified in Fig. 4.2-1 where the respective applications programs are denoted as procedures. The real time operating system and applications modules for the MCS are coded in Microbasic high level language.

4.2.2.1 MCS Control Software

In addition to the standard arithmetic and program control functions that are required for each MCS microprocessor, the following software functions are implemented: (1) a function to read analog-to-digital inputs; (2) operations to input discrete status signals; (3) operations for inter-task and interprocessor control; and (4) an operation to start and stop independent tasks. Environmental data are acquired from the respective sensors and are processed and transmitted to the system controller (Fig. 4.2-1) in the following sequence: (1) acquire "raw" sensor data; (2) perform a limit check; (3) perform a consistency check; (4) perform continuity check when appropriate; (5) execute environmental algorithms; (6) format data; and (6) store formatted data in a transmit queue. Each MCS contains a configuration table that identifies control parameters and sensor limit data. For example, the configuration table indicates which MCS incorporates the respective environmental algorithms. A complete description of table formats is given in Appendix B.

Each MCS is programmed with its own default configuration table. Each MCS will transmit its current configuration on request. Each configuration can be changed by "downloading" a new table. A new configuration controls the respective MCS until a "hard reset" occurs. A hard reset occurs when power is removed from the MCS and then reapplied. The MCS is completely re-initialized and the default configuration reloaded. A soft reset occurs when the MCS logic detects a system fault and reinitializes the respective



Note 1: MCS #1 Scan Variables

A. Wind Variables

1. Status
2. True Wind Speed
3. True Wind Direction
4. Gusts
5. Squall
6. Wind Shift
7. Variable Wind
8. Ship's Direction
9. Ship's Speed

B. Visibility Variables

1. Status
2. Average Day Visibility
3. Scattering Coefficient
4. Average Night Visibility

C. Cloud Height Variables

1. Status
2. Cloud Layer Heights
3. Sky and Ceiling
4. Remarks

Note 2: MCS #0 Scan Variables

A. Air Temperature Variables

1. Status
2. Air Temperature
3. Dew Point
4. Relative Humidity
5. Max/Min. Temperatures

B. Sea Water Variables

1. Status
2. Sea Water Temperature

C. Barometric Pressure Variables

1. Status
2. Station Pressure
3. Sea Level Pressure
4. Altimeter Setting
5. Density Altitude
6. Pressure Altitude

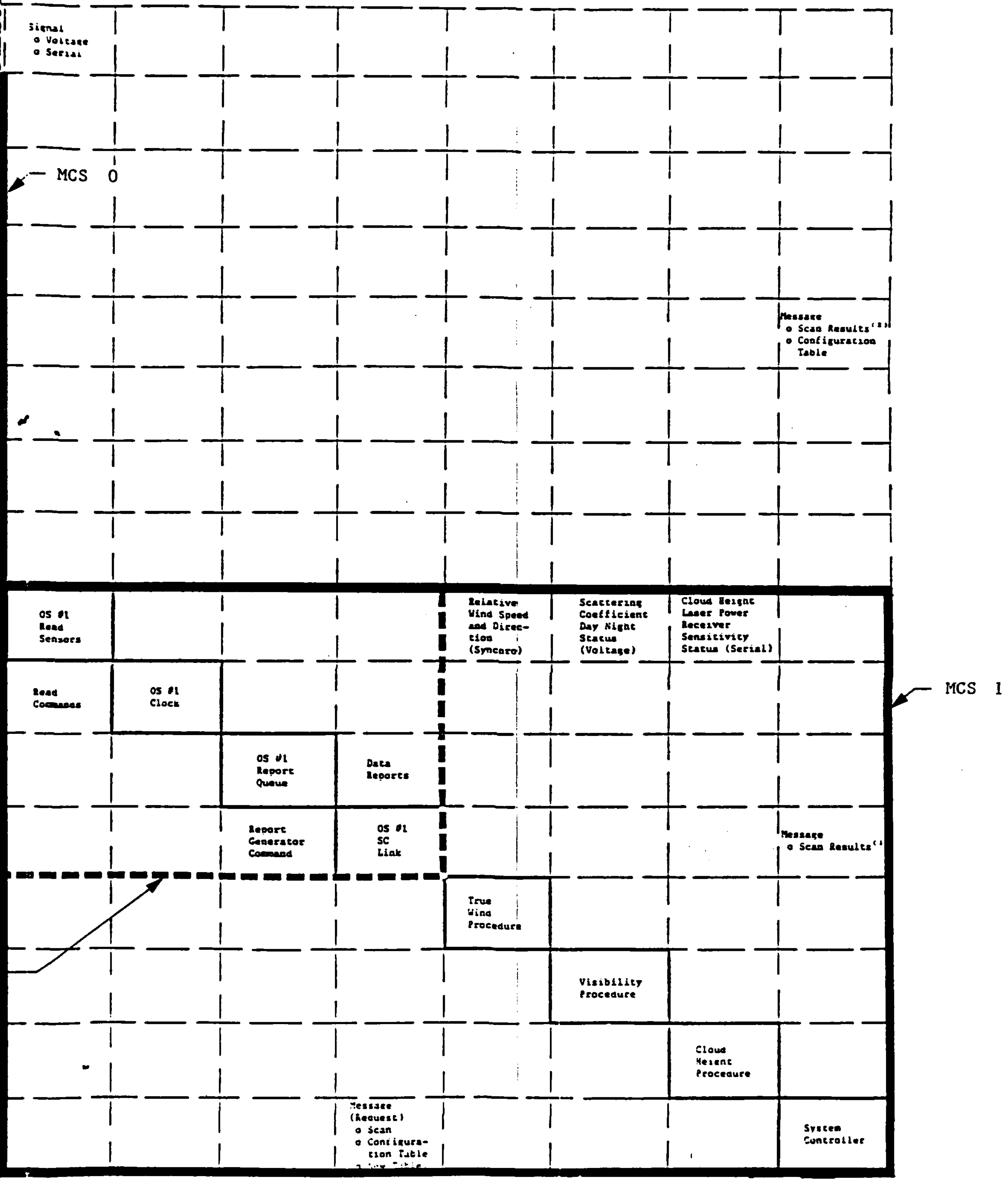


Fig. 4.2-1 SMOOS ADM System MCS Data Flow Diagram

algorithm execution. The current configuration table is retained and continues to control the MCS operation.

4.2.2.2 Environmental Algorithms

The environmental algorithms used during the ADM development phase are based on Automated Surface Observation System (ASOS) algorithms which were developed by the National Weather Service to convert meteorological sensor output into a standard surface weather observation report. These algorithms were modified to satisfy SMOOS requirements. The algorithms incorporated are atmospheric pressure, wind, air temperature, dew point, visual range, and sky condition. A sea water temperature algorithm was developed for the present application. Land based wind algorithms were modified to output shipboard wind parameters described below. Each algorithm is designed to provide updated parameters each minute. Provisions are made for reporting special observations and generating remarks. These algorithms were designed to be sensor independent. The algorithms are described in Appendix B.

4.2.2.3 Data Transmittal

Data transmitted between each MCS and the system controller are contained in message packets that consist of either a command or data set. The command codes are transmitted by the system controller. Each command contains an identifier noting the MCS (either 0 or 1) for which the message is directed. The command codes are:

No.	Command
1	Scan Results
2	Download Configuration
3	Upload Configuration.

The Scan Results command directs the respective MCS to send its latest data set. The Upload and Download configuration commands direct the MCS to receive a new configuration or in the latter command to send its current configuration.

Scan result formats from each MCS are loaded into a transmit queue for transmission to the system controller. Data obtained from each MCS and the order in the transmit messages are denoted on Fig. 4.2-1. Data transmitted from MCS 0 are given in Note 2 (Fig. 4.2-1) and data from MCS 1 are given in Note 1.

The format of data messages transmitted between the MCS and the system controller is presented in Appendix D.

4.2.3 System Communication

The SMOOS communication link conforms to the RS-422 standard and connects the system controller to the MCS, remote displays, and operator's terminal. (See Fig. 3.5.2 for the system block diagram.) The system controller and each MCS are conncected via a multidrop line which provides a full duplex function of command transmission from the controller to a MCS and the response transmission back to the controller. All MCS subassemblies are listeners in the attention mode and only the MCS to which a command is directed responds to the system controller. To accomplish this, each MCS is assigned an identification address through an existing personalization switch assembly - a feature of the microMac 5000. The message packet and data transfer format transmitted between the controller and each MCS are described in Section 4.2.2.3 and Appendix D.

4.2.4 Handshaking Procedure

The SMOOS ADM handshaking procedure operates on a stimulus-response basis. Each MCS operates continuously in a stand alone mode (i.e., acquiring environmental data, formatting and updating its transmit queue). The system controller polls each MCS on a periodic basis. When polled each MCS acknowledges the request and transmits data stored in its transmit queue. Upon receipt of the transmission the system controller acknowledges the transmission. A maximum of three attempts to poll each MCS is executed before the controller terminates a poll sequence. When this occurs the controller reports an MCS malfunction.

4.3 REMOTE DISPLAY UNITS (RDU)

Three interactive displays (touch screen) were used to disseminate the data to remote users. These RDUs are neon orange plasma discharge types manufactured by IEE, Inc. The unit (PEP Model 480) is operator interactive with the host computer by touching the screen at menu-defined touch points. The panel consists of a plasma display with all necessary electronics to provide drive and refresh functions. Data output are alphanumeric characters and are accomplished through menu-type prompts which collectively output specific data groups. Display reports available to the user are the Surface Weather Observation Report, Aviation Weather Report, and Special Remarks Reports. Each is selectable from a Master Menu which is automatically displayed at power-up. All display formats available to the operator are supported by software residing in the system controller. Two levels of brightness are provided in the display design to allow contrast selection for either daytime or nighttime operation. In addition, a glare shield was installed around three sides of the display. A power switch and fuse completed the RDU design.

4.4 SENSOR NETWORK

The following sensors comprise the SMOOS ADM sensor network.

4.4.1 Cloud Height Indicator

The cloud height sensor selected for the SMOOS ADM was the Impulsphysik Model LDWHL. This is a microprocessor-controlled Laser Ceilograph that automatically detects the height of up to two cloud layers to 5000 feet. The sensor has a measuring repetition rate of four times a minute using a pulsed gallium arsenide light emitting diode array with an operating wavelength of 906 nanometers as the transmitter, and a photodiode range gating receiver. The sensor was connected to MCS 1 via a 0-20 mA communications link. This unit was modified for sea service as follows:

1. Units were painted gray at the Navy's request.
2. All accessible fasteners were secured by an anti-loosening compound.
3. The RS-422 communication interface was replaced by a 0-20 mA interface.
4. A power contactor was added to allow power control from the MCS.

4.4.2 Visibility Sensor

The visibility sensor for ADM is the Model VR 301 manufactured by HSS, Inc. The VR 301 is a forward scattering meter which measures radiation scattered by airborne aerosols in the vicinity of the sensor. A scattering coefficient is computed from this measurement. The scattering coefficient is virtually identical to the total extinction coefficient of the atmosphere at visible wavelengths. The radiation source is a pulsed 880-nanometer light emitting diode. The scattered energy is synchronously detected to produce a voltage which is proportional to the scattering coefficient. The output of the VR-301 is converted to a suitable voltage level by a QMX-03 signal conditioning module residing at the MCS. This unit was modified for sea service as follows:

1. The fault card was laid out and fabricated on a printed circuit card.
2. Parts and connectors were secured to prevent damage or disengagement during high vibration levels.
3. The auxiliary box containing the power supplies was shock mounted.
4. A waterproof connector was added to the auxiliary box.

4.4.3 Dew Point and Air Temperature

Dew point and air temperature are measured by a hygrothermometer manufactured by Technical Services Laboratories, Inc. (TSL Model 1063). The sensor unit combines an air temperature sensor with a dew point sensor in a single instrument. The air temperature is measured with a platinum resistance thermometer. Dew point temperature is obtained from a chilled mirror assembly in which a reversible thermoelectric cooler with a feedback control loop maintains the temperature of a reflective surface at the dew point temperature of the ambient air. Both sensors are shielded from ship induced heating and extraneous radiation by an aspirated shield. Air temperature and dew point data are digitized by the hygrothermometer and transmitted to the MCS via a serial digital data communication link.

The sensor unit is an off-the-shelf assembly that was modified as follows:

1. Parts and connectors were secured to prevent damage or disengagement during high vibration levels.
2. The auxiliary box containing the power supplies was shock mounted.
3. A waterproof connector was added to the auxiliary box.
4. A rugged mount was designed for the mechanical interface between the TSL sensor and the ship.
5. The RS-232 communication interface was replaced by a 0-20 mA interface to the measurement and control system (MCS).

4.4.4 Sea Water Temperature

A resistance temperature device (RTD) manufactured by HyCal was used in the SMOOS ADM program and interfaced to a current loop transmitter and bridge completion electronics unit also manufactured by HyCal. Part numbers for the device used are identified in the parts list.

Sea Water Temperature

1. Installed aboard USS IOWA only. (The USS KENNEDY engineering officer refused permission to make installation.)
2. Sensor located at No. 3 condensor inlet.
3. Displays located in No. 3 engine control room.

4.4.5 Atmospheric Pressure

Two Rosemount Model 1201F2A3 pressure transducers were collocated inside the weather room and near the existing aneroid barometer. Both transducers were packaged inside a shock isolated enclosure. Both transducers were manifolded and vented to the weather room through a sieve filter of sintered metal to protect the transducers against overpressure due to armament discharge. A dc power supply was provided internal to the housing to power both transducers. The output of each sensor was connected to one of the analog input ports of the MCS.

Both sensor outputs were compared to identify possible erroneous data outputs. The criterion for determining erroneous data was a difference between the sensor outputs greater than 0.03 in.Hg. Where this condition was detected an error status was posted to the operator's terminal screen, and all pressure related parameters were reported as "missing" until the error condition criterion was no longer met. If the difference test was successful, the lower of the two pressure readings was reported and used in pressure parameter calculations. (See Atmospheric Pressure Algorithm, page C-11, Appendix C.)

4.4.6 Wind and Ship Velocity Inputs

Apparent wind speed and direction were obtained from the existing electromechanical anemometers located aboard the ships. These anemometers were the Synchro-Type B and Synchro Type F defined by MIL-W-15805 and MIL-E-22900, respectively. Ship's speed was obtained from the ship's electromechanical pit log and ships direction was obtained from the gyrocompass. All four signals were interfaced to MCS 0. Signal conditioning was provided by Analog Device Model SAC-1763-622 synchro to linear voltage converters located in electronics bay 1 of MCS 0. The output of the converters was digitized and the digital data was used to compute the true wind speed and direction (see Wind Algorithm, page C-17, Appendix C).

5.0 SHIPBOARD INSTALLATION

Specific equipment locations and items of special note are as follows:

MCS

One located in a sheltered environment on each ship
One located in an unsheltered environment on each ship.

SC

1. Shock mounted to deck outside the weather office on USS IOWA
2. Processor was removed from short rack and installed in an existing electronic rack aboard the USS KENNEDY.

RDU Installation

	Bridge	Met Room	CEC
USS KENNEDY		X	
USS IOWA	X	X	X

Cloud Height Indicator

Located at 07 level on USS IOWA and 08 level on USS KENNEDY.

Amospheric Pressure Assembly

Located inside the weather office on both ships and near the existing pressure sensor.

Visibility Sensor

1. A Lockheed designed and fabricated mouting was provided on both ships.
2. Located on 07 level on USS Iowa and on 08 level on USS Kennedy.

Temperature - Dew Point Sensor

1. Collocated with the visibility sensor on both ships
2. A Lockheed designed and fabricated mounting was provided.

Shipboard installation was conducted in accordance with the respective installation briefs for the USS IOWA and USS KENNEDY. These installation briefs are detailed instructions for equipment location, equipment mounting, cable runs, and electrical connections. Pictorial Representation of equipment installations are shown in Fig. 5.0-1.

Installation aboard the USS KENNEDY occurred during the middle of December 1985. Check out and dock-side testing were complete by 10 January 1986. Installation aboard the USS IOWA was completed during the first week in January 1986.

Dockside tests were completed aboard the USS IOWA by 10 February 1986.

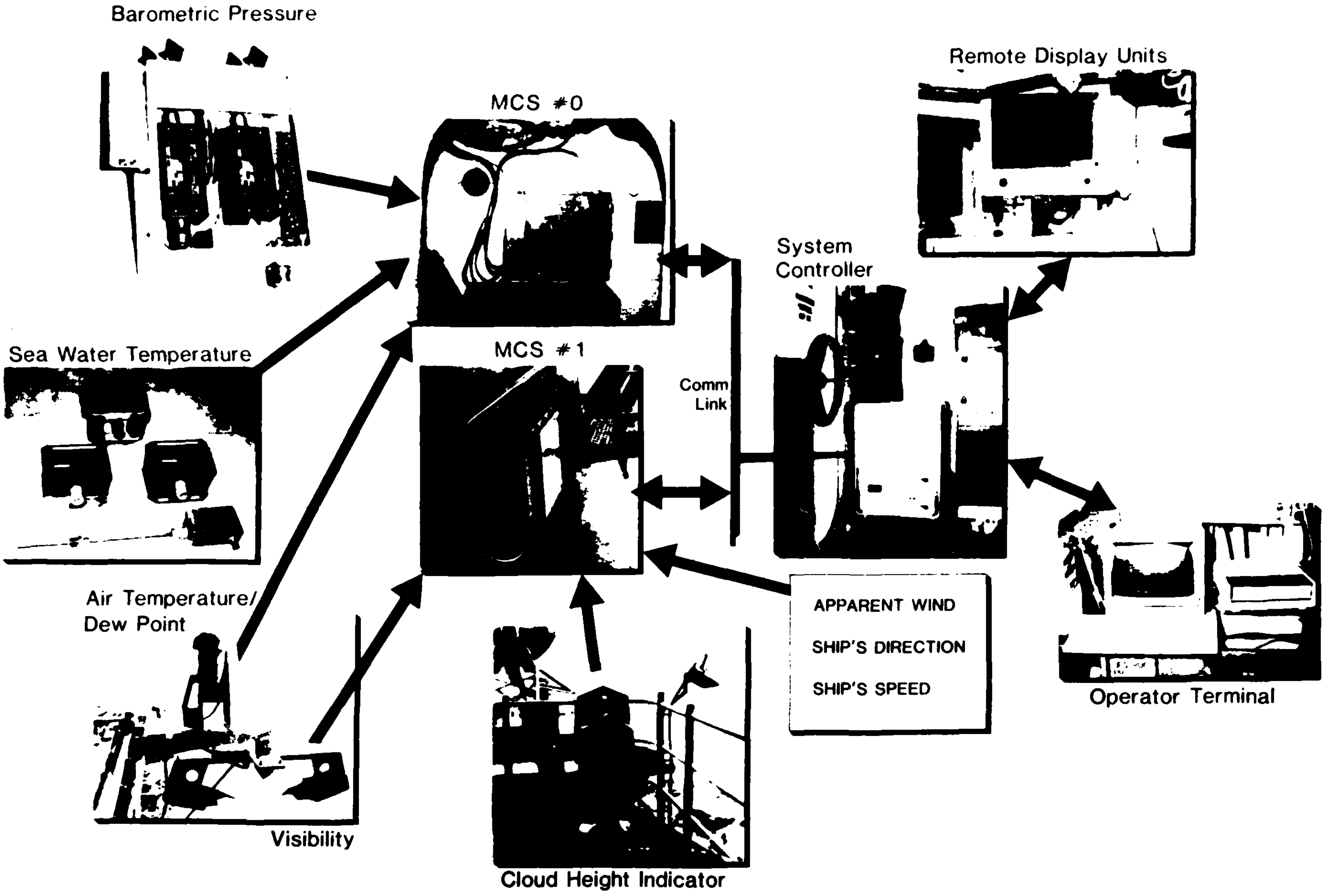


Fig. 5.0-1 Typical Shipboard Installation

Equipment locations aboard each ship were:

Item	Location USS IOWA	 USS KENNEDY
CHI	07 Level	08 Level
Visibility	07 Level	08 Level
Hygrothermometer	07 Level	08 Level
Pressure	Met Room, 04 Level	Met Room, 06 Level
Sea Temperature	Condenser	--
Operator's Terminal	Met Room	Met Room
MCS 1	04 Level	Met Room
MCS 2	07 Level	08 Level
RDU 1	Met Room	Met Room
RDU 2	CEC	--
RDU 3	Bridge	--

6.0 SHIPBOARD TEST

Table 6.0-1 shows that the combined test time aboard both ships exceeds 2800 hours with shipboard time distributed as shown in Table 6.0-1.

Table 6.0-1 SHIPBOARD TEST PERIOD

Ship	Test Condition	Duration	Estimated Operating Hours
USS IOWA	In Port	4 wks	672
USS IOWA	At Sea	5-1/2 wks	924
USS KENNEDY	In Port	5 wks	240
USS KENNEDY	At Sea	4 wks	672

Shipboard SMOOS installation and deinstallation was performed by a subcontractor, Pac Ord, Inc., under the direction of Lockheed. Shipboard testing was conducted by NADC personnel and supported by Lockheed. One-hundred-thirty days of testing aboard ship were logged during the test program. The climatic extremes are shown in Table 6.0-2. Other conditions of note were: (1) ten to 12 hours of daily air operations aboard the USS KENNEDY and (2) four gunnery demonstrations of firepower aboard the USS IOWA.

Table 6.0-2 SOV CLIMATIC EXTREMES

Dew Point	6 F to 74 F
Air Temperature	26 F to 87.5 F
Cloud Height	100 ft to 5600 ft
Atmospheric Pressure	29.52 to 30.44 in.Hg
Wind Speed	0 to 47 knots
Wind Direction	360 deg

Reliability. Total system test time (i.e., three systems) as of 30 March 1986 is 7572 hours. Test time consists of 4580 hours at the Lockheed-Huntsville facility and 3108 hours of shipboard testing. The land based system at Lockheed-Huntsville was subjected to temperature extremes ranging from 0 F to 95 F; a wide humidity range and variable weather.

The SMOOS ADM reliability assessment is summarized in Fig. 6.0-1. Less test time was accumulated during shipboard testing than during landbased testing.

There were *no system failures* in shipboard testing after 3108 operating hours under a variety of operating conditions. It can therefore be stated that the demonstrated mission reliability of the shipboard systems, expressed in terms of mean time between failures (MTBF) is in excess of 830 hours. The demonstrated reliability of the landbased system is in excess of 1200 hours.

The predicted MTBF of the SMOOS was obtained by the "Parts Count" method of MIL-HDBK-217. The predicted MTBF is 205 hours. The system outperformed this prediction by a wide margin.

SOV Maintenance Assessment. During the SOV shipboard test the sensor components were continuously monitored. The maintenance actions are summarized in Table 6.0-3.

SOV Test Assessment. The SOV test analysis and assessment will be published by the U.S. Navy under separate documentation.

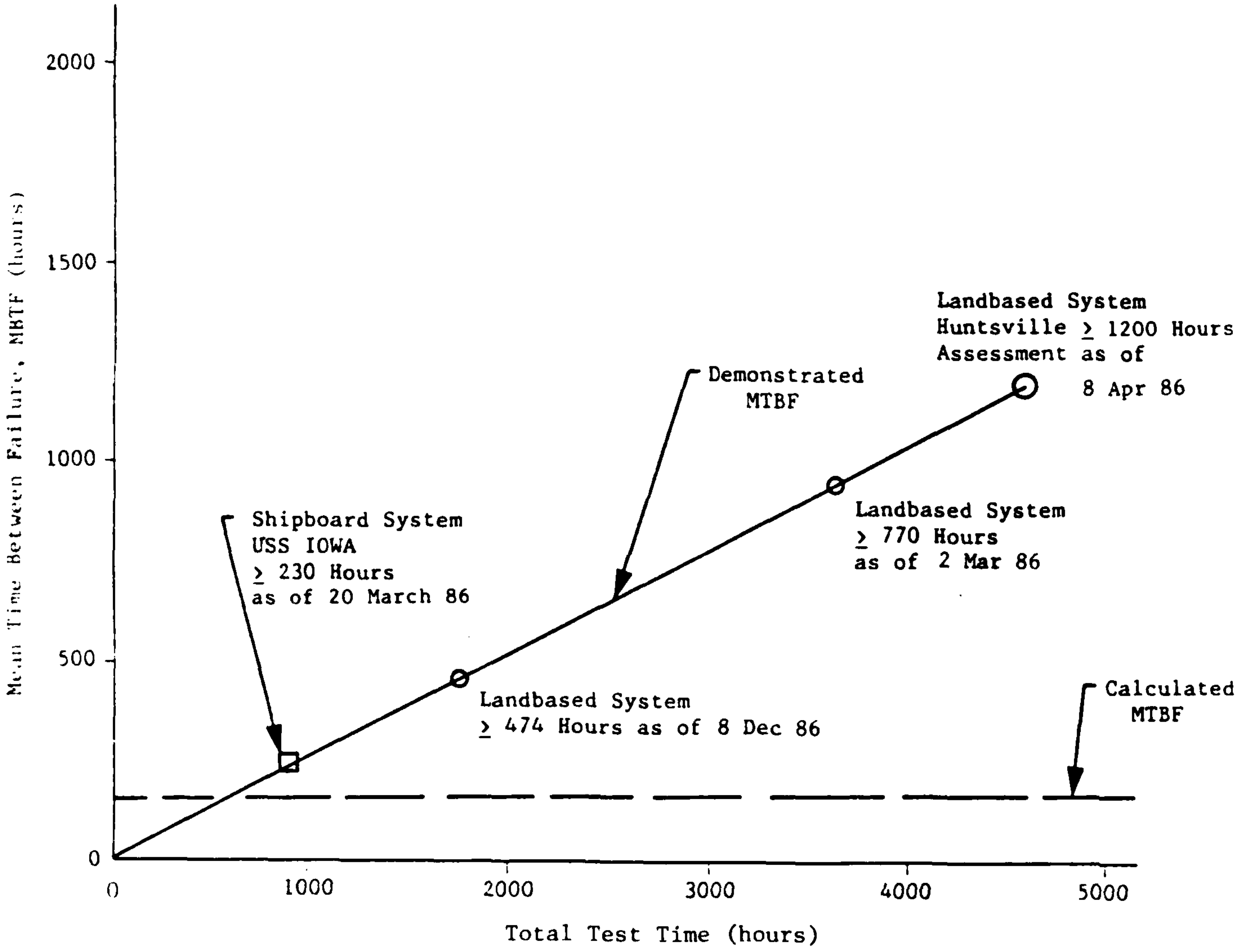


Fig. 6.0-1 SMOOS Mission Reliability Assessment

Table 6.0-3 MAINTENANCE DURING SOV

Sensor	USS KENNEDY	USS IOWA
CHI	Cleaned windows weekly. (BIT did not indicate need for this.) Data remained good.	Cleaned windows weekly. (BIT did not indicate need for this.) Data remained good.
Visibility	Cleaned windows at start, and one intermediate cleaning. (BIT did not indicate need for this.) Data remained good. Checked calibration twice, no recalibration required.	Cleaned windows weekly, BIT indicated dirty windows last week at sea. Checked calibration weekly recalibrated three times although no degradation of data.
Hygrothermometer	Cleaned mirror weekly although no indication of degraded data. Jet exhaust residue (oily) observed. Calibration check okay for duration.	Checked mirror weekly. Did not require cleaning although outside of sensor was salt encrusted. Calibration check okay for duration.
Atmospheric Pressure	No maintenance required or performed.	No maintenance required or performed.
Seawater Temperature	N/A. No sea water temperature sensor installed.	No maintenance required or performed.

Appendix A

ADVANCED DEVELOPMENT MODEL
PARTS LISTS
SHIPBOARD METEOROLOGICAL AND OCEANOGRAPHIC
OBSERVING SYSTEM (SMOOS)

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183300-501	SMOOS ADM SYSTEM	3	TOP DWG	LOCKHEED
1183301	SYSTEM CONTROLLER	1	1183300-501	LMSC SPEC D951785
1188302	RACK, MOUNTING	1	1183302	
1183303	BASE, MOUNTING	1	1183302	
1183304	CASE, OUTER	1	1111302	
1183305	FAN, COOLING	0	1183302	
1183306	INST'L FTGS	1	1183302	
1183307	FRAME	1	1183302	
1183308	FILTER	1	1183302	
1183309	SLIDE HARDWARE	1	1183302	
1183310	POWER SUPPLY ASS'Y	1	1183301	MORROW RMBC/2
1183311	PWR CONDITIONING UNIT	1	1183310	
1183312	FUSE, POWER SET	1	1183310	
1183313	SWITCH, POWER	1	1183310	
1183314	MOUNTING PROVISION	1	1183310	
1183316	POWER CONNECTOR	1	1183310	
1183317	POWER SUPPLY	1	1183310	
1183320	PANEL, INPUT-OUTPUT	1	1183301	
1183321	PANEL, FACE	1	1183320	
1183322	CONNECTORS	1	1183320	
1183325	ENCLOSURE	1	1183301	ECS CO #CR-346-8033
1183330	COMPUTER	1	1183300	
1183331	CARD CARRIAGE ASSEMBLY	1	1183330	MORROW RBC-1
1183332	MOUNT. SHOCK	1	1183331	
1183333	CAGE, CARD	1	1183331	
1183334	BACK PLANE ASS'Y	1	1183331	
1183335	HARNESS, WIRE	1	1183331	
1183340	CARD, CPU-86/12A	1	1183330	INTEL iSBC-86 12A
1183341	CARD, DYNAMIC RAM(128K)	1	1183330	PLESSEY #PSM-512
1183342	CARD, CLOCK/CALENDAR	1	1183330	DIGITAL PATHWAYS TCU410
1183344	CARD. MULTIBUS SUPV CARD	1	1183330	MORROW #MT-1004
1183345	CARD, MUMER DATA PROCESSOR	1	1183330	INTEL #iSBC-337
1183346	CARD, BUBBLE MEMORY CARD	1	1183330	MORROW #MT-BM256/1
1183347	CARD, MULTI CH COMM CONTROL	1	1183330	MORROW MX-422A
1183360	CABLES, INTERFACE	0	1183301	
1183361	POWER, ELECTRICAL	0	1183360	
1183371	CONNECTOR, J151 SYS CTL	1	1183370	MS-27499E-128-22S
1183372	CONNECTOR, P151 SYS CTL	1	1183370	MS-27473E-12A-12P
1183373	CONNECTOR, J152 SYS CTL	1	1183370	MS-27499E-128-22S
1183374	CONNECTOR, B152 SYS CTL	1	1183370	MS-27473E-12A-12P
1183375	CONNECTOR, J153 SYS CTL	1	1183370	MS-27499E-128-12S
1183376	CONNECTOR, P154 SYS CTL	1	1183370	MS-27499S-12A-12P
1183367	SIG'L DISTRIBUTION MANIFOLD	1	1183361	
1183370	DISPLAY, RDU CABLE	1	1183360	
1183373	INDICATOR LIGHT	1	1183310	
1183390	HARNESS, SYSTEM-CONTROLLER	0	1183360	
1183391	CABLE	0	1183390	
1183392	CONNECTOR	0	1183390	
1183400	SOFTWARE	1	1183301	LMSC SPEC D951786
1183401	OPERATING SYSTEM	1	1183400	MCP INTERPRETER/KERNAL
1183402	APPLICATIONS PROGRAMS	1	1183400	
1193410-301	MEAS. & CONTROL SUBSYSTEMS	2	1183300-501	LMSC SPEC D951786
1183412-301	ENCLOSURE, ASSY, MCS BOX	1	1183413-301	C. W. ASHBY
1183412-1	BRACKET, MOUNTING-EXTERNAL	2	1183411-301	1020 STEEL 1/8 THICK
1183412-2	BRACKET, MOUNTING EXTERNAL	2	1183411-301	1020 STEEL 1/8 THICK

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183412-3	RECEPTABLE	4	1183411-301	DZUS FASTNER
1183412-4	SPRING PLATE	2	1183411-301	DZUS
1183412-5	FASTNER	24	1183411-301	
1183412-6	SCREW-PAN HD	8	1183411-301	MS51957-27 #6-32X5/16 LG
1183412-7	SCREW-PAN HD	4	1183411-301	MS51957-14 4-40X5/16 LG
1183412-8	LOCKWASHER	4	1183411-301	MS35338-135 #4
1183412-9	NUT-HEX	4	1183411-301	MS35649-244 #4-40
1183412-10	LOCKWASHER	8	1183411-301	MS35338-136 #6
1183413-301	MCS ASS'Y	0	1183410-301	
1183634-1	HINGE, HALF	8	1183413-301	
	SCREW, FH. HD.	28	1183413-301	MS24693-24 6-32X1/4 LG
	SCREW, PAN HD.	12		MS35206-226 6-32X1/4 LG
1183413-1	CHAIN, HATCH	2		1020 STEEL .05 THICK
	SASH CHAIN	1		4 FT. 3607t56 McMASTER, CARR
	SPRING SNAP	3		3960TL, McMASTER. CARR
	SCREW, FH HD	3		MS24693-75 6-32X5/16 LG
	NUT, HEX	3		MS35649-264 #6-32
	LOCKWASHER	3		MS35338-136 #6
	CHAIN SECTION	1		
	CHAIN SECTION	1		
	CHAIN SECTION	1		
	SCREW, PAN. HD.	3		MS35206-213 #4-40X1/4 LG
	LOCKWASHER	3		MS35338 #4
	NUT, HEX	2		MS35649-244 #4-40
1183420	CABLES, INTERCONNECT BAY	0	1183410-401	
1183421	CABLE, W1-SIG I/O-EL. BAY 1	1	1183420	LINK TO TSL
1183422	CABLE,W1	1	1183421	SERIAL DIGITAL 20MA LOOP + AC
1183430	CABLE, W2-SIG I/O-COM. BAY	1	1183420	ANALOG + SERIAL SIGNAL TO MAC 5000
1183431	CONNECTOR, P-38 @ INTRCN BAY	1	1183430	SOURIAN 851-08RC-10-6-P50
1183432	CABLE, W2	1	1183430	
1183433	CONNECTOR, P-28 @ MAC 5000	1	1183430	SOURIAU 851-08RC-10-6-S50
1183440	CABLE,W3-SIG I/O-EL. BAY 2	1	1183420	SHIP VECTOR & WIND VECTOR SYNCRO SIG
1183441	CABLE, W3	1	1183440	
1183443	CONNECTOR, P39-INTERCN@EB1	1	1183440	SOURIAU 851-08RC-14-19-P50
1183444	CONNECTOR, P-31 - @ EB1	1	1183440	SOURIAU 051-08RC-20-41-P50
1183460	CABLE, W5-EL. BAY TO COMP	1	1183420	SYNCRO SIGNAL TO MAC 5000
1183462	CONNECTOR, P-32 @EB1	1	1183460	851-08RC-10-6-P50 SOURIAU
1183462	CABLE W-5	1	1183460	SYNCRO ANALOG
1183463	CONNECTOR, P-29 @ CB	1	1183460	851-08RC-14-19-P50 SOURIAU
1183470	CABLE, W6 POWER CON.-COMP.	1	1183420	PWR TO MAC 5000 FROM PWR CTRL
1183471	CABLE, W6	1	1183470	
1183472	CONNECTOR, P34 @ CB	1	1183470	SOURIAN 851-08RC-18-32-S50
1183473	CONNECTOR, P36 @ PWA CTRL	1	1183470	SOURIAN 851-08RC-10-6-S50
1183480	CABLE, ASSY, L-7	1	1183420	PWR TO & FROM INSTRUMENTS
1183481	CABLE, W7 IN/OUT PWR	1	1183480	
1183483	CONNECTOR, P40 MCS INTERCN	1	1183480	SOURIAN 851-08RC-14-19-P50
1183484	CONNECTOR, P45 MCS PWR CTL	1	1183480	SOURIAN 851-08RC-10-6-P50
1153490	CABLE,W8-POWER CON.-EL.BAY1	1	1183420	
1183491	CABLE, W8	1	1183490	PWR TO EB1
1183492	CONNECTOR, P33 TO EB1	1	1183490	SOURIAN 851-08RC-18-32-S50
1183493	CONNECTOR, P35 MCS PWR CTL	1	1183490	SOURIAN 851-08RC-10-6-S50
1183590	ASSEMBLY, SIGNAL I/O	0	1183410	
1183595-1	CONNECTOR,J9 INPUT POWER AC	1	1183612	KFS12AA1P1 CANNON
1183596-1	CONNECTOR,J10 MSC1-TSL	1	1183612	KFS12AB12, CANNON
1183596-1	CONNECTOR, J-11	1	1183612	KFS12-A-B-1-P1, CANNON

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183596-1	CONNECTOR, LJ-12 PRESS MCS-1	1	1183612	KFS12-A-B-1-S3, CANNON
1183596-1	CONNECTOR,J14 @MCS1 TO SEA	1		CANNON KFS12-A-B-1-S4, MCS1 TO SEA T
1183596-1	CONNECTOR,J16 SHIP VECTOR S	1		CANNON KFS12-A-B-1-P5
1183596-1	CONNECTOR,J17 @ MCS-2	1		CANNON KFS12-A-B-1-S6 RS-422 TO MCS-
1183596-1	CONNECTOR,J18 WIND DIR. @ M	1		KFS12-A-B1-P5 CANNON
1183612-301	INTERCONNECT BAY ASSY	1	1183410	DRAWING
1183613-101	INTERCONN. PANEL	1	1183612-301	DRAWING
1183614-101	I/C BAY WALL ASS'Y	1	1183612-301	DRAWING, PAINT, ANODIZE
1183614-1	WALL	1	1183612-301	.063 5052-H32 AL QQ-A-25018
	PEMNUT	8	1183612-301	PENN ENG CORP
1183615-101	I/C BAY WALL ASS'Y	1	1183612-301	DRAWING, PAINT, ANODIZE
1183615-1	I/C BAY WALL	1	1183615-101	.063 AL ALLOY 5052-H32 QQ-A-25018
	PEM NUT, 6-32	4	1183615-101	CLS-632-2 PENN ENG CORP
1183616-101	MOUNTING PLATE ASS'Y	1	1183612-301	DRAWING, PAINT, ANODIZE
1183616-1	MOUNTING PLATE	1	1183616-101	
	PEM NUT, 6-32	4	1183616-101	CLS-632-2 PENN ENG CORP
1183617-101	COVER, INTERCONNECT BAY	1	1183613-101	ASS'Y, DRAWING, PAINT, ANODIZE
1183617-1	COVER	1	1183617-101	.08AL 5052-1-1 32
1183617-2	BASKET	1	1183617-101	#8645K21, SILICON SPON GE AVLLE
1183620-301	ASSEMBLY, BAY#1 ELECTRONICS	1	1183410	
1183620-101	HOUSING ASSY	1	1183410	
1183621-101	ELECTRONICS BOX ASS'Y	1	1183620-301	
1183621-2	FLANGE	1	1183621-101	.090 6061-T6 AL. ALLOY 09-A-250/11
1183622-1	BOX	1	1183621-101	ZERO CORP.Z104-2488-60
	PEM NUT	10	1183621-101	CLS-832-3
1183623-1	CONNECTOR, I/O J-31	1	1183620	851-02R-20-41-P50
1183624-1	CONNECTOR, I/O J-32	1	1183620	851-02R-14-19-S50
1183625-1	CONNECTOR, AC POWER J-33	1	1183620	851-02R-10-6-P50 SOURIAU
1183626-1	SPACER	12	1183620	PIC B7-13
1183626-1	SPACER	4	1183650	PIC B7-13
1183626-3	SPACER	1	1183620	
1183627	SCREW, BOARD MOUNTING	0	1183621	
1183628-1	POWER SUPPLY,+-15V	1	1183620	LAMBDA #LND-Y-152
1183629-1	CONVERTER, SYNC. TO LINEAR	4	1183620	ANALOG DEV. SAC1763 - 622
1183630-101	HINGED PANEL ASS'Y, EB1	1	1183620	DRAWING, PAINT
1183631-1	PANEL	1	1183630-101	.090 SHEET ALUM 5052-H32 QQ-A-250/8
1183631-1	HINGE LEAF	1	1183630-101	.090-5052
1183631-101	EB1 DETAILS	1	1183620-1	
1183631-2	CLAMP BAR	2	1183631	.063 SHEET ALUM 5052 H32 QQ-A-250/8
1183631-1	PANEL	1	1183630-101	.090 SHEET ALUM 5052 H-32 QQ-A-200/8
1183634-1	HINGE, DETACHABLE	7	1183413	
1183634-1	FEMALE LEAF	7	1183634	MAKE FROM H.A.GUDEN CO.NO.NHPS32020C
1183634-2	HINGE, MALE LEAF	7	1183720-101	
1183634-2	HINGE, DETACHABLE	2	1183660	
1183634-2	HINGE, DETACHABLE	2	1183630	
1183634-2	HINGE, DETACHABLE	3	1183711	
1183634-2	HINGE, DETACHABLE	2	1183720	
1183635-1	MYLAR .014 SHEET	1	1183620	
1183617-101	INTERCONNECT COVER	1	1183620	
1183640	HARNESS,WIRE-POWER&SIG DIS	0	1183620	
1183641	CABLE	0	1183640	
1183642	CONNECTOR	0	1183640	
1183650-301	ASSEMBLY, BAY-POWER CONTROL	0	1183410-301	
1183651-101	PWR CTRL BOX ASS'Y	1	1183650-301	
1183651-1	HOUSING	1	1183651-301	M/F1183622-1 ZERO

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183651-2	FLANGE	2	1183651-301	6061-T6 ALUM .09 THK. QQ-A-250/11
	PEM NUT	8	1183651-301	PENN ENGRG CORP. CLS-632-2
1183653-1	CONNECTOR, J-36, @ PWR CTR	1	1183650	851-08RC-10-6-PSD SOURIAU
1183654	CONNECTOR, J-45	1	1183650-301	851-02R-14-19-S50 SOURIAU
1183655	CONNECTOR, J-35	1	1183650-301	851-02R-10-6-S50 SOURIAU
	CONNECTOR, J-37	1	1183650-301	851-02R-14-19-S50 SOURIAU
1183660-101	PANEL, FRONT ASS'Y P.C. BA	1	1183650-301	DRAWING, ANODIZE, PAINT
1183661-1	SWITCH, TOGGLE	7	1183650	MS24524-23
1183662	SWITCH, CONTROL-52 EXT	0	1183660-001	
1183663	SWITCH, CONTROL-53 EL.BAY	0	1183660-001	
1183664	SWITCH,CONTROL-54 COM.BAY	0	1183660-001	
1183665-1	LAMP, STATUS	7	1183650-301	DAILIGHT 181-8836-0931-553
1183666-1	LAMP, STATUS	7	1183650-301	DAILIGHT CTA (NE-2D)
1183667-1	TEST JACK	4	1183650	105-0202-200 MS16108-2A JOHNSON
1183668	LAMP,STATUS-DS4 COM. BAY	0	1183660-001	
1183669-1	FUSE, HOLDER	7	1183650	TYPE FHL32W
1183670-1	FUSE	7	1183650	TYPE F02
1183671	FUSE,ELECT-EL. BAY#1 PWR	0	1183660-001	
1183672	FUSE,ELECT.-COMP. BAY PWR	0	1183660-001	
1183673-1	PROTECTION CIRC.,TRANSIEN	1	1183650	120-RB-15TS ATLANTIC SCIENTIFIC
1183674	SCREW,COVER RETAINER	0	1183660-001	
1183675	HINGE, DETACHABLE	0	1183660-001	
1183676	HARNESS,WIRE-PWR$SIG DIS.	0	1183660-001	
1183677	CABLE	0	1183660-001	
1183678	CONNECTOR	0	1183660-001	
1183680	ASSEMBLY,BAY-COMPUTER	0	1183410-301	
1183681-101	ENCLOSURE - ASSEMBLY	1	1183680	
1183682-101	HOUSING	1	1183681	
1183682-101	HOUSING	1	1183682-101	
1183683	CONNECTOR, AC PWR	0	1183681	
1183684	CONNECTOR,SPARE-J-43	0	1183681	
1183685	CONNECTOR,422-J10	0	1183680	
1183686	CONNECTOR,422-J11	0	1183681	
1183687	CONNECTOR,SIG.INP J-28	0	1183681	
1183688	CONNECTOR, SIG. INP. J-29	0	1183681	
1183689	CONNECTOR, SIG.INP. J-34	0	1183681	
1183690	CONNECTOR, DATA INPUT P-1	0	1183681	
1183691	CONNECTOR, DATA INPUT P-2	0	1183681	
1183692	CONNECTOR,DATA INPUT P-3	0	1183681	
1183693	ENCLOSURE,SINGLE BOARD	0	1183681	
1183694	POWER SUPPLY, ELECTRICAL	0	1183681	
1183695-1	COMPUTER	1	1183681	VMAC 5000 ANALOG DEVICES
1183700	SYSTEM,MEAS/CONTROL PROG.	0	1183681	
1183701	PLUG,P-47 CONFIGURATION	0	1183700	
1183702	PLUG,P-48 MICROMAC 422	0	1183700	
1183703	PLUG,P-49 MICROMAC DATA	0	1183700	
1183704	CONDITIONER,SIG QMX 04	0	1183700	
1183705	SPACER	0	1183681	
1183706	MODULE, SIG. CONDITIONER	0	1183681	
1183710	PANEL, FRONT	0	1183680	
1183711-101	PANEL,COMPUTER BAY	1	1183681	
1183711-1	PANEL	1	1183711-101	.090 SHEET 6061-T6
1183712	HINGE, DETACHABLE	0	1183710	
1183713	FASTENER, QUARTER TURN	0	1183710	
1183720-101	PANEL, ASS'Y, EB 2	1	1183413	

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183721-1	PANEL, EB2	1	1183720-101	.090 SHEET, 6061-T6
MS20426AD	RIVET	4	1183721-1	
MS20426	RIVET	4	1183660-101	
MS20426	RIVET	6	1183711-101	
MS20426	RIVET	4	1183630-101	
1183722	CONNECTOR	0	1183720-101	
1183730	SOFTWARE	1	1183680	LMSC SPEC. D795782
1183731	OPERATING SYSTEM	1	1183730	M&C BASIC REV. 1.3
1183732	APPLICATIONS PROGRAM	1	1183730	
1183740	TERMINAL, OPERATIORS	1	1183300-501	HP 2392A DISPLAY TERM
1183741	TERMINAL	1	1183740	HP TERMINAL
1183742	KEYBOARD	1	1183740	HP KEYBOARD
1183750-501	DISPLAY, REMOTE	3	1183300-501	
1183751-301	DISPLAY	3	1183750-501	IEE MODEL 480 #4282-01
1183752-301	POWER SUPPLY-MODIFIED	1	1183750-501	
67F4077	STANDOFF	4	1183752-301	.250DX.25L 6-32 ID.
MS35338-135	LOCKWASHER	4	1183752-301	#8
MS51957-13	SCREW	4	1183752-301	#8-32 BUTTON HEAD .25 LG.
1183753-301	ENCLOSURE-BOX MODIFIED	1	1183750-501	
1183754-1	POWER SUPPLY	1	1183752-301	IEE ARGUS 3096-10
1183755-1	ENCLOSURE	1	1183753-301	HOFFMAN-A 1210 CH
1183756-1	POWER PACK	1	1183750-501	CP HE-381
1183757-1	TERMINAL BLK	1	1183750-501	9 PAIR TERMINALS KULKA SMITH
1183758-1	FUSEHOLDER /W FUSE	1	1183750-501	MR-F-19207/21E TYPE FHL32W
1183758-11	HEX JAM NUT	1	1183750-501	5/8-32 (PART OF ITEM 8)
1183758-12	LOCKWASHER	1	1183750-501	5/8 (PART OF ITEM 8)
1183759-1	SWITCH	1	1183750-501	2TL1-3 MICROSWITCH MS24524-23
1183759-11	HEX JAM NUT	2	1183750-501	15/32-32 (PART OF ITEM 9)
1183759-12	LOCKWASHER	1	1183750-501	15/32 (PART OF ITEM 9)
1183760-1	SWITCH GUARD	1	1183750-501	MS25224-2
1183761-1	INDICATOR LIGHT	1	1183750-501	375-0463-0131-223 DIALITE
1183762-1	CONNECTOR	1	1183750-501	KJ24 MS-27513E-12-A-22P CANNON
1183763-1	CONNECTOR	1	1183750-501	MS27499E/2 CANNON
1183764-1	SPACER	4	1183750-501	KS67F4028 1/4 KULKA SMITH
1183765-1	BACK PLATE	1	1183750-501	.19 AL ALLOY SHEET 6061-T6
1183780-501	BAROMETRIC PRESSURE ASSEMBLY	1	1183300-501	
1183781-501	PRESSURE TRANSDUCER ATMOSPH	2	1183787	ROSEMOUNT 1201F2A3B1BEP6
1183782-1	ENCLOSURE-MODIFIED	1	1183780-501	
1183783	POWER SUPPLY	1	1183787-501	
1183784-301	TUBE, VENT ASSEMBLY	1	1183780-501	
1183784-1	TUBE	1	1183784-301	1/4 OD AL TUBE 6061-TL .035 WALL
1183784-2	SNUBBER	1	1183784-301	CAJON SS-4-SM-A-400 EQ
1183784-3	CONNECTOR	1	1183784-301	PARKER-HANNIFAN 1/4GG-SS
1183785-1	GROMMET, VENT TUBE	1	1183780-501	AM LOCK 31F2002 .25 ID. X 56 OD.
1183786-101	TUBE COVER ASSEMBLY	1	1183780-501	
1183786-1	COVER	1	1138786-101	.125 ALUM ALLOY 5052-H34
1183786-2	CAP	1	1183786-101	.125 ALUM ALLOY 5052-H34
1183786-3	MOUNTING FLANGE	1	1183786-101	.125 ALUM ALLOY 5052-H34
1183788-1	POWER SUPPLY	1	1183780-501	ACOPIAN 28EB-30
1183789-1	ENCLOSURE	1	1183782-1	HOFFMAN 1008LP JIC BOX
1183799-301	ACCUMULATOR	1	1183780-501	DWG, WELD, PAINT, ANODIZE
1183799-2	PIPE	1	1183799-301	AL ALLOY 6063-TL 1.9X1.76 ID
1183799-3	END CAP	1	1183799-301	AL 6061-TL .090
1183799-4	END CAP	1	1183799-301	AL 6061-TL .090
1183799-5	T. E. PLATE	1	1183799-301	AL 6061-TL 1/4 IN

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
1183732	HOSE CONNECTOR	1	1183799-301	CAJON SS-4-HC-1-2
1183799-6	HELICOIL	1	1183799-301	1185-06-CN-0138
1183530	CABLE ASSEMBLY - W-112	1	1183780-501	CABLE ASSEMBLY MCS TO PRESSURE
1183531	CONNECTOR, P12	1	1183780-501	M28840/16-AB1P4 CANNON @ MCS
1183532	BACKSHELL	1	1183780-501	M28840/827WA 90 DEG # 13 SUNBANK
1183533	CABLE - W-112	1	1183780-501	ANALOG + AC PWR
1183534	CONNECTOR, P-112	1	1183780-501	M28840116-AB1S3 CANNON @ PRESSURE
1183535	BACKSHELL	1	1183780-501	M28840/627WA #13 SUNBANK
1183536	CONNECTOR, J-112	1	1183780-501	KFS12-A-B-1-P3 CANNON @ PRESSURE
1183790-501	TEMP. AND DEW PT. AMBIENT	1	1183781-501	TSL MODEL 1063 HRGROTHRM
1183791-501	HYGROTHERMOMETER INSTLN	1	1183300-501	
1183799-2	PIPE	1	1183799-301	1 1/2" SCHEDULE 5 ALUM ALLOY
1183799-3	END CAP	1	1183799	AL 6061-T6 .090
1183799-4	END CAP	1	1183799-301	AL 6061-T6 .090
1183799-5	T. E. PLATE	1	1183799-301	AL6061-T6 1/4"
1183799-301	ACCUMULATOR	1	1183780	
1183800-501	VISIBILITY	1	1183800-501	HSS-MODEL VR-301
1183801-501	VISIBILITY SENSOR INSTLN	0	1183300-501	
1183802-1	CHASSIS (MOD)	1	1183802-101	
1183802-2	SB SUPPORT (MOD)	1	1183802-101	
1183802-3	PCB #1063-204 (MOD)	1	1183802-101	
1183802-4	HINGED STANDOFF	1	1183802-101	KEYSTONE 355
1183802-5	AL ANGLE 1.5X1.0X.12	1	1183802-101	6061-T6
1183810-501	CLOUD HEIGHT INDICATOR	1	1183811-501	IMPULSEPHY. LD-WHL MOBIL
1183811-501	C.H.I INSTALLATION	0	1183300-501	
1183820-3	MOUNTING PLATE	1	1183820-501	INC. W/ HOFFMAN BOX-ITEM 1
1183820-10	LATCH LOCK	1	1183820-501	.50 WIDE STL X .125 (MAX)
1183820-501	TEMPERATURE, SEA WATER INS.	1	1183300-501	
1183821-301	ENCLOSURE, MODIFIED	1	1183820-501	
1183822	SIGNAL CONDITIONER	0	1183820	
1183823	CONNECTOR, SENSOR CABLE	0	1183820	
1183824	CABLE, SENSOR	0	1183820	
1183825	HARNESS, WIRE	0	1183820	
1183826-1	ENCLOSURE	1	1183821	HOFFMAN BOX#A664DL
1183827-1	SEAWATER TEMP SENSOR	1	1183820	RTS-37U-1000B-3X1 HY-CAL
1183828-1	POWER SUPPLY	1	1183820	FERROTRAN #ML-28
M7793/3-007	COUNTER METER	1	1183650-301	MIL-M-7793/7 ELECTRO DYNAMICS
MS21045-106	NUT, LOCK	6	1183681-101	#6-32 STEEL, CAD PL.
MS24693-24	SCREW-ST'L.	8	1183681-101	6-32 X 1/4 LG.
MS24693-C25	SCREW FH	8	1183410	#6-32X5/16 LG ST. STEEL
MS24693C-2	SCREW	2	1183650-301	4-40X1/4 PAN HD. CRES.
MS24693-43	SCREWS #8-32	2	1183802-101	
MS24693C-46	SCREW	10	1183650-301	8-32X1/4PAN HD, CRES
MS35206-216	SCREW	8	1183750-501	#4-40 X .438 LG.
MS35265-13	SCREW	8	1183820-501	#4-40 SCREW X 3/8" LG.
MS35265-13	SCREW	4	1183750-501	#4-40 BUTTON HEAD SCREW .250 LG.
MS35265-15	SCREW	12	1183681-101	4-40X 3/8
MS35265-15	SCREW	8	1183750-501	#4-40
MS35265-26	SCREW	1	1183820-501	#6-32 P.H. SCREW X.38LG.
MS35265-28	SCREW	4	1183750-501	#6-32X.38 BUTTON HD.
MS35265-31	SCREW	8	1183820-501	#6-32X.625 LG. P.H.
MS35265-45	SCREW	4	1183820-501	#8-32 PAN HEAD SCREW 1/2" LG.
MS35265-46	SCREW	4	1183750-501	#8-32 BUTTON HEAD SCREW .625 LG.
MS35338-135	LOCKWASHER	48	1183612-301	#4 ST. STEEL
MS35338-135	LOCKWASHER	12	1183750-501	#4

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
MS35338-135	SPLIT LOCKWASHER	8	1183820-501	#4
MS35338-135	LOCKWASHER	18	1183650-301	#4
MS35338-136	LOCKWASHER	4	1183650-301	#6
MS35338-136	LOCKWASHER	12	1183820-501	#6-32
MS35338-136	LOCKWASHER	8	1183410	#6 ST. STEEL
MS35338-137	LOCKWASHER	4	1183750-501	#8
MS35649-242	NUT	8	1183820-501	#4-40
MS35649-242	NUT	12	1183681-101	4-40
MS35649-244	NUT 4-40	12	1183620	
MS35649-244	NUT 4-40	12	1183681	
MS35649-244	NUT 4-40	8	1183750	
MS35649-244	NUT 4-40	18	1183650	
MS35649-244	NUT	48	1183612-301	#4-40 ST. STEEL
MS35649-264	NUT	12	1183820-501	#6-32
MS35649-264	NUT	4	1183650-301	6-32 HEX. CRES.
MS35649-284	NUT (HEX)	2	1183750-501	#8-32 UNC
MS51957-15	SCREW 4-40 x 3/8	12	1183620	
MS51957-15	SCREW 4-40 X 3/8	12	1183681	
MS51957-15	SCREW 4-40 X 3/8	8	1183750	
MS51957-15	SCREW 4-40 X 3/8	8	1183780	
MS51957-15	SCREW 4-40 X 3/8	48	1183612	
MS51957-15	SCREW 4-40 X 3/8	16	1183650	
MS51957-26	SCREWS #6-32	5	1183802-101	
MS51957-27	SCREW	8	1183410	#6-32X5/16 LG ST. STEEL
MS51957-30	SCREW 6-32 X 1/2	2	1183620	
MS51957-30	SCREW 6-32 X 1/2	8	1183820	
MS51957-30	SCREW 6-32 X 1/2	4	1183650	
MS51957-31	SCREW	4	1183612-301	#6-32X5/8 LG. ST. STEEL
MS51957-33	SCREW 6-32 X 7/8	2	1183620	
MS51957-27	SCREW 6-32 X 5/16	8	1183620	
MS51957-35	SCREW 6-32 X 1 1/4	6	1183620	
MS51958-63	SCREW 10-32 X 1/2	4	1183620	
MS24693C-46	SCREW P.H. 8-32 X 1/4	8	1183620	
MS24693C-46	SCREW P.H. 8-32 X 1/4	8	1183650	
LAC374037	WHITE EPOXY PAINT	0	1183620	A/R
LAC374037	WHITE EPOXY PAINT	0	1183630	A/R
LAC374037	WHITE EPOXY PAINT	0	1183631	A/R
LAC374037	WHITE EPOXY PAINT	0	1183682	A/R
LAC374037	WHITE EPOXY PAINT	0	1183711	
LAC374037	WHITE EPOXY PAINT	0	1183720	A/R
MS20426AD5-6	RIVET	4	1183630	
MS20426AD5-6	RIVET	6	1183711	
MS20426AD5-6	RIVET	4	1183720	
MS20426AD5-6	RIVET	4	1183660	
94812A112	4-40 NYLON NUT	6	1183681	
90263A059	#4 WASHER NYLON	6	1183681	
94611A146	6-32 X 3/8 NYLON SCREW PH.	6	1183682	
4403	1/4 X 1 3/8 SPACER	6	1183682	
118506CN0138	6-32 HELICOIL	8	1183682	
MS51957-28	SCREW 6-32 X 3/8 LG.	4	1183750	
MS51957-28	SCREW 6-32 X 3/8 LG.	1	1183820	
MS51957-28	SCREW 6-32 X 3/8 LG.	10	1183780	
MS51957-46	SCREW 8-32 X 5/8	4	1183750	
MS51957-13	SCREW 4-40 X 1/4 LG.	4	1183750	
MS35649-264	NUT	4	1183612-301	#6-32 ST. STEEL

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
MS35649-284	NUT #8-32	2	1183750	
MS35338-137	LOCKWASHER #8	4	1183750	
MS35338-137	LOCKWASHER #8	6	1183620	
MS35338-137	LOCKWASHER #8	8	1183780	
MS35338-135	LOCKWASHER #4	12	1183750	
MS35338-135	LOCKWASHER #4	8	1183780	
MS35338-135	LOCKWASHER #4	48	1183612	
MS35338-135	LOCKWASHER #4	18	1183650	
MS35338-136	LOCKWASHER #6	4	1183820	
MS35338-136	LOCKWASHER #6	12	1183620	
MS35338-136	LOCKWASHER #6	2	1183780	
MS35338-136	LOCKWASHER #6	10	1183612	
MS35338-136	LOCKWASHER #6	4	1183650	
MS35649-264	NUT #6-32	4	1183820	
MS35649-264	NUT #6-32	2	1183780	
MS35649-264	NUT #6-32	4	1183650	
MS51957-45	SCREW #8-32 X 1/2 LG.	4	1183820	
MS51957-43	SCREW 8-32 X 3/8	9	1183780	
1183756-1	POWER SUPPLY	1	1183750	COMPUTER PROD. HE-381
1183757-1	TERMINAL BLOCK-KULKA SMITH	1	1183750	670-9-F
1183758-1	FUSE HOLDER 21E	1	1183750	MIL-F-19207/TYPE FHL32W
1183759-1	SWITCH 2TL1-3 MICROSWITCH	1	1183750	MS24524-23
1183760-1	SWITCH GUARD	1	1183750	MS25224-2
1183761-1	INDICATOR LIGHT, DIALITE	1	1183750	
1183762-1	CONNECTOR	1	1183750	MS27513E-12-A-22P KJ2R CANNON
MS35649-244	NUT 4-40	12	1183620	
MS35649-242A	NUT 4-40	4	1183780	
MS35649-264	NUT 6-32	12	1183620	
MS35649-284	NUT 8-32	4	1183620	
1183764-1	SPACER	4	1183750	KULKA-SMITH 67F4028 TYPE 8521
1183765-1	BACKPLATE-RDU	1	1183750	
1183763-1	CONNECTOR	1	1183750	(MS 27499E-12-A-3P) CANNON
1183784-1	TUBE	1	1183784-301	1/4 O.D. AL. TUBE .035 WALL 6061-T6
1183784-2	CAJON SNUBBER	1	1183784-301	SS-4-SM-A-400EG
1183784-3	PARKER-HANNIFIN 1/4GG-SS	1	1183784-301	
1183796-1	BACK PLATE-BAROBOX	1	1183780	
1183792-1	PRESSURE FTG	2	1183780	SWAGELOK S-200-A-4ANF
1183793-1	CONNECTOR	2	1183780	MS 3112E-12-10P
1183794-1	TERMINAL BLOCK	2	1183780	670-10-F KULKA-SMITH
1183795-1	CONNECTOR	1	1183780	M 28840/12AB1P3 ITT CANNON KFS12-AB-
1183809-1	HOLE PLUG	1	1183780	P-750 HEYCO
1183797-1	STRAIN RELIEF BUSHING	1	1183780	7P-2 HEYCO
1183798-1	T-ADAPTER	1	1183780	TS-6455-15 COLE-PARMER
1183799-301	ACCUMULATOR	1	1183780	
1183823-1	CONNECTOR	1	1183820-501	SIZE 11 SHELL KFS12-AALP1
1183826-1	CONNECTOR	1	1183820-501	SIZE 13 SHELL KFS12-AB1
1183829-1	TERMINAL BLOCK	2	1183820-501	44F8163C KULKA-SMITH
1183830-1	FLEX. PLASTIC TUBING	1	1183780	OMEGA TY-14-100, .25ID 16"LONG
1183832	HOSE CONNECTOR	1	1183799-301	CAJON SS-4-HC-1-2
1183833	PEM NUT	1	1183799-301	PEM SELF-CLINCHING
1183780-2	TUBE SUPPORT	1	1183780	
1183831-1	CONNECTOR	2	1183780	MS3116E-12-10S TYPE B ITT CANNON
1183780-3	CLAMP	1	1183780	
MS35206-245	SCREW-PAN HD 8-32 X .5	6	1183620	
MS35206-230	SCREW-PAN HD 6-32 X .5	6	1183620	

PDN	COMPONENT IDENTIFICATION	QTY	NHA	SUPPLIER
MS35206-235	SCREW-PAN HD 6-32 X 1.25	2	1183620	
MS35206-226	SCREW-PAN HD 6-32 X .25	4	1183620	
M7793/3-007	COUNTER METER	1	1183650	
1183651-1	HOUSING	1	1183651	M/F1183622-1
1183651-2	FLANGE	1	1183651	.090 ALUM 6061-T6
1183612-301	CONNECTOR BAY ASSY MCS	1	1183410	
1183613-1	CONNECTOR PANEL	1	1183612	
1183614-1	WALL-CONN. PANEL MCS	1	1183612	
1183615-1	WALL-CONN. PANEL MCS	1	1183612	
1183616	MTG. PLATE, CONN. BAY MCS	1	1183612	
MS24693C-25	6-32 X 5/16 SCREW	8	1183612	
MS51957-31	6-32 X 5/8 SCREW	10	1183612	
M7793/3-007	COUNTER METER	1	1183650	
MS24693C-2	SCREW 4-40 X 1/4 P/H	2	1183650	

Appendix B

MEASUREMENT AND CONTROL SUBSYSTEM CONFIGURATION TABLE FORMAT

The table format for each MCS is:

Field 1,2 - Algorithm Flag denoting barometric pressure, sea water temperature, visual range, sky, air temperature, and wind

Field 3 - Serial device identifier which denotes whether the MCS interfaces to the cloud height or hygrothermometer

Field 4,5 - Analog port identifiers (12 per MCS) that assigns ports as follows:

PORT ASSIGNMENTS FOR MCS 0 AND 1
FOR ADM CONFIGURATION

Port # =	MCS 0	MCS 1
Port 0 =	PS1	VR1
Port 1 =	PS2	VR2
Port 2 =	SWT	VR3
Port 3 =	---	---
Port 4 =	---	SST
Port 5 =	---	SDT
Port 6 =	---	WDR
Port 7 =	---	WSR

where

PS1 = Pressure Sensor 1
PS2 = Pressure Sensor 2
SWT = Sea Water Temperature
VR1 = Visibility Data Channel
VR2 = Visibility Day/Night Channel
VR3 = Visibility BITE Channel
SST = Ship's Speed
SDT = Ship's Course (i.e., Ship's Direction)
WDR = Apparent Wind Direction
WSR = Apparent Wind Speed

Field 6 - Not presently used

Field 7 - Voltage scale assignments for analog ports Nos. 1-12 (ADM configuration) are:

VOLTAGE ASSIGNMENTS FOR MCS 0 AND 1

Port #	MCS 0	MCS 1
Port 0 =	5	10 V
Port 1 =	5	5 V
Port 2 =	4-20 MA	5 V
Port 3 =		
Port 4 =		10 V
Port 5 =		10 V
Port 6 =		10 V
Port 7 =		10 V

Field 8 - Analog ports Nos. 1-12 integration periods; default values are:

0. .01666 sec
1. .01666 sec
2. .01666 sec
3. .01666 sec
4. .01666 sec
5. .01666 sec
6. .01666 sec
7. .01666 sec

Note: All integration periods are .01666. This integration period was selected to cancel out any 60 Hz line noise that may be present in the sensor.

Field 9 - Sensor Field; the default values are:

Lower limit for pressure	SLL	= 26.577
Upper limit for pressure	SUL	= 31.302
Height of platform	HP	= 0
Cloud height lower limit	CHLL	= 25
Cloud height upper limit	CHUL	= 5600
Air temperature lower limit	TASLL	= -76
Air temperature upper limit	TDSUL	= 140
Dew point lower limit	TDSLL	= -76
Dew point upper limit	TDSUL	= 140
Wind sensor upper limit	WSUL	= 100
Ship speed upper limit	SSUL	= 40
Sea water in C lower limit	SWTSLL	= -18
Sea water in C upper limit	SWTSUL	= 38
Vis raw sensor lower limit	VSLL	= 0
Vis raw sensor upper limit	VSUL	= 99.9

Appendix C

ENVIRONMENTAL ALGORITHMS

SKY CONDITION The sky condition algorithm that follows is based on the single sensor continuous display mode algorithms published in NWS T&ED Report No. 780. It will produce an output in a format suitable for transmission in an aviation observation. Cloud height and amount will be output for up to three layers, as well as any pertinent remarks. If the visibility is less than two miles, an obscuration is reported. Since there is no available technology for directly determining the presence of obscurations, the algorithm will only provide an indication of obscuration.

SKY CONDITION ALGORITHM (Radius of Validity = 5-6 km, 15-30 Minute Time Validity)

A. Sample the cloud sensor every 15 seconds. One height should be reported for each scan, only the lowest reported height is used if more than one is reported.

B. Determine if the reading falls within the sensor limits. If the reading is below the lower limit (CHLL), consider the reading bad, insert the last good value. Two bad values are acceptable, inserting the last good value for each bad value. On the third consecutive occurrence of a bad value, the ceilometer will be considered inoperative and an error message will be generated. (MM to screen, CH BLO "CHLL" to maintenance log). A reading above the upper limit of the sensor will not be considered bad, but will be treated as a "no hit".

C. Each input value shall be rounded to the nearest 100 feet and placed in appropriate bins. These bins will be established as follows:

From the surface to 5000 feet - 100-foot bins
Above 5000 feet - 200-foot bins using the even numbers
(i.e., 5000, 5200, 54000, 56000...)

D. Thirty minutes of cloud data from the ceilometer are needed to fully determine the sky condition.

E. Determine the number of possible cloud hits during the 30-minute period mentioned in D. This total is the number of sample scans, including when a cloud was detected and when a cloud was not detected (120 for SMOOS ADM).

F. If less than 30 minutes of data are available, "missing" (MM) shall be reported for the first 10 minutes. After 10 minutes of data have been collected from the sensor, output a cloud observation prefixed with "E" for estimated.

G. Once 30 minutes of cloud heights are available, delete the "estimated" indicator from the observation. If the observation at the end of the 30 minutes contains a ceiling (i.e., broken or overcast layer), prefix the lowest broken or overcast layer with "M" for measured.

H. Clustering - If there is more than one height value recorded from the ceilometer during the sampling period, the values shall be tested and, if needed, clustered using the following criteria:

1. Determine the number of bins. If there are five or fewer bins (clusters) go to Step I, otherwise continue.

2. The bins shall be ordered from the lowest to the highest height.

3. Calculate the least square distance of all adjacent bins using

$$D^2 = \frac{[N(J) \times N(K)] \times [H(J) - H(K)]^2}{N(J) + N(K)}$$

where

D = least square distance
H = bin height
N = number of cloud hits in that bin.

4. Determine the two adjacent bins having the smallest least square distance. If more than one pair of bins have the same least square distance, combine the pair with the lowest heights.

5. Combine the bins using the formulas below

$$H(L) = \frac{[N(J) \times H(J)] + [N(K) \times H(K)]}{N(J) + N(K)}$$

$$N(L) = N(J) + N(K)$$

where H(L) is the height of the combined bin rounded (after combination) to the nearest 100 feet, and N(L) is the number of samples.

6. Retain the range of height values in hundreds of feet within the cluster (i.e., the maximum and minimum bin values in the cluster).

7. H(L) and N(L) shall replace H(J), H(K), N(J), and N(K).

8. If after the clustering process there are more than five bins (or clusters) return to Step 3; otherwise, continue.

I. *Combine Layers - After clustering* has been completed, determine if the clusters can be combined using the following criteria:

1. Group the clusters in ascending order.

2. Compute the height differences of all adjacent clusters.

3. If the lower height of any adjacent pair is less than or equal to 1000 feet, and the difference between heights is 250 feet or less, go to 7 and combine the clusters using the equations. If the difference is greater than 250 feet, continue to the next pair.

4. If the lower height of any adjacent pair is greater than 1000 feet, and the difference between heights is 350 feet or less, go to 7 and combine the clusters using the equations. If the difference is greater than 350, continue to the next pair.

5. If the lower height of any pair is greater than 3000 feet, and the difference between heights is 450 feet or less, go to 7 and combine the clusters. If the difference is greater than 450 feet, continue to the next pair.

6. If the lower height of any adjacent pair is 5000 feet or higher, and the difference between heights is 600 feet or less, go to 7 and combine the clusters using the equations. If the difference is greater than 600 feet go to the next pair.

7. Combine the clusters according to the following:

$$H(L) = \frac{[H(J) \times N(J)] + [H(K) \times N(K)]}{N(J) + N(K)}$$

$$N(L) = N(J) + N(K)$$

When two clusters are combined, the range of value of the cluster shall be maintained, the new cluster shall replace the two that were combined, the clusters reordered, and the process of combining is continued.

8. All adjacent pairs should be examined until no further combining is required.

J. At the end of this process, if any cluster has fewer than five hits it is not considered any further in the program, and the number of hits is not added to any other cluster. However, the total possible hits as calculated in E shall not be reduced. All cluster heights should now be rounded to:

Surface to 5000 feet: nearest 100 feet
Above 5000 feet: nearest 500 feet (5000, 5500, 6000)

All clusters will now be referred to as layers.

K. Compute Cloud Amount.

1. Obtain the total number of possible hits from E.

2. Calculate the cloud cover factor R_L using the following for each layer, starting with the lowest:

$$R_L = \frac{\sum_{L=1}^{n} \text{(Layer Hits)}}{\text{Total Possible Hits}}$$

where n = layer order number starting with the lowest layer. For more than one layer, apply the summation principle as given in Federal Meteorological Handbook (FMH) #1. That is, if a lower layer at height h_1 has 25 hits and the next layer at height h_2 has 13 hits, R_L for h_2 would be computed using 38 for the number of hits in that layer.

3. If there are fewer than five hits from the ceilometer, enter "CLR BLO CHUL" where "CHUL" is the upper limit of the ceilometer (in hundreds of feet).

4. If there are five or more hits and $R_L \leq 0.06$ (5,6 or 7 hits) for any layer, enter "CLR BLO CHUL" and add a remark "FEW CLDS hh" where "hh" is the height in hundreds of feet of lowest layer.

5. If there is more than one layer and the lowest layer is the only layer with five hits or more and with $R_L \leq 0.06$, add the remark "FEW CLDS hh" to indicate clouds below the first reportable layer.

6. If $0.06 < R_L \leq 0.55$, the layer will be reported as scattered (SCT). (8 through 66 hits)

7. If $0.55 < R_L \leq 0.87$, report the layer at that height as broken (BKN). (67 through 104 hits)

8. If $R_L > 0.87$, the layer at that height shall be reported as overcase (OVC). (105 through 120 hits)

9. If more than one layer has $R_L > 0.87$, add the remark "HIR CLDS VSB" for higher clouds visible.

L. Report Variable Ceiling

1. For ceilings below 3000 feet (i.e., the lowest broken or overcast layer), calculate the standard deviation using the equation

$$SD = \frac{1}{N} \sqrt{N \sum H^2 - (\sum H)^2}$$

where H is the individual height values within the layer.

NOTE: Variable conditions are only reported with broken or overcast layers

2. If the height is 1000 feet or below and the standard deviation is greater than 100, report variable as shown in 5 below.

3. If the height is greater than 1000 feet but less than or equal to 2000 feet and the standard deviation is greater than 300, report variable as shown in 5 below.

4. If the height is greater than 2000 feet but less than 3000 feet and the standard deviation is greater than 400, report variable as shown in 5 below.

5. If a variable remark is required, output a remark of the form

   CIG min height V max height (in 100 ft)

   where the min and max heights are the highest and lowest values within that particular layer.

M. Report Obscurations - At least 30 minutes of data are required to report obscurations. If there are less than 30 minutes of data skip this section and go to N.

1. Total Obscurations

   Obtain the visibility each minute from the visibility algorithm. If the visibility is missing or above 2 miles, proceed to N. Obtain the average temperature each minute from the temperature algorithm.

   If there are less than five hits in the last 10 minutes, output cloud height and amount as follows:

W1X	if visibility $\leq$ 1/4 mile (100 ft vertical VSBY)
W2X	if visibility > 1/4 mile and < 1 1/2 miles (200 ft vertical VSBY)
W2X	if visibility $\geq$ 1 1/2 miles and < 2 and temperature is missing
W7X	if visibility $\geq$ 1 1/2 miles and < 2 miles and air temperature $\leq$ 36F; (700 ft vertical VSBY)

2. Partial Obscurations

   If there are five or more cloud hits during the last 10 minutes, visibility < 1 1/2 miles or the temperature $\leq$ 36 F and visibility < 2 miles, use the instructions below to report a partial obscuration. If the temperature is missing, output partial obscurations when visibility $\geq$ 1 1/2 miles and < 2 miles.

   a. If $R_L \leq 0.06$ for all layers, output -X for the cloud observation

   b. If $R_L > 0.06$, multiply each cloud layer amount, R_L, by 0.8. Then, add 0.2 to each cloud layer amount and use these new cloud layer amounts in the subsequent steps. Prefix the first reported cloud layer with -X.

N. Report Cloud Layers and Their Priority

1. If totally obscured, use instructions in M.

2. If clear, report "CLR BLO CHUL."

3. Up to three layers can be reported; however, if there is more than one overcast layer, only the lowest overcast layer is reported. (See K.9, HIR CLDS VSB)

4. Layers shall be reported from the lowest to the highest.

5. If there are more than three layers, report three using the priority listed below:

   a. the lowest scattered (SCT) layer
   b. the lowest broken (BKN) layer
   c. the overcast (OVC) layer
   d. the second lowest (SCT) layer
   e. the second lowest (BKN) layer
   f. the highest (BKN) layer
   h. the highest (SCT) layer.

O. Report Variable Layer Amounts

1. If the lowest BKN layer has $0.55 < R_L \leq 0.59$, put in remarks "BKN V SCT.' (67, 68, 69, or 70 hits)

2. If the highest BKN layer has $0.85 < R_L \leq 0.87$, put in remarks "BKN V OVC." (102, 103, or 104 hits)

3. If the overcast layer has $0.87 < R_L \leq 0.89$, put in remarks "OVC V BKN." (105 or 106 hits).

P. Report Priority for Remarks - Output only one sky condition remark per observation according to the priority below:

1. FEW CLDS hh
2. CIG min V max
3. HIR CLDS VSB
4. BKN V SCT
5. BKN V OVC
6. OVC V BKN

Q. Format of Cloud Observation - Report cloud height in hundreds of feet. Prefix a ceiling, lowest broken (BKN) or lowest overcast (OVC) layer, with the designator "M" if 30 minutes of data are available. Prefix the entire cloud observation with the designator "E" if less than 30 minutes of data are available.

R. Test for Special Observation - If less than 30 minutes of data are available, do not test for specials.

At the end of 30 minutes if the current ceiling (i.e., lowest BKN or OVC layer or A in WAX) is below 3000 feet generate a special observation. (Any WAX message, See M.1)

1. Each minute compare the newly generated sky condition with the previous one. Generate a special when the ceiling (i.e., lowest BKN or OVC) forms below, decreases to less than, or if below increases to equal or exceeds:

   a. 3000 feet
   b. 1500 feet
   c. 1000 feet
   d. 500 feet
   e. 300 feet

2. Each minute compare the newly generated sky condition with the previously transmitted SA, RS, or SP. Generate a special if a layer of clouds is present below 1000 feet and no layer below 1000 was reported in the last RS, SA, or SP.

VISIBILITY The visibility algorithm uses a measurement of the local optical conditions of the atmosphere to calculate the approximate visual range limit due to these conditions.

VISIBILITY ALGORITHM (3 km Radius of Validity, 5-10 Minute Time Validity)

A. Each minute obtain one value of the scattering coefficient (SC) from the sensor

B. Determine if the reading is outside sensor limits. If so, the value is bad and the previous good reading can be inserted. Two bad readings are acceptable, each time inserting the last good reading. If there is a third consecutive bad reading, use of the sensor shall be discontinued and appropriate notification made. (MM to screen, "AVG VSBY", SCRNLM, "SC" to maintenance log)

C. Check to see if the day/night switch should be set. Read the switch each minute. If night, calculate night VSBY and day VSBY otherwise just day VSBY. (Night VSBY goes to miscellaneous display).

D. Convert each One-minute value of extinction coefficient to Sensor Equivalent Visibility (SEV) DSV for day, NSV for night) in nautical miles using the appropriate equations given in Section 3.2. If SEV < 1/16 Nmi store zero and if SEV > 9 1/2 Nmi store 10.

E. Store 10 minutes of data. If less than 10 minutes of SEV values have been collected, linearly average the available values and prefix that average with an "E" for estimated. Otherwise compute a 10-minute average (ADSV) and update it each minute. Round ADSV to the nearest reportable value (ADV) according to Table 3.1-E. The required reportable visibility values for SMOOS are:

0, 1/16, 1/8, 1/4, 1/2, 3/4, 1, 1 1/2, 2, 2 1/2, 3, 4, 5, 6, 7, 8, 9, 10. (Note: ADV is Average Day Visibility. ANV, Average Night Visibility, is treated the same way as ADV).

Table 3.1-E ADV OR ANV ROUND OFF

If ADSV or ADNV is greater than or equal to 0 and less than or equal to 0.03125 then ADV or ANV is equal to 0.

If ADSV is >	0.03125	and ≤	0.9375	then ADV =	1/16
	0.09375		0.1875		1/8
	0.1875		0.375		1/4
	0.375		0.625		1/2
	0.625		0.875		3/4
	0.875		1.25		1
	1.25		1.75		1-1/2
	1.75		2.25		2
	2.25		2.75		2-1/2
	2.75		3.5		3
	3.5		4.5		4
	4.5		5.5		5
	5.5		6.5		6
	6.5		7.5		7
	7.5		8.5		8
	8.5		9.5		9
	9.5				10

F. Examine the last 10 minutes of SEV values to check for variable visibility. Compare each SEV value with its preceding value. If $|SEV_i - SEV_{i-1}|$ is greater than 1/2 mile, increment a counter. After comparing all 10 values, if the counter is greater than or equal to 3 and ASV is less than 3 miles, add a "V" to the reported ADV and report variable visibility in remarks. The remark should be in the form

VSBY minVmax

where

min = minimum DSV value generated during the last 10 minutes and rounded to the nearest reportable value

max = maximum DSV value generated during the last 10 minutes and rounded to the nearest reportable value.

G. Test for Special Observations - For the first 10 minutes after system initialization (i.e., while visibility is estimated), do not test for specials. At the end of 10 minutes, if the current ADV < 3 miles, generate a special.

Each minute compare the newly generated ADV with the previous one. Generate a special when ADV decreases to less than, or if below increases to equal or exceeds

a. 3 miles
b. 2 miles
c. 1 1/2 miles
d. 1 mile

CONVERSION OF SCATTERING COEFFICIENT TO VISIBILITY

After the day/night switch has been read, use the appropriate equation below to convert the scattering coefficient (SC), which is in nautical miles^{-1}, to visibility (SEV) in nautical miles.

A. For Day Visibility
SEV = 2.90/SC
(Koschmeider Relation with Contrast Threshold of .055)

B. For Night Visibility
$0.00336 = (e^{-(SC) \times (SEV)})/SEV$
where e = 2.718
(Allards Law for 25 cp steady light against moderately lighted background)

If the photometer is inoperative, use only the day visibility equation.

SENSOR PREPROCESSING

Since the output of the visibility sensor is not in scattering coefficient, preprocessing is necessary to use the sensor-independent algorithm in Section 3.1. Below are instructions for converting the HSS VR-301 output to scattering coefficient (SC).

SC = Scattering Coefficient
V = Volts (output of HSS-301, 0 to 10 volts)
SC = K (V - .01) n.mi.$^{-1}$ if V is greater than .01
SC = .001 K n.mi.$^{-1}$ if V is less than or equal to .01
K = VSUL/9.99 (K = 10 for ADM)

Atmospheric Pressure: The following definitions are employed in the implementation of this algorithm:

ALTIMETER SETTING (AS) - The pressure value to which an aircraft altimeter scale is set so that it will indicate the altitude above mean sea level of an aircraft on the ground. For SMOOS this is the sea level pressure expressed in inches of mercury.

BAROMETRIC PRESSURE - The pressure exerted by the atmosphere as a consequence of gravitational attraction exerted upon the column of air directly above the point in question.

DENSITY ALTITUDE (DA) - The altitude in the standard atmosphere where air density is the same as that measured or calculated. SMOOS determines DA for sea level.

PRESSURE ALTITUDE (PA) - The altitude in the standard atmosphere where the air pressure is the same as that measured or calculated. SMOOS determines PA for sea level.

REDUCTION OF PRESSURE - The conversion of a barometric pressure to the value it would theoretically have at another level. This applies most often to reducing the observed pressure at the barometer height, Hz, to a computed value for Hp or Hpc (the removal correction) and then reducing that pressure to sea level. The removal correction is generally used for height changes of less than 100 feet (30 m), whereas reduction to sea level is done for stations at high and low altitudes. For the later case, the pressure is reduced through an imaginary air column from the station to sea level. The temperature and humidity characteristics of this column are based on climatological and empirical factors.

REMOVAL CORRECTION - A correction applied for the purpose of reducing the pressure at the actual elevation of the barometer to the pressure at an adopted station elevation or other level. SMOOS uses this method to determine altimeter setting and sea level pressure.

SEA LEVEL PRESSURE (SLP) - The atmospheric pressure at mean sea level. It is either measured directly, or, most commonly, reduced from the station pressure.

STANDARD ATMOSPHERE - A hypothetical vertical distribution of atmospheric temperature, pressure, density, and other physical properties that, by international agreement, is taken to be representative of the atmosphere.

STATION ELEVATION (Hp) - The officially designated height above mean sea level to which station pressure pertains. SMOOS uses the height of the barometric pressure sensor above the water line.

STATION PRESSURE (PS) - The atmospheric pressure computed for the level of the station elevation Hp.

ALGORITHMS (120 km Radius of Validity, 30 Minute Time Validity)

STATION PRESSURE: The most important of the pressure algorithms is the station pressure. The station pressure will be used in the computations of the other pressure parameters. For SMOOS the station pressure is the pressure measured at the pressure sensor.

A. Read two pressure sensors (located at elevation Hp) every second to the nearest 0.001 inch and compute a 1-minute average for each sensor, P1 and P2 (APS1, APS2).

B. Check the 1-minute values to determine if they fall within sensor limits. If not, output pressure as missing (i.e., MM to screen; PS1 = "APS1" RNLMT, PS 2 = "APS2" to maintenance log).

C. Every 10 seconds, check the individual reading at that time for each sensor with the previous 1-minute average from that sensor. If this reading is not within 0.03 inch of mercury of the 1-minute average, output missing for pressure (i.e., MM to screen, PS1 = "PS1" ROCLM, PS2 = "APS2" to maintenance log).

D. There should now be two station pressures, APS1 and APS2, reported to the nearest 0.001 inch. If APS1 and APS2 differ by more than 0.03 inch of mercury, output all pressure parameters as missing (PS1 = "APS1", PS2 = "APS2", INCNSTNT, goes to maintenance log).

E. Output, when required, to the nearest 0.001 inch the lower value as the station pressure, APS. If the station pressure is determined to be "missing," all other pressure parameters shall be reported as missing.

SEA LEVEL PRESSURE:

A. From the station pressure algorithm, use the station pressure, APS.

B. Calculate sea level pressure, SLP, using the equation:

$$SLP = 33.86389\ (APS) + .0361328\ HP$$

where

SLP = sea level pressure in millibars (to nearest 0.1 mb)
HP = station elevation to nearest foot

ALTIMETER SETTING:

A. Using the value of APS calculate the altimeter setting using the equation:

$$AS = APS + 0.001067\ HP$$

where

AS = altimater setting to the nearest 0.01 in.-Hg
HP = station elevation to the nearest foot
APS = station pressure to the nearest 0.001 in.-Hg

DENSITY ALTITUDE:

A. Obtain the altimeter setting, AS

B. From the dry-bulb temperature algorithm obtain the current 5-minute average temperature, t (in degrees F). If the temperature is missing, report density altitude as missing.

C. Compute density altitude, DA, in feet using:

$$DA = 145448\ (1 - ((17.33565\ AS)/(459.7 + ATA))^{.23496});\ \text{where}$$

AS = Altimeter Setting to nearest .01 in Hg
ATA = Average Air Temperature to nearest 0.1 F

D. Report density altitude to the nearest 100 feet. Note that density altitude is reported only as an updated parameter (i.e., aviation weather display only).

PRESSURE ALTITUDE:

A. Obtain the Altimeter Setting AS.

B. Calculate the Pressure Altitude using

$$PA = 145448 \ (1 - (AS/29.9213)^{.19026})$$

C. Report pressure altitude to the nearest 100 feet (Aviation weather display only).

TEMPERATURE AND HUMIDITY

Algorithms for reporting dry-bulb and dew point temperatures in an aviation observation are given below. While relative humidity is not transmitted in the observation, personnel are generally interested in this parameter, so an algorithm has been developed.

DRY-BULB TEMPERATURE (8 km Radius of Validity, 10-20 Minute Time Validity)

ALGORITHM:

A. Read the temperature sensor at least once every minute. (TA)

B. Determine if the reading is within predetermined sensor limits. If not, indicate missing (MM) in the observation. (MM to screen; "ATA", RNLM, "TA" to maintenance log)

C. Check to see if the temperature exceeded a rate of change of 6 F within the past minute. If so, replace with previous reading. If test is failed more than twice indicate missing (MM to screen, ATA = "ATA", ROCLM, "TA" to maintenance).

D. If the temperature reading has passed the checks in B and C, store the reading. Compute a 5-minute average (ATA) and output this temperature in the observation.

E. Update the 5-minute average each minute (i.e., calculate 5-minute running average).

F. At the time of the hourly observation, store the highest and lowest 5-minute averages calculated during the preceding one hour. These temperatures will be used maximum/minimum temperature algorithm.

DEWPOINT TEMPERATURE: ALGORITHM (8 km Radius of Validity, 10-20 Minute Time Validity)

A. Read the dew point sensor once every minute.

B. Determine if the reading is within predetermined sensor limits. If not, generate missing (MM) (MM to screen; ATD = "ATD", RNLM, "TD" to main- tenance).

C. Check to see if the dew point has exceeded a rate of change of 6 F within the past minute. If so, generate missing remark message.

MM to screen; ATD = "ATD", ROCLM, "TD" to maintenance)

D. If the dew point value passed the checks above, store the 1-minute reading and compute a 5-minute average. If the dew point average is 1 or 2 F higher than the dry-bulb average, the dew point shall be reported as equal to the dry bulb. If the dew point exceeds the dry bulb by more than 2 F, output missing (MM) for the dew point. (MM to screen; ATD = "ATD", INCNSTNT W TA to maintenance). If the dry bulb is not available, omit the comparison.

E. Each minute update the 5-minute average (ATD); i.e., calculate a running 5-minute average. Report ATD as the Dew Point Temperature each minute.

RELATIVE HUMIDITY: Relative humidity, expressed as a percentage, is the ratio of the actual vapor pressure of the air to the saturation vapor pressure. This parameter is not saved as part of the surface weather observation but is displayed as an updated parameter on the aviation weather displays.

ALGORITHM:

A. Obtain the current dry bulb and dew point temperatures (5-minute average) in degrees Fahrenheit. If either is missing, report relative humidity as missing. (MM)

B. Compute relative humidity (in percent) using the equation

$$H = e^{(4.60517-(9788.4/(ATD+459.688))+(9788.4/(ATA+459.688)))}$$

where $e = 2.71828$

RH is reported to the nearest 1 percent.

WIND: Wind is measured in terms of speed and direction. There are various characteristics associated with speed and direction that are of great interest to the aviation user. This section includes algorithms for reporting speed, direction, wind gusts, squalls, variable wind direction, and wind shifts.

WIND SPEED AND DIRECTION (2-3 km Radius of Validity, 5-Minute Time Validity): A literature search by the National Weather Service on the subject of wind observations has resulted in the use of a 2-minute average for reporting both speed and direction. The 2-minute average has been incorporated into the following algorithms. Particular attention is given to the wind direction anomaly which occurs when an average value is required when direction varies about 0 degrees (e.g., 350 to 10 degrees) resulting in erroneous averages.

ALGORITHM:

A. Interrogate the wind speed (WSR), wind direction (WDR), Ship Speed (SST) and Ship Direction (SDT) once every second.

B. If the speed exceeds the upper limit of the wind speed or ship speed sensor (WSUL or SSUL) output missing. If WSR > WSUL send MM for WST and WDT. If SST > SSUL send MM for WST, WDT, and SST.

NOTE: If the wind sensor is out of limit the algorithm "resets," therefore ship speed and direction will be reported as missing as well as wind speed and direction.

C. Each second calculate the true wind speed (WST) and direction (WDT) using the following method:

From ship's heading (SDT) and relative wind direction (WDR) we obtain the total wind angle parameter (Ta).

(1) Ta = SDT + WDR

Using Ta; relative wind speed (WSR), ship's speed (SST), and SDT we obtain the wind speed from the East (EW)

(2) EW = WSR * SIN (Ta) - SST * SIN (SDT)

and the wind speed from the North (NW)

(3) $NW = WSR * COS (Ta) - SST * COS (SDT)$

from EW and NW we obtain true wind speed (WST) and true wind direction (WDT)

(4) $WST = \sqrt{EW^2 + NW^2}$

(5) $WDT = ATAN2 (EW, NW)$

A TAN2 (A,B) is a special library function that calculates the arc tan of A/B for 0 to 360 degrees. It can be replaced by a short routine that considers the signs of A and B to determine the quadrant of the angle of interest in those processors that don't have the ATAN2 library function.

D. Each minute calculate a 2-minute running average for speed (AWST) and direction (AWDT). The direction should be rounded to the nearest ten degrees and the speed should be rounded to the nearest knot.

E. For direction, output only the hundreds and tens digits (e.g., 160 degrees should be output as 16). Zero degrees shall be output as 36. When the speed is less than or equal to 2.5 knots, output "00" for direction and "00" for speed indicating calm winds.

F. Test for Special Observations - Do not test for specials until there are 2 minutes of data and the current average speed, $AWST_i$, is > 25 knots.

Each minute compare the current average speed, $AWST_i$, with the previous one, $AWST_{i-1}$. If $AWST_i \geq 2AWST_{i-1}$ generate a special observation.

WIND GUSTS: From a literature search, a decision was made to use a 5-second sampling average for determining gusts. The gust will be carried on all observations for 10 minutes unless it falls to within 3 knots of the current 2-minute average.

ALGORITHM:

A. Calculate a 5-second average wind speed and update each second.

B. Each minute store the highest 5-second average; save for 10 minutes.

C. Compare the current 2-minute average speed and the highest 5-second average for that minute. If the 2-minute average equals or exceeds 9 knots and the difference between the 5-second average and the 2-minute average equals or exceeds 5 knots, store that 5-second average as a GUST.

D. Compare the current 2-minute average and the highest GUST (if any) stored during the last 10 minutes. If this GUST is at least 3 knots higher than the 2-minute average, add this GUST to the wind observation. Use the form:

Ggg

where

G = gust indicator
gg = speed of gust

SQUALLS:

A. Using the maximum 5 second average per minute (MWST) from the gust algorithm determine if a squall occurred within the previous 5 minutes as follows

B. If the current MWST is within 15 knots of MWST 6 minutes ago ($MWST_T - MWST_{T-6} < 15$) and:

C. MWST 5 minutes ago $\geq$ 20 knots and:

D. MWST has increased by at least 15 knots in 1 minute 6 minutes ago ($MWST_{T-5} - MWST_{T-6} \geq 15$) and:

E. MWST 2 minutes later remains 15 knots or more higher than MWST 6 minutes ago ($MWST_{T-4} - MWST_{T-6} \geq 15$) then:

F. Report a squall occurrence in format Q "QWST". QWST is maximum MWST during previous 6 minutes.

VARIABLE WIND DIRECTION: The wind direction is described as variable when it fluctuates by 60 degrees or more during the period of observation and when the wind speed is greater than 6 knots.

ALGORITHM:

A. Calculate a 5-second average direction and update each second, store for 2 minutes

B. Round the 5-second averages to the nearest 10 degrees

C. if the wind speed is greater than 6 knots, compute each minute the range of wind directions on each side of the mean direction during the last 2 minutes. (Each second WDT is compared to the most recent AWDT)

D. If the total range is 60 degrees or more, a variable direction should be reported in the remarks section of the observation

E. Report the extreme in a clockwise direction around the 2-minute average direction using the form where xx and yy are the extremes of variability in tens of degrees; e.g., WND 27V34.

F. Carry the remark on the observation for only 1 minute.

WIND SHIFT:

A. Compare AWDT with AWDT 15 minutes ago. If $|AWDT_{T-15} - AWST_{T} > 45|$ report a windshift to remarks column

SEA WATER TEMPERATURE: The sea water temperature algorithm is essentially the same as the air temperature algorithm.

ALGORITHM:

A. Sample sea water temperature (SWT) once per minute.

B. Compute 5-minute running average (ASWT). (Send MM, NTRDY to screen first 5 minutes.)

C. Check for data out of sensor upper and lower limits. Send MM to screen; ASWT = "ASWT", RNLMT, "SWT" to maintenance log if so.

D. Check for rate of change. Send MM to screen; AWST = "AWST", ROCLM, "SWT" to maintenance log if SWT changes more than 5.4 F in one minute.

E. Check for inconsistency with air temperature. Send MM to screen; AWST = "AWST", INCNSTNT-TA to maintenance log if AWST and ATA differ by more than 40 F.

Appendix D

MESSAGE FORMAT FOR DATA TRANSMITTED BETWEEN THE MCS AND SYSTEM CONTROLLER

Transmission between such MCS and the system controller is accomplished via messages that either consist of a command or a data set. The command codes are:

No.	Command Code
1.	Scan Results
2.	Download Configuration
3.	Upload Configuration

Messages transmitted between the system controller and MCS network are constructed as follows:

Byte	(1) Single Block SC to MCS	(2) Single Block SC to MCS	(3) Single Block MCS to SC	(4) Multi-Block MCS to SC
0	SOM	SOM	SOM	SOM
1	ID	ID	ID	ID
2	CMD	CMD	Status	Status
3	DATA	Blocks	Status	Status
4	DATA	SEQ	CMD ECHO	CMD ECHO
5	DATA	DATA	DATA	Blocks
6	DATA	DATA	DATA	SEQ
7	DATA	DATA	DATA	DATA
-	DATA	DATA	DATA	DATA
N-2	DATA	DATA	DATA	DATA
N-1	PMCS	PMCS	PMCS	PMCS
N	EOM	EOM	EOM	EOM

where

Blocks = Bus address; either
SOM = Start of message (ASCII STX, decimal 2)
ID = 0,1 for MCS 0 or MCS 1 (ASCII 0-7)
CMD = Command Echo; command sent to the MCS
DATA = Command dependent parameters
SEQ = Current block number (ASCII 1-9)
PMCS = Checksum
N = Last byte in address message (would be less than equal to 239)
Status = MCS status

Bit	Definition
0	Parity error
1	Context error
2	Syntax error
3	PMCS error

4	Power up flag
5	0
6	1
7	Parity
8	0
9	Not used
10	Secondary status alert
11	Halt mode
12	Battery flag
13	0
14	1
15	Parity

Columns three and above constitute the MCS response to a system controller command. Column three is the format used to transmit messages of less than 240 bytes. Column four is the format used to transmit 240 byte or longer messages. The upload (i.e., MCS to system controller) message format is: (Note: NAF = Numeric ASCII Field)

NAF	Byte	Bit	Identification
	0	0	Algorithm Flag - Barometric Pressure
		1	Algorithm Flag - Sea Water Temperature
		2	Algorithm Flag - Visual Range
		3	Algorithm Flag - Sky (Cloud Conditions)
		4	Algorithm Flag - Air Temperature
		5	0
		6	1
		7	Parity
	1	0	Algorithm Flag - Wind
		1-5	0
		6	1
		7	Parity
	2	0-4	Serial Device Identifier (1 = cloud height, 2 = temperature/dew point)
		5	0
		6	1
		7	Parity
	3	0-4	Analog Port 1 Device Identifier (1 = VR1, 2 = VR2, 3 = VR3, 4 = SST, 5 = SDT, 6 = WDR, 7 = WSR, 8 = PS1, 9 = PS2, 10 = SWT, 11 = , 12 = , ... 31 = XX)

		5	0
		6	1
		7	Parity
	4-14	0-4	Analog Port 2-12 Device Identifiers
		5	0
		6	1
		7	Parity
	15		ASCII Comma
0-11	16-N		Analog Port 1-12 Voltage Scales
12-23	16-N		Analog Port 1-12 Integration Periods
24	16-N		SUL (31.3) (in.Hg)
25	16-N		SLL (28.58) (in.Hg)
26	16-N		HP (Ft.)
27	16-N		CHUL (50) (100 ft)
28	16-N		CHLL (1) (100 ft)
29	16-N		TASLL (-70) (F)
30	16-N		TASUL (130) (F)
31	16-N		TDSLL (-40) (F)
32	16-N		TDSUL (130) (F)
33	16-N		WSUL
34	16-N		SSUL
35	16-N		SWTSLL
36	16-N		SWTSUL
37	16-N		VSLL
38	16-N		VSUL

The download format (i.e., system controller to MSC) is the same. The MCS scan response format is:

Field	Byte	Bit	Identification
	0	0-4	Virginal Scan Count (decimal 0-31)
		5	0
		6	1
		7	Parity
	1	0	Serial Device Failure Flag
		1	Algorithm Flag - Barometric Pressure
		2	Algorithm Flag - Sea Water Temperature
		3	Algorithm Flag - Visual Range
		4	Algorithm Flag - Sky (Cloud Conditions)
		5	0
		6	1
		7	Parity

2	0	Algorithm Flag Air Temperature
	1	Algorithm Flag - Wind
	2-5	0
	6	1
	7	Parity

O-N	U-N	
0 4,	8	Output from Barometric Pressure Algorithm
1 1,	1	Output from Sea Water Temperature Algorithm
2 2,	4	Output from Visual Range Algorithm
3 7,	15	Output from Sky (Cloud Conditions) Algorithm
4 4,	6	Output from Air Temperature Algorithm
5 3,	7	Output from Wind Algorithm

The individual output fields are included only if the corresponding bit is set in the prefix bytes.

The output formats for the environmental data transmissions are:

BAROMETRIC PRESSURE ALGORITHM

NAF	Byte	Bit	Bit Status	Description
	0	0	Set	APS = MM
		1	Set	PS1 = "APS1", RNLM
		2	Set	PS1 = "PS1", ROCLM
		3	Set	PS2 = "APS2", RNLM
		4	Set	PS2 = "PS2", ROCLM
		5	0	
		6	1	
		7	Parity	
	1	0	Set	PS1 = "APS1"
		1	Set	PS2 = "APS2"
		2	Set	INCNSTNT
		3	Set	SLP = MM
		4	Set	ALSTG = MM
		5	0	
		6	1	
		7	Parity	
	2	0	Set	DA = MM
		1	Set	PA = MM
		2	Set	APS = "APS"
		3	Set	SLP = "SLP"
		4	Set	ALSTG = "AS"
		5	0	
		6	1	
		7	Parity	

3	0	Set	PA = "PA"
	1	Set	DA = "DA"
	2-5	0	
	6	1	
	7	Parity	
4		ASC II	Comma
		6 "APS1"	(if Byte 0 Bit 1 or Byte 1 Bit 0)
		6 "PS1"	(if Byte 0, Bit 2)
		6 "APS2"	(if Byte 0 Bit 3 or Byte 1 Bit 1)
		6 "PS2"	(if Byte 0 Bit 4)
		6 "APS"	(if Byte 2 Bit 2)
		6 "SLP"	(if Byte 2 Bit 3)
		6 "AS"	(if Byte 2 Bit 4)
		6 "PA"	(if Byte 3 Bit 0)
		6 "DA"	(if Byte 3 Bit 1)

Note: Individual NAFs are included only if particular bits are set in the prefix bytes.

AIR TEMPERATURE ALGORITHM

NAF	Byte	Bit	Bit Status	Identification
	0	0	Set	ATA = MM
		1	Set	ATA = MM NTRDY
		2	Set	ATA = MM, "ATA", RNLM, "TA"
		3	Set	ATA = MM, "ATA", ROCLM, "TA"
		4	Set	MMT = "MATA", "MITA"
		5	0	
		6	1	
		7	Parity	
	1	0	Set	ATA = "ATA"
		1	Set	ATD = MM
		2	Set	ATD = MM, NTRDY
		3	Set	ATD = MM, "ATD", RNLM, "TD"
		4	Set	ATD = MM, "ATD", ROCLM, "TD"
		5	0	
		6	1	
		7	Parity	
	2	0	Set	ATD = MM, "ATD", INCNSTNT W ATA
		1	Set	ATD = "ATA"
		2	Set	ATD = "ATD"
		3	Set	RH = MM
		4	Set	RH = "RH"
		5	0	
		6	1	
		7	Parity	

	3	0	Set	Hygrothermometer failure
		1-5	0	
		6	1	
		7	Parity	
	4		ASCII	Comma
O-N			"ATA"	(if Byte 0 Bit 2 or Byte 0 Bit 3 04 Byte 1 Bit 0 or Byte 2 Bit 1)
			"TA"	(if Byte 0 Bit 2 or Byte 0 Bit 3)
			"MATA"	(if Byte 0 Bit 4)
			"MITA"	(if Byte 0 Bit 4)
			"ATD"	(if Byte 1 Bit 3 or Byte 1 Bit 4 or Byte 2 Bit 0 or Byte 2 Bit 2)
			"TD"	(if Byte 1 Bit 3 or Byte 1 Bit 4)
			"RH"	(if Byte 2 Bit 4)

Note: Individual NAFs are included only if particular bits are set in the prefix bytes.

WIND ALGORITHM OUTPUT

NAF	Byte	Bit	Bit Status	Identification
	0	0	Set	WST = MM
		1	Set	WDT = MM
		2	Set	SST = MM
		3	Set	WDT = MM NTRDY
		4	Set	WST = MM NTRDY
		5	0	
		6	1	
		7	Parity	
	1	0	Set	AWST = "AWST"
		1	Set	AWDT = "AWDT"
		2	Set	GSWT = G "MGWST"
		3	Set	QWST = Q "MWST"
		4	Set	WND = "XX" V "YY"
		5	0	
		6	1	
		7	Parity	
	2	0	Set	WSHFT = "TSHFT"
		1	Set	SP
		2	Set	SDT = "SDT"
		3	Set	SST = "SST"
		4-5	0	
		6	1	
		7	Parity	

	3		ASCII	Comma
O-N		0	"AWST"	(if Byte 1 Bit 0)
		1	"AWDT"	(if Byte 1 Bit 1)
		2	"MGWST"	(if Byte 1 Bit 2)
		3	"MWST"	(if Byte 1 Bit 3)
		4	"XX"	(if Byte 1 Bit 4)
		5	"YY"	(if Byte 1 Bit 4)
		6	"TSHFT"	(if Byte 2 Bit 0)
		7	"SDT"	(if Byte 2 Bit 2)
		8	"SST"	(if Byte 2 Bit 3)

Note: Individual NAFs are included only if particular bits are set in the prefix bytes.

SEA WATER TEMPERATURE ALGORITHM

NAF	Byte	Bit	Bit Status	Identification
	0	0	Set	ASWT = MM NTRDY
		1	Set	ASWT = MM "ASWT", RNLM, "SWT"
		2	Set	ASWT = MM, "ASWT", ROCLM, "SWT"
		3	Set	ASWT = MM, "ASWT", INCNSTNT W TA
		4	Set	ASWT = "ASWT"
		5	0	
		6	1	
		7	Parity	
	1		ASCII	Comma
		5	"ASWT"	(if Byte 0 Bit 1 or Byte 0 Bit 2 or Byte 0 Bit 3 or Byte 0 Bit 4)
		5	"SWT"	(if Byte 0 Bit 1 or Byte 0 Bit 2)

Note: Individual NAFs are included only if particular bits are set in prefix bytes.

VISUAL RANGE ALGORITHM OUTPUT

NAF	Byte	Bit	Bit Status	Identification
	0	0	Set	VSBY = MM "ADV" SCRNLM "SC"
		1	Set	SP
		2	Set	VSBY = E "ADV"
		3	Set	VSBY = "ADV"
		4	Set	"MISV" V "MASV"
		5	0	
		6	1	
		7	Parity	

1	0	Set	[E "ANV"]
	1	Set	["ANV"]
	2	Set	Sensor Failure
	3-5	0	VSBY = MM
	6	1	
	7	Parity	
2		ASCII	Comma
	5	"ADV"	(if Byte 0 Bit 0 or Byte 0 Bit 2 or Byte 0 Bit)
		"SC"	(if Byte 0 Bit 0)
		"MISV"	(if Byte 0 Bit 4)
		"MASV"	(if Byte 0 Bit 4)
		"ANV"	(if Byte 1 Bit 0 or Byte 1 Bit 1)

Note: Individual NAFs are included only if particular bits are set in prefix bytes.

SKY (CLOUD CONDITIONS) ALGORITHM OUTPUT

NAF	Byte	Bit	Bit Status	Identification
	0	0	Set	CH = MM BLO "CHLL"
		1	Set	CH = MM NTRDY
		2	Set	E
		3	Set	-X
		4	Set	CLR BLO "CHUL"
		5	0	
		6	1	
		7	Parity	
	1	0	Set	Few Clds "hh_1"
		1	Set	W1X
		2	Set	W2X
		3	Set	W7X
		4	Set	SP
		5	0	
		6	1	
		7	Parity	
	2	0	Set	CIG "hhmin" V "hhmax"
		1	Set	HIR Clds VSB
		2	Set	BKN V SCT
		3	Set	BKN V OVC
		4	Set	OVC V BKN
		5	0	
		6	1	
		7	Parity	

	3	0	Set	"hh$_2$" SCT1
		1	Set	"hh$_3$" SCT2
		2	Set	"hh$_4$" SCT3
		3	Set	"hh$_5$" BKN1
		4	Set	M "hh$_6$" BKN1
		5	0	
		6	1	
		7	Parity	
	4	0	Set	"hh$_7$" BKN2
		1	Set	"hh$_8$" BKN3
		2	Set	"hh$_9$" OVC
		3	Set	M "hh$_{10}$" OVC
		4	Set	Sensor OK
		5	0	
		6	1	
		7	Parity	
	5	0	Set	Sensor Failure
		1	Set	Temperature too Low
		2	Set	Temperature too High
		3	Set	Solar shutter closed
		4	Set	Laser Power % "XXX"
		5	0	
		6	1	
		7	Parity	
	6	0	Set	Receiver sensitivity "YYY"
		1-5	0	
		6	1	
		7	Parity	
	7		ASCII	Comma
O-N			"CHLL"	(if Byte 0 Bit 0)
			"CHUL"	(if Byte 0 Bit 4)
			"hh$_1$"	(if Byte 1 Bit 0)
			"hhmin"	(if Byte 2 Bit 0)
			"hhmax"	(if Byte 2 Bit 0)
			"hh$_2$"	(if Byte 3 Bit 0)
			"hh$_3$"	(if Byte 3 Bit 1)
			"hh$_4$"	(if Byte 3 Bit 2)
			"hh$_5$"	(if Byte 3 Bit 3)
			"hh$_6$"	(if Byte 3 Bit 4)
			"hh$_7$"	(if Byte 4 Bit 0)
			"hh$_8$"	(if Byte 4 Bit 1)
			"hh$_9$"	(if Byte 4 Bit 2)
			"hh$_{10}$"	(if Byte 4 Bit 3)
			"XXX"	(if Byte 5 Bit 4)
			"YYY"	(if Byte 6 Bit 0)

Note: Individual NAFs are included only if particular bits are set in prefix bytes.

END

DATE

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