

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM
MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT
CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED
IN THE INTEREST OF MAKING AVAILABLE AS MUCH
INFORMATION AS POSSIBLE

JPL PUBLICATION 80-40

(NASA-CR-163363) SATELLITE REMOTE SENSING
FACILITY FOR OCEANOGRAPHIC APPLICATIONS
Final Report (Jet Propulsion Lab.) 76 p
HC A05/MF A01

N80-28847

CSCL 08C

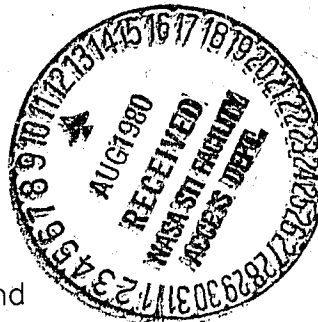
G3/43

Unclas
28145

Satellite Remote Sensing Facility for Oceanographic Applications

R. H. Evans
S. S. Kent
J. B. Seidman

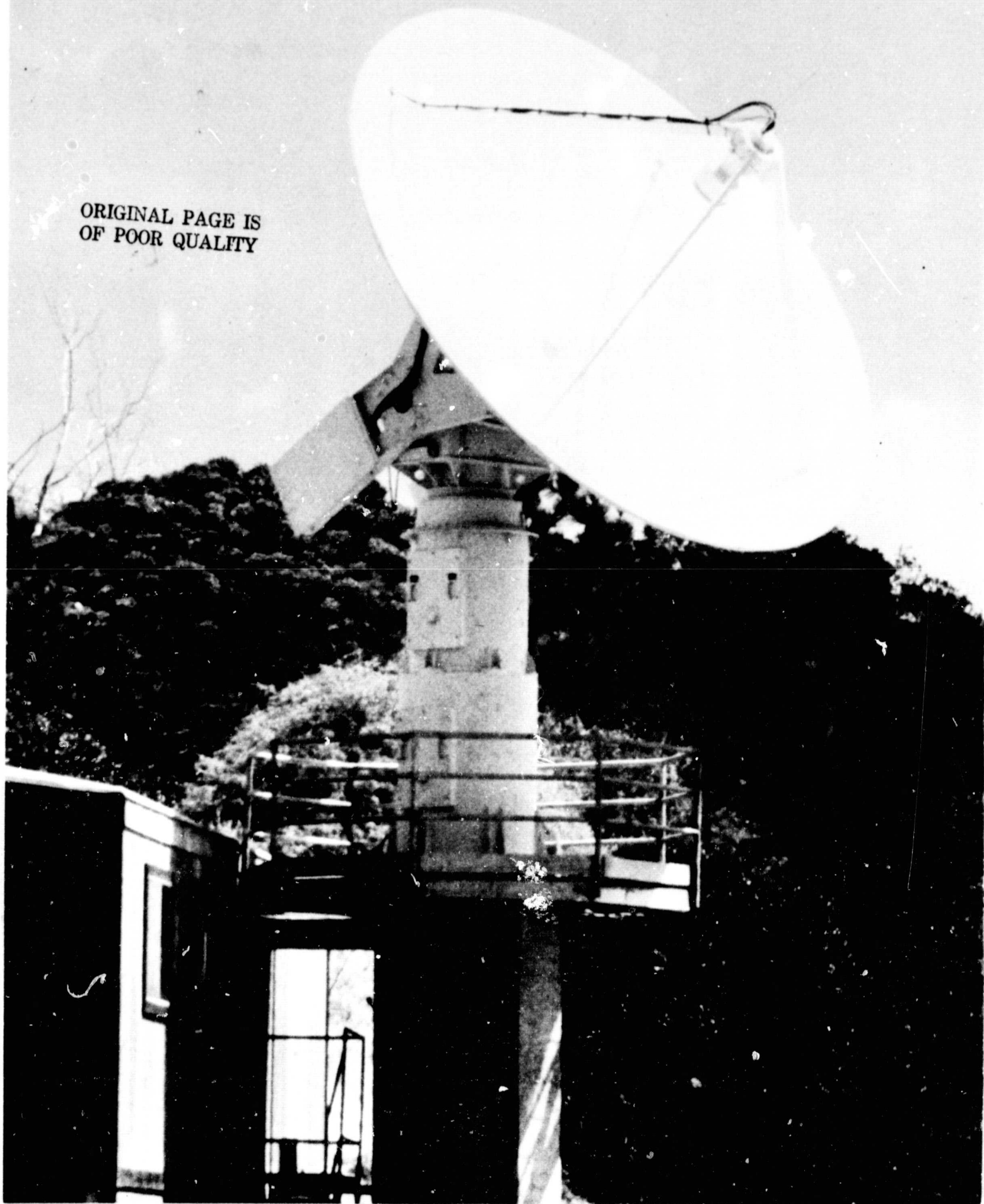
July 1, 1980



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

ORIGINAL PAGE IS
OF POOR QUALITY



JPL PUBLICATION 80-40

Satellite Remote Sensing Facility for Oceanographic Applications

R. H. Evans
S. S. Kent
J. B. Seidman

July 1, 1980

National Aeronautics and
Space Administration


Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

The research described in this publication was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract No. NAS7-100.

PREFACE

This document is a final report on the engineering and installation of a Remote Sensing Facility for oceanographic research at La Jolla, California. The work was accomplished by the Jet Propulsion Laboratory under the sponsorship of the Office of Space and Terrestrial Applications of the National Aeronautics and Space Administration (NASA). NASA also joined with the Office of Naval Research in sponsoring the total project activity. The National Science Foundation (NSF) shares in funding the continuing operation.

The facility was planned, designed, and implemented under the auspices of the Scripps Institution of Oceanography Remote Sensing Committee, which was formed and chaired by the Director, Dr. W. Nierenberg, in 1976. The committee membership consisted of representatives from Scripps, the Jet Propulsion Laboratory in Pasadena, California, and the Navy Ocean Systems Center in San Diego, California. The Remote Sensing Facility has been in operation since October 1979.


N. A. Renzetti
Technical Manager
Engineering

ACKNOWLEDGEMENT

The authors of this report wish to acknowledge the following personnel for their participation in the accomplishment of the Remote Sensing Facility at La Jolla, California:

R. S. Bernstein, Scripps Institution of Oceanography; N. Ortwein, Naval Ocean Systems Center; and B. McGlamery, SIO Visibility Laboratory, who were team members in carrying out the engineering and installation of the facility; R. D. Casperson of JPL, and R. A. Thorburn of University of California, San Diego for their assistance in site selection and construction of the facility; and finally, C. Vermillion and members of the staff of the Goddard Space Flight Center who assisted in the early formulation of the required capability and design options for this facility.

ABSTRACT

This document is a final report on the engineering and installation of a Remote Sensing Facility for oceanographic research at La Jolla, California. The facility was planned, designed, and implemented under the auspices of the Scripps Institution of Oceanography Remote Sensing Committee.

CONTENTS

I.	INTRODUCTION -----	1-1
II.	REMOTE SENSING FACILITY PROJECT -----	2-1
A.	BACKGROUND AND RATIONALE -----	2-1
B.	PROJECT ORGANIZATION AND MANAGEMENT -----	2-3
C.	FACILITY REQUIREMENTS -----	2-3
1.	Data Types -----	2-3
2.	Data Access -----	2-4
3.	Facility Operation -----	2-5
D.	DESIGN PROCESS -----	2-5
1.	Design Team -----	2-5
2.	Engineering Plan -----	2-5
3.	Direct Data Acquisition Survey -----	2-6
4.	Data Processing and Display Survey -----	2-6
5.	Indirect Data Acquisition Survey -----	2-7
6.	Recommended Facility Design -----	2-7
E.	PROCUREMENT AND CONSTRUCTION -----	2-8
1.	Vendor Selection -----	2-8
2.	Site Selection and Construction -----	2-9
3.	Equipment Installation and Transfer to Operations -----	2-10
III.	FACILITY DESCRIPTION -----	3-1
A.	GENERAL DESCRIPTION -----	3-1
B.	FUNCTIONAL DESCRIPTION -----	3-1
1.	Direct Reception Terminal -----	3-1
2.	Information Handling Subsystem -----	3-4

3.	Data Processing and Display Subsystem -----	3-8
REFERENCES	-----	4-1
APPENDIXES		
A.	SATELLITE FACILITY WORKING GROUP DESIGN RECOMMENDATIONS -----	A-1
B.	SIO PROJECTED REMOTE SENSING FACILITY USAGE -----	B-1
C.	SIO SATELLITE REMOTE SENSING FACILITY ENGINEERING SPECIFICATION -----	C-1
D.	SIO SATELLITE REMOTE SENSING FACILITY DIRECT RECEPTION TERMINAL -----	D-1
E.	SIO SATELLITE REMOTE SENSING FACILITY PROGRAM PLAN -----	E-1

Figures

2-1.	Project Organization -----	2-4
3-1.	Satellite Remote Sensing Facility Block Diagram -----	3-2
3-2.	Direct Reception Terminal Block Diagram -----	3-3
3-3.	Information Handling Subsystem Block Diagram -----	3-6
3-4.	Data Processing and Display Subsystem -----	3-8

Tables

2-1.	Oceanographically Useful Data Sets -----	2-2
3-1.	Direct Reception Terminal Specifications -----	3-5
3-2	Information Handling Subsystem Specifications -----	3-7

SECTION I

INTRODUCTION

This document describes the project organization, design process, and construction of the Scripps Institution of Oceanography (SIO) Satellite Remote Sensing Facility, which provides satellite oceanographic data to investigators at Scripps in real time. The facility is capable of receiving, processing, and displaying data from NASA's NIMBUS-7¹ satellite, the NASA/National Oceanic & Atmospheric Administration's (NOAA's) TIROS-N satellite, and the NOAA-A through NOAA-G follow-on third-generation satellites both directly via a five-meter antenna and receiving system, and indirectly via magnetic tape exchange. The data are primarily imaging data, representing the multispectral ocean emissions and reflectances covering the visible, infrared, and microwave portions of the spectrum, and are accumulated during 8- to 10-minute satellite passes over the California coast.

The most important feature of the facility is the reception and processing of satellite data in real time. Investigators can immediately act to confirm and enrich satellite-derived information by directing research ships and aircraft to areas of interest for on-site verification and experiments, particularly when a time-sensitive oceanographic phenomenon is taking place.

¹NIMBUS-7, earlier in the planning stage before launch, was referred to as NIMBUS-G. The appendixes are from earlier documentation that uses the -G designator.

SECTION II

REMOTE SENSING FACILITY PROJECT

A. BACKGROUND AND RATIONALE

During 1976, The Scripps Institution of Oceanography initiated plans to acquire new and diverse satellite data that would be available in quantity by mid-1978. A wealth of oceanographically useful data would be provided by the upcoming polar orbiters NIMBUS-7, TIROS-N, the NOAA series, and SEASAT-A.¹ A daily scan of any given portion of the oceans would be available, with sensors providing dozens of spectrum samples from the microwave, infrared, and visible portions of the spectrum, including color and reflected sun glint. Table 2-1 is a summary of the available data.

The Coastal Zone Color Scanner (CZCS) has a history restricted to a few manned missions, but there is evidence that the blue-green color differential across major ocean currents, as well as in upwelling zones, is detectable and can be used, perhaps even when thermal differences are masked (Reference 2-1). Recent work by Smith (Reference 2-2) demonstrates that the instrument should permit useful classification of chlorophyll and biological productivity levels.

The microwave instruments on SEASAT-A have limited histories. The SMMR promises to provide sea surface temperatures independent of cloud conditions. Although of low spatial resolution, these data would nicely complement the high-resolution AVHRR data in the infrared. In addition, microwave instruments for achieving higher spatial resolutions, which can be flown on the Shuttle, will only become a reality if oceanographers begin to work with the present data. The active microwave devices should give, through radar backscattering, information on waveheight, wave spectrum, and roughness. Data from radar altimeters, available now on the GEOS-3 satellite, indicate routine detection of surface slopes across the Gulf Stream. The SEASAT-A instrument and additional laser tracking stations may permit the detection of smaller amplitude features, but progress in this area will require increased interaction between oceanographers and geodesists.

The AVHRR has a history (VHRR, DMSP) that clearly demonstrates the oceanographic value of thermal infrared and sun glint patterns (e.g., References 2-3, 2-4, and 2-5).

For the study of a given oceanographic feature, such as upwelling, it is impossible to state which combination of the above data sets will be most valuable. All must be available, in original digital form, to permit the investigator to interactively examine them simultaneously in a multispectral sense.

¹ Direct reception capability was not implemented for SEASAT-A data. However, baseband recorded data can be processed by the facility.

TABLE 2-1. Oceanographically Useful Data Sets

Satellite	Sensor	Spectral Channels	Derivable Information
NIMBUS-7	Coastal Zone Color Scanner (CZCS)	0.433 to 0.453 μ m 0.510 to 0.530 μ m 0.540 to 0.560 μ m 0.660 to 0.680 μ m 0.700 to 0.800 μ m 10.5 to 12.5 μ m	Ocean color-sediment load, chlorophyll indicators. 800-m resolution; 2-day repeat cycle.
SEASAT-A	Scanning Multichannel Microwave Radiometer (SMMR)	6.6, 10.69, 18, 22.23, 37 GHz	Sea surface temperature (100-km spatial resolution); atmospheric liquid and water vapor content; sea ice information.
SEASAT-A	Scatterometer	13.9 or 14.595 GHz	Wind speed and direction.
SEASAT-A	Radar Altimeter (ALT)	13.9 GHz	Surface topography, surface wave height.
TIROS-N	Advanced Very High Resolution Radiometer (AVHRR)	0.6 to 0.7 μ m 0.7 to 1.0 μ m 3.7 to 4.1 μ m 10-5 to 11.1 μ m 11.5 to 12.0 μ m	Sea surface temperature, sun glint, 1-km spatial resolution; 6-h repeat cycle.
TIROS-N	Atmospheric Sounder	3.7, 4.3, 9.7, 11.1, 13, 3, 13.6, 14.0, 14.3, 14.5, 14.7, 15.0, 18.8, 23.1, 29.4 μ m	20- to 70-km spatial resolution; atmospheric temperature and water vapor profiles.
TIROS-N	ARGOS Data Collection System	Not applicable	RAMS follow-on; buoy location and data mission.

The Director of Scripps, Dr. William Nierenberg, formed a Remote Sensing Committee with the objective of developing a program and a facility that would make the best oceanographic use of satellite data. There were three basic drivers for the Committee. First was the availability of new oceanographic data types. Second was the absence of an adequate, research-oriented satellite data facility at a recognized oceanographic institution. Such a facility would allow oceanographers access to satellite data in combination with conventional data, and would provide sufficient computational power for exploring a wide variety of algorithms to extract maximum oceanographic information. Third, and most important, was real-time access to satellite data. Since most oceanographic features are extremely time-variant, a real-time capability would allow investigators to take full advantage of the satellite information by directing research ships and aircraft to the point of interest to perform more detailed on-site data collection.

B. PROJECT ORGANIZATION AND MANAGEMENT

The Remote Sensing Committee membership, initially composed of SIO investigators, was expanded in 1977 to include interested investigators from the Naval Ocean Systems Center (NOSC) in San Diego, and the Jet Propulsion Laboratory (JPL).

With broadened participation in the project, a Program Plan was generated to define the program and its objectives, establish the project organization, management responsibilities, and procedures. Identification of project participants and the project organizational structure is shown in Figure 2-1. The overall program objective was defined as the development and subsequent operation of a Satellite Remote Sensing Facility for a broad range of users at Scripps and other institutions. In detail, the program was to develop a real-time receiving capability, provide information displays, allow for data replay, and develop the necessary support facilities that would result in a viable, easy-to-use research facility at SIO.

C. FACILITY REQUIREMENTS

The broadly essential requirements for the facility were formulated and specified by the full committee in terms of data types and data access.

1. Data Types

The data of interest were agreed to, and given the following priority:

First: NIMBUS-7 Coastal Zone Color Scanner (CZCS) data.

Second: TIROS-N Advanced Very High Resolution Radiometry (AVHRR) data, and data from all other on-board instruments.

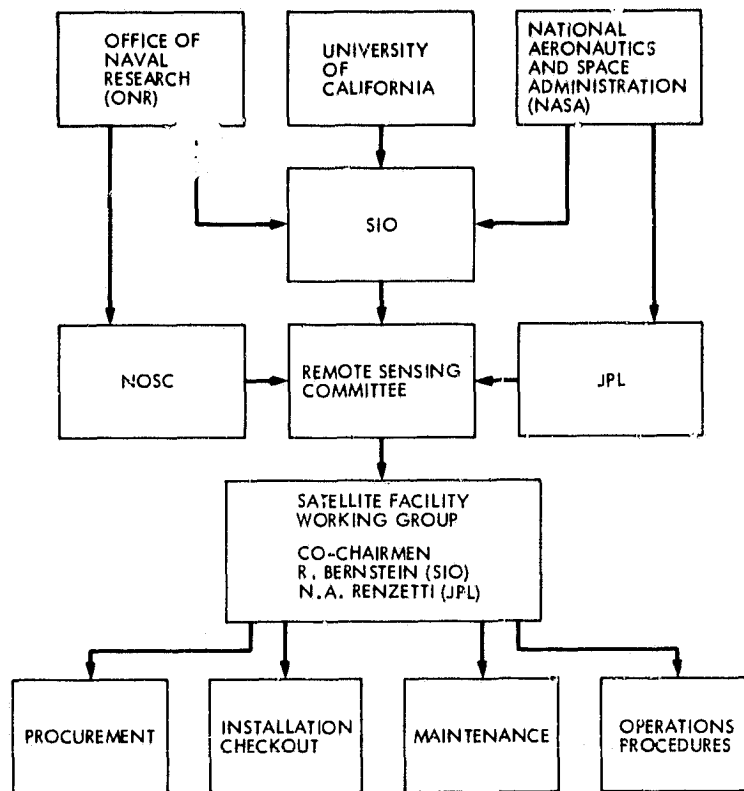


Figure 2-1. Project Organization

Third: SEASAT-A Scanning Multichannel Microwave Radiometer (SMMR), Scatterometer, and Radar Altimeter (ALT) data.

2. Data Access

It was agreed that direct reception of transmissions from a given satellite was the strongly preferred data path. Direct reception would insure timely receipt of complete data in its original form, undisturbed by truncations, previous formatting, or ground transmission errors that impact data that is sent via ground lines from another receiving source.

Alternate methods considered for receiving data were given the following priority:

- First: Real-time transmission of digital data via common carrier communication lines from NASA and NOAA ground tracking stations.
- Second: Near-real-time transmission of computer-compatible data via common carrier communication lines from NASA

and NOAA satellite project operations/processing centers.

Third: Nonreal-time delivery of analog baseband or computer-compatible tapes from a satellite data acquisition facility having a magnetic tape exchange interface.

3. Facility Operation

The design of the facility was to permit its operation by researchers in a straightforward manner, so as to encourage investigators, students, and faculty to utilize remotely sensed information.

D. DESIGN PROCESS

1. Design Team

In December 1977, the Committee formed a seven-member Satellite Facility Working Group to investigate and recommend the most feasible design for a satellite data acquisition and processing facility that could be placed in operation by October 1, 1978. The members of the Working Group were:

Robert Bernstein, Cochairman	SIO Northern Pacific Experiment
Nicholas Renzetti, Cochairman	JPL, Tracking and Data Acquisition
Robert Evans	JPL, Tracking and Data Acquisition
Steven Kent	JPL, Telecommunications
Norman Ortwein	NOSC, Telecommunications
Ben McGlamery	SIO, Visibility Laboratory
Joel Seidman	JPL, Image Processing Laboratory

2. Engineering Plan

On January 4, 1978, the Satellite Facility Working Group began the design process by conceptually configuring the facility into major subsystems and outlining a preliminary set of requirements for each. The product of the Working Group was to be a comprehensive report to the full Remote Sensing Committee at the end of February, recommending a firm, cost-effective design for achieving the basic facility requirements, and a set of detailed engineering specifications and functional requirements as a basis for approaching industrial contractors for bid.

The component engineering tasks were defined and assigned to the appropriate group members. A series of field surveys were conducted to study and evaluate NASA and commercial antenna facilities, data and image processing systems and equipment, satellite project operations interfaces, and ground communications lines and services for transferring data from other ground receiving locations.

3. Direct Data Acquisition Survey

The NASA inventory of tracking antenna facilities (both active and inactive) was surveyed for candidate equipment that could be obtained either by a NASA long-term loan to SIO or by transfer to an SIO-related government funding agency (e.g., Office of Naval Research or National Science Foundation). The candidate antenna equipment was inspected on the site, and cost estimates were generated for rehabilitation, modification, transfer to SIO, erection, and maintenance. Comparison costs for commercially available new antenna systems equipment were obtained from visits to selected manufacturers.

4. Data Processing and Display Survey

The basic facility requirements made it immediately clear that a general computation and color image display was required. Because of the funding constraints and the closeness of the October 1978 operational goal, the design study was directed toward two types of systems:

- (1) A commercially available, self-contained, "turn-key" system, comparable to those used for Landsat processing.
- (2) A copy of a noncommercial system in operation at a university or government facility for which software and technical assistance would be available at acceptable cost.

The local development of a hardware/software system from commercially available components was rejected because of its inherently long and costly developmental and debugging stages.

A list of possible commercial sources for turn-key image processing systems and candidate noncommercial hardware/software systems was compiled. The candidates for evaluation were:

(1) Commercial Systems

International Imaging Systems (I²S):

Series 500 and System 101

Electromagnetic Systems Laboratories (ESL): IDIMS II

MacDonald, Dettwiler & Associates (MDA)

System Development Corporation (SDC)

Comtal: Vision One

Interpretation Systems, Inc. (ISI): System 470

General Electric (GE): Image 100

(2) Noncommercial Systems

Jet Propulsion Laboratory: VICAR

University of Kansas: Kandidats

Purdue University: LARSYS

Scripps Institution of Oceanography:

Visibility Lab System

In addition, existing and planned processors at SIO were included in the evaluation for possible cost savings through shared use.

Evaluation of the candidate systems consisted of the following activities:

- (1) Benchmark running of specific sample computer tasks on candidate computers, and comparison with published performance capability.
- (2) Interviews with system vendors or providers to determine system capability, current applications, and users.
- (3) In-depth interviews with system users to determine level of satisfaction with system capability, performance, system reliability, and vendor support.
- (4) Demonstrations of the candidate systems using problems provided by the Working Group. By the time this was done, the realistic choices had been narrowed to the I²S System 101 and the ESL IDIMS, both of which incorporate an HP-3000 computer.

The performance and cost data obtained from the evaluation provided sufficient confidence that an adequate configuration of a commercial system that would meet the established functional requirements could be procured within the available budget. An equipment specification was prepared, generally describing the minimum acceptable configuration, including the software.

5. Indirect Data Acquisition Survey

This assignment resulted in an in-depth feasibility study and cost analysis of both real-time and nonreal-time transmission of data from satellite receiving centers to SIO via NASA or commercial ground communications facilities (e.g., ground lines, satellite communications, or magnetic tape exchange). NASA/NOAA sites and centers were visited and existing arrangements for the handling of TIROS-N, NIMBUS-7, and SEASAT-A data were carefully reviewed with personnel within those projects to seek feasible ways of connecting to project data terminals. Requirements and associated costs were compiled for additional communications hardware, personnel, tape management, and communications management that would be needed to service SIO. Discussions were held with RCA American Satellite Communications, Inc., with respect to applicable communications link services and costs.

6. Recommended Facility Design

By the middle of February, the Working Group had generated a realistic technical specification, and established a firm block diagram design. Additionally, several contacts with the NASA Office of Space

and Terrestrial Applications had resulted in an invitation to submit a proposal for the loan of a portable 7.3-m (24-ft) LANDSAT antenna system, and Goddard Space Flight Center was approached for loan of a 6-m (20-ft) antenna. On March 6, 1978, the technical specification and block diagram were submitted to the full Remote Sensing Committee as the recommended facility design. Dr. Robert Bernstein, Cochairman of the Working Group, described the basic design elements, the estimated procurement cost, the procurement approach, and expected funding sources. The substance of this presentation is contained in Appendix A, which is presented here in essentially original form.

The Working Group design recommendations were accepted by the full Remote Sensing Committee, with a request to proceed with procurement and implementation, and to definitely pursue the opportunity to obtain the loan of an antenna system from NASA. Historic documents relevant to this phase are included as Appendixes B, C, and D, which have been edited from the original only for consistency and to eliminate redundancy.

During June 1978, The NASA Office of Space and Terrestrial Applications initiated a formal study of direct support for the SIO Satellite Facility. The center of the study was the feasibility and cost effectiveness of a long-term loan of the LANDSAT-C RCA portable antenna system and/or the installation at Scripps of a communications satellite terminal. An analysis of these options versus the Scripps program and facility requirements indicated that neither would be cost-effective when compared to the procurement of a commercially available antenna and receiving system. On August 1, the Associate Administrator for Space and Terrestrial Applications recommended to the NASA Administrator the endorsement of the Scripps Satellite Oceanography Facility concept and funding for the antenna and data acquisition equipment. The NASA participation completed the required funding shared by the Office of Naval Research (image processing equipment) and the National Science Foundation (start-up and ongoing operations).

E. PROCUREMENT AND CONSTRUCTION

1. Vendor Selection

Vendor selection was based on competitive bids on two bid packages, which were prepared by the Working Group and issued to selected vendors in August 1978. One package contained requirements for the antenna and the Direct Reception Terminal. The second package covered requirements for both the Information Handling Subsystem (analog recorders, bit and frame synchronizers, and control unit) the Data Processing and Display Subsystem (the turn-key image processing system), and the necessary interface equipment.

Proposals for the antenna and Direct Reception Terminal were received from Scientific-Atlanta Corp. and Daytron Systems, respectively. The proposals were considered responsive and within the range of available funding. The Scientific-Atlanta Corporation was awarded the contract in December, 1978.

Proposals for the Information Handling Subsystem and the Data Processing and Display Subsystem were received from MacDonald, Dettwiler & Associates (MDA), System Development Corporation (SDC) and Electromagnetic Systems Laboratories (ESL). The ESL proposal was within the available budget and essentially consisted of their IDIMS system with some modifications to software and hardware to meet SIO requirements. ESL was awarded the contract in December 1978. The contract also included responsibility for system integration and end-to-end checkout.

2. Site Selection and Construction

In early September 1978, the Working Group appointed a Facility Site Selection Team, consisting of representatives from the SIO staff, University of California, San Diego Campus Office of Architects and Engineering, and the JPL technical staff. The JPL Site Selection Criteria For Deep Space Station Facilities was used as a basis for developing a site evaluation data matrix. Candidate sites were given a relative numerical rating.

All candidate sites were located on the SIO campus; these included open ground areas and rooftop locations on some of the campus buildings. Sites were evaluated for construction access, operation and maintenance access, availability of electrical power, communications access, RF mask, security, architectural appearance, and proximity to user offices. A primary consideration was the visual impact of the antenna facility relative to its location on the campus. The roof sites were also evaluated for structural integrity, building and safety codes, and fire protection. After completing their evaluations, the Site Selection Team submitted recommendations to the Working Group for evaluation and final decision. The site chosen was next to the Northern Pacific Experiment (NORPAX) Facility on the SIO campus.

The Campus Office of Architects and Engineers accepted responsibility for site design, the site preparation contract award, and administration of the construction contract.

JPL representatives agreed to:

- (1) Provide a soils engineering investigation and a recommended foundation allowable load for the antenna.
- (2) Provide a design for the antenna foundation, and concrete pedestal, steel ladder, and access platform, based on the antenna manufacturer's interface drawings and load restraints.
- (3) Participate in the contractor proposal evaluations and the selection of the construction contractor, and oversee construction to assure compliance with drawings and specifications.

- (4) Measure and record the centerline orientation of the north and south anchor bolts with respect to true north by celestial survey (within 20 arc seconds).

The site construction bid packages were released in March 1979. The successful bidder, the Joseph Bass Co., La Jolla, California, began construction in April and completed the concrete antenna pedestal, installation of the mobile trailer-type housing, and electrical power connections on June 5, 1979.

3. Equipment Installation and Transfer to Operations

Scientific-Atlanta delivered the antenna and Direct Reception Terminal equipment to the site in June and completed installation during the first week of July. Hewlett-Packard and ESL delivered equipment and began installation of the Information Handling and Data Processing and Display Subsystems in mid-July. Installation and subsystem integration was completed on August 6 and was followed by a 30-day period of system tests and operational performance evaluations and operator training, which included the successful support of a ship experiment off the Southern California coast.

On October 12, 1979, the Satellite Remote Sensing Facility was formally dedicated at ceremonies conducted on the site.

SECTION III

FACILITY DESCRIPTION

A. GENERAL DESCRIPTION

The Satellite Remote Sensing Facility is a self-contained, independent structure located on the SIO campus adjacent to the NORPAX building. The system and all its subsystem components are housed within the main structure, with the exception of the 5.0-meter antenna, which is more permanently located on a concrete pedestal within a few meters of the main structure. The facility was designed to initially receive imaging data from three satellites: TIROS-N, NOAA-6, and NIMBUS-7. The facility can receive data directly from the satellites, or indirectly through magnetic tape exchange. The facility is capable of tracking satellite signals (L & S band) from 1650 to 1750 MHz and from 2200 to 2300 MHz. The analog tape transport is capable of recording and playback of either 2.54cm (1-in.) or 1.27-cm (1/2-in.) magnetic tape. The antenna is equipped with a conventional azimuth-elevation mount, employs a focal point feed, and is designed to operate in the open environment without a radome.

B. FUNCTIONAL DESCRIPTION

A block diagram of the facility is shown in Figure 3-1. The system is divided into a Direct Reception Terminal (DRT), Information Handling Subsystem (IHS), and a Data Processing and Display Subsystem (DPDS). Data communications lines to/from other locations were not utilized or equipped initially.

1. Direct Reception Terminal

The Direct Reception Terminal (DRT) consists of the tracking antenna, low-noise RF preamplifiers, a single-channel telemetry and tracking receiver, and a simple interface panel, which delivers the demodulated data to the Information Handling Subsystem. The DRT is specifically designed to track and receive telemetry data from the NIMBUS-7, TIROS-N, and NOAA series satellites, which transmit right-hand circularly polarized signals at S-band frequencies. The system-gain to system-temperature ratio (G/T) ratio is sufficient to enable high-quality reception and coverage.

A simplified block diagram of the DRT is shown in Figure 3-2. The antenna feed consists of five crossed dipoles located at the focal point of the parabolic reflector. The center element of the feed is located on axis and collects the spacecraft signal for telemetry data recovery. The other four elements are arranged off-axis to form a conventional monopulse feed for automatic tracking purposes.

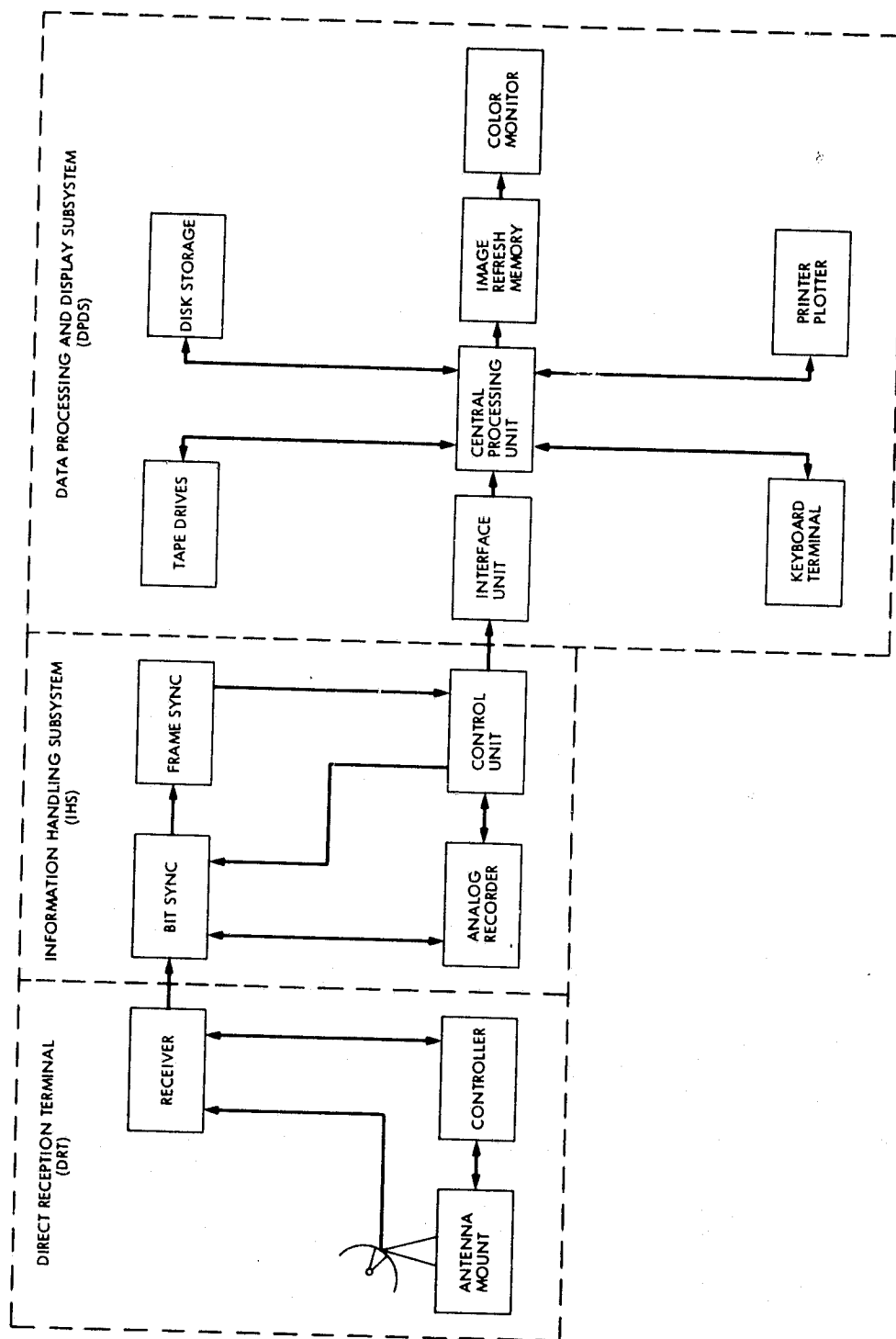


Figure 3-1. Satellite Remote Sensing Facility Block Diagram

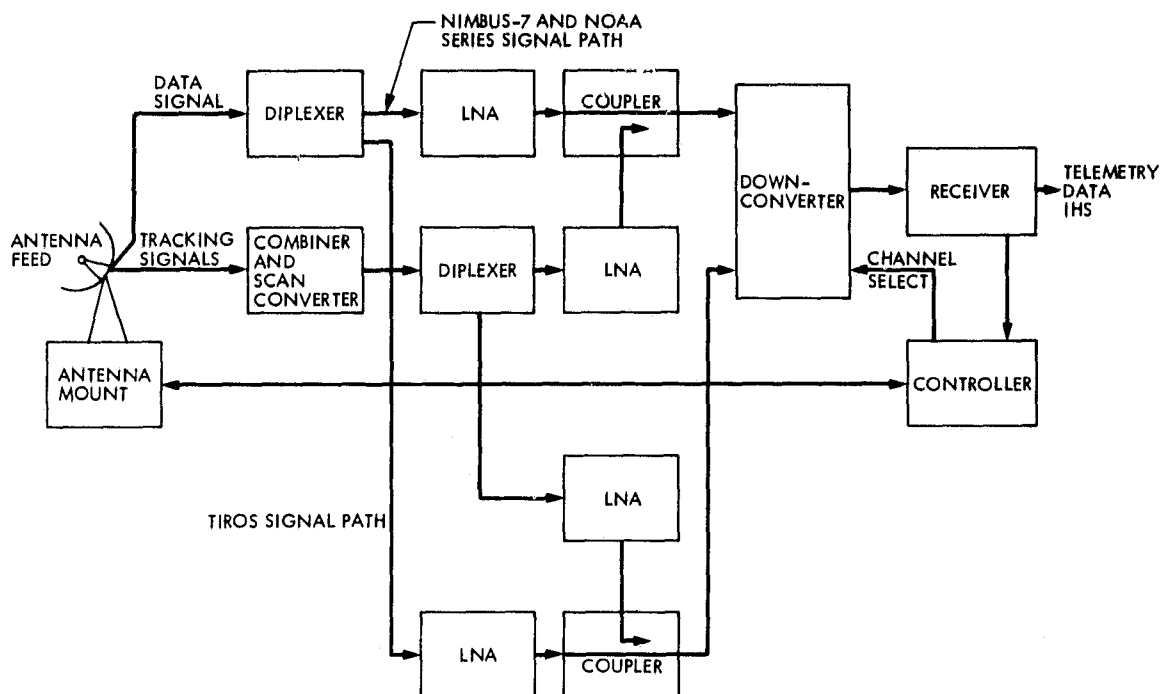


Figure 3-2. Direct Reception Terminal Block Diagram

Although the antenna feed is broad-banded and is capable of operation from 1650 MHz to 2300 MHz, the DRT is limited to the ranges of 1650 to 1750 MHz and 2200 to 2300 MHz due to low-noise-amplifier limitations. Specifically, the DRT is crystalized to operate at the TIROS-N and NOAA series frequencies of 1698.0 and 1707.0 MHz, and at the NIMBUS-7 frequency of 2273.5 MHz.

The parabolic reflector is 5 meters in diameter and is mounted on a conventional elevation-over-azimuth drive pedestal. At 2273.5 MHz, the gain of the antenna is 38.4 dB, while at 1698.0 and 1707.0 MHz, respectively, it is 36.1 dB and 36.2 dB.

Each low-noise-amplifier (LNA) is a GaAs field effect transistor (FET) device operating at ambient temperature with a noise temperature of about 110 Kelvins and a gain greater than 30 dB. The resulting G/T are 14.2 dB at 2273.5 MHz and 12.1 dB at 1707.0 MHz. These ratios were determined by a combination of measurements and calculations, and are for antenna elevation angles of 5 degrees above the local horizon.

The down-converter has two inputs, but provides only one output to the receiver. Basically, it consists of two mixer-amplifiers, three crystal oscillator-multiplier chains, and three coaxial transfer switches. This combination allows any one of the three incoming frequencies (2273.5, 1707.0, or 1698.0 MHz) to be down-converted to 288.5 MHz for tracking by the receiver. The receiver employs standard phase-lock techniques to acquire and track the incoming signal for telemetry data recovery. Since the desired data is biphase demodulated from the incoming signal carrier, a wideband phase demodulator is

employed to recover the baseband telemetry data for further processing in the Information Handling Subsystem. The receiver also contains phase detectors for demodulating the antenna error tracking signals to enable automatic antenna pointing for tracking the incoming satellite signals.

The controller performs all of the monitor and control functions of the DRT. It contains a microprocessor that enables the DRT to operate in a completely unattended mode. The unit is capable of predicting satellite passes, storing selected passes (up to ten) for tracking, and controlling the antenna track in a preprogrammed mode, in the autotrack mode, or in a combination mode. Two minutes prior to a selected pass, the controller checks out the antenna cable wrap-ups and positions the antenna at the predicted azimuth angle at the horizon in anticipation of receiving the signal. As the satellite rises, the antenna tracks it in the selected mode from horizon to horizon. Upon completion of a track, the antenna is put in the "stowed" position to await the next track.

Table 3-1 summarizes the DRT specifications.

2. Information Handling Subsystem

The Information Handling Subsystem (IHS) consists of a pulse-code modulation (PCM) bit synchronizer, two frame format synchronizers, an analog tape recorder and a buffer control unit. The IHS is specifically intended to format-synchronize telemetry data from the NIMBUS-7, TIROS-N and NOAA series satellites and buffer the data for further processing in the DPDS. All of the components of this subsystem are under remote programming and control from the DPDS central processing unit (CPU) via the buffer control unit. Local programming and manual operation of the components are available via front panel controls.

A simplified block diagram of the IHS is shown in Figure 3-3. Three main functions are performed by the IHS: (1) data transfer from the DRT or the analog recorder to the buffer memory via bit and frame synchronizers; (2) data transfer from the buffer memory to the CPU of the DPDS; (3) data transfer (initialization and control) from the CPU to the bit synchronizer, the NIMBUS frame synchronizer, and the analog recorder tape transport. The baseband data, from either the DRT or the analog recorder, goes into the bit synchronizer where phase-locked loop techniques are employed to enable reconstruction of the PCM data stream. The synchronized, reconstructed data is converted to NRZ-L and BIØ-L data streams with an accompanying coherent quadrature clock and sent to the frame synchronizers for format synchronization. The reconstructed PCM data is also available to the analog recorder for temporary or permanent storage.

Two frame format synchronizers are employed: one for the NIMBUS format and the other for the TIROS-N and NOAA series format. The formatted data is sent to the buffer control unit for buffering until requested by the CPU of the DPDS. The control and status monitoring of the IHS components is done by the CPU via the buffer control unit.

Table 3-2 summarizes the IHS specifications.

Table 3-1. Direct Reception Terminal Specifications

G/T	14.2 dB	2273.5 MHz
	12.1 dB	1707.0 MHz
Antenna		
Type	Parabolic reflector with focal point feed	
Diameter	5.0 meters	
Gain (nominal)	38 dB	2300 MHz
	36 dB	1700 MHz
Feed	Five crossed dipoles in a monopulse arrangement	
Polarization	Right circular polarization (RCP)	
Mount	Elevation over azimuth	
Travel	0 to 90 deg el within 270 deg az	
Tracking modes	Automatic, programmed	
Frequency range	1650 to 2300 MHz (nominal)	
TIROS-N and NOAA Series	1698.0 MHz, 1707.0 MHz	
NIMBUS-7	2273.5 MHz	
Receiver		
Type	Phase-locked loop	
Loop bandwidth	30, 100, 300, 1000 Hz	
IF bandwidth	3.3 MHz, 5 MHz	
Telemetry output	PM data, 4V p-p (nominal), 75-ohm load	
Telemetry BW	20, 50, 100, 200, 500, 1000 kHz	
Selectable		
By-pass	10 Hz to 1 MHz	

Table 3-1. Direct Reception Terminal Specifications (Continuation 1)

Autotrack	
Type	Single channel
Output	AM video signals
Controller	
Operation modes	Standby, Manual, Auto, Remote
Status indicators	Digital antenna position display (azimuth, elevation), servo error meter
Inputs	Track receivers drive, manual and digital position commands
Outputs	Dc drive signals, position display, mode status

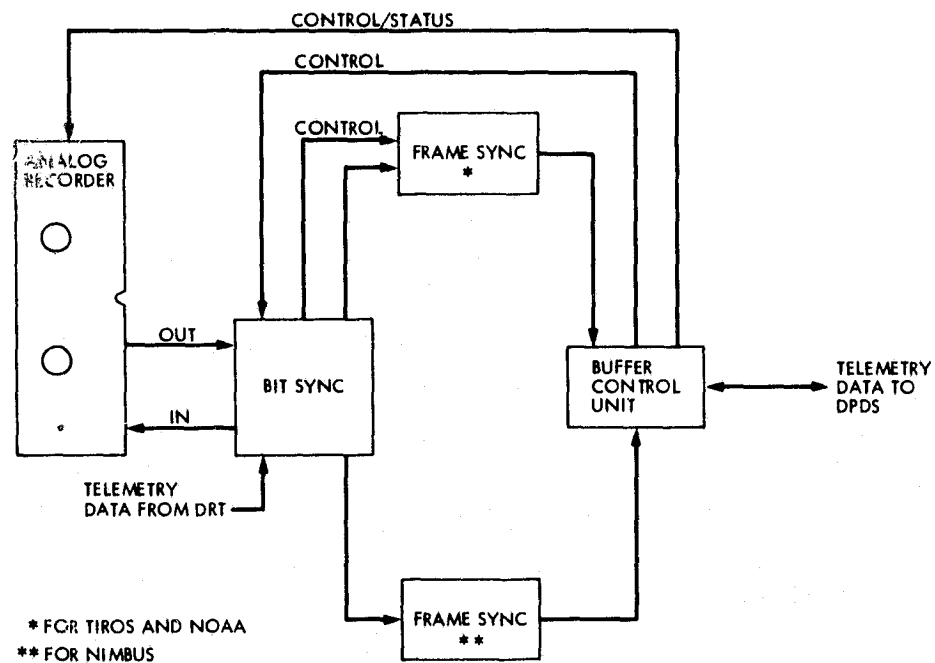


Figure 3-3. Information Handling Subsystem Block Diagram

Table 3-2. Information Handling Subsystem Specifications

Bit synchronizer

Control	Local and computer
Inputs (2)	Biphase modulation (level, mark, space)
Input level	1.0-V nominal
Bit rate	1 bit/s to 5 mbit/s
Outputs (2)	Serial NRZ-L and 0-deg clock
Loop bandwidth	Selectable: 0.1, 0.5, 1.0 or 2% of selected bit rate

Format synchronizers (2)

TIROS-N and NOAA series	PCM high-resolution picture transmission (HRPT) data format
NIMBUS-7	Zonal Information Processor (ZIP) data format Digital Information Processor (DIP) data format

Analog Recorder

Tape width	1.27 cm (0.5 in.) or 2.54 cm (1 in.)
Record/reproduce head	7- or 14-track IRIG
Transport speeds	38.1, 76.2, 152.4, and 304.8 cm/s (15, 30, 60, and 120 in./s)
Data electronics	Direct record/reproduce
SNR	20 dB
Flutter (IRIG specification)	0.1% 304.8 cm/s (120 in./s)
Bandwidth	
152.4 cm/s (60 in./s)	400 Hz to 1.0 MHz
304.8 cm/s (120 in./s)	400 Hz to 2.0 MHz

3. Data Processing and Display Subsystem

The Data Processing and Display Subsystem (DPDS) is essentially a custom configuration of a commercially available image processing system. The system, Interactive Digital Image Manipulation System (IDIMS), is manufactured by ESL, Inc., and is centered around a Hewlett-Packard Model 3000-II general-purpose computer with 256 kilowords (16 bits per word) of main memory. A color CRT monitor working in conjunction with a special-purpose digital storage/display refresh memory is the primary data display device. Character and graphical data can be displayed on an electrostatic printer/plotter. A block diagram of the DPDS is shown in Figure 3-4.

The function of the DPDS is to accept raw telemetry data from the IHS, coming either directly from a satellite or from a magnetic tape copy of the data, perform any of a number of possible computations, and display the processed data to the investigator. The DPDS is also capable of storing and retrieving intermediate, partially processed data on computer compatible tape and on digital disk.

Along with the central processor, the subsystem includes two disk drives for bulk data storage (HP Model 7925). Each drive accepts a removable disk pack storing 120 megabytes. There are three tape drives; one operating at a density of 2 kbit/cm (800 bit/in.) (HP Model 7970B) and two drives each capable of operating at 4 and 15.6 kbit/cm (1600 and 6250 bit/in.) (Telex Model 66).

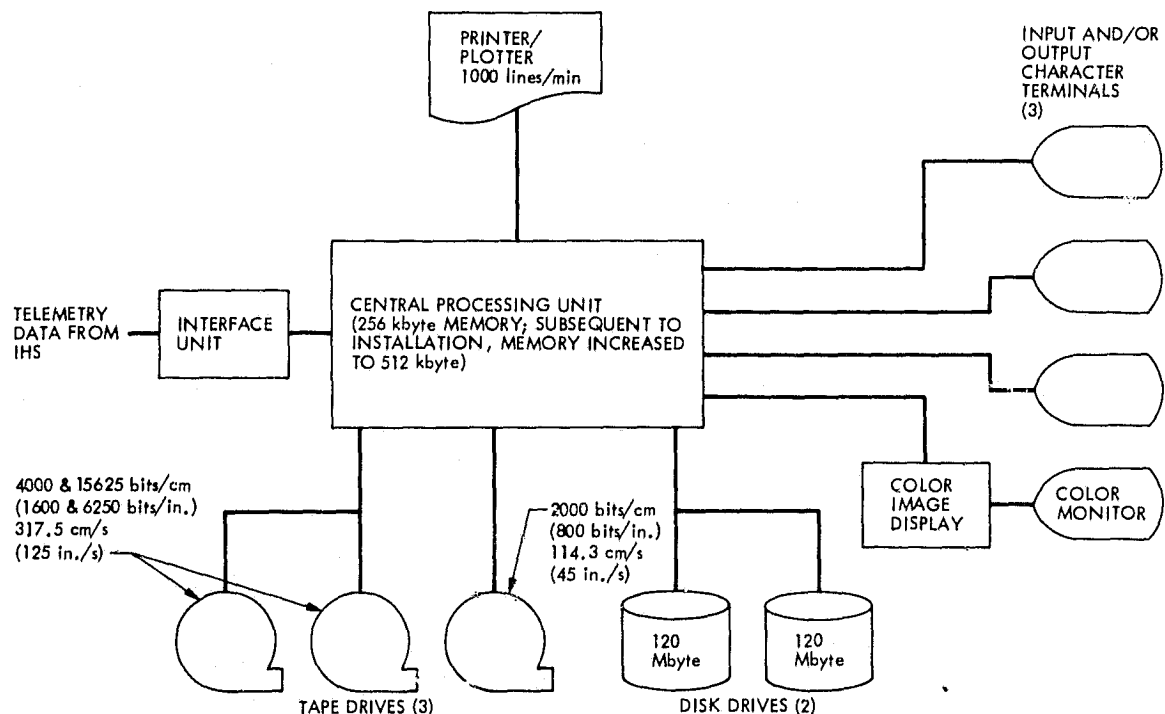


Figure 3-4. Data Processing and Display Subsystem

The electrostatic printer/plotter (Versatec Model 1200A) produces 1000 lines per minute and graphical data at a density of 500 points/cm (200 points/solidus in.) Three character terminals with CRT displays operate at 240 characters per second. One user can enter image processing commands while additional users are performing program development, text file editing, etc.

The color image display (DeAnza Model 5532) stores up to four 512×512 images of 8-bit pixels, plus four 512×512 graphic overlays of 1-bit pixels. Any three of the stored images can be directed to the three-color inputs of the color CRT monitor, generating a visual color image of the stored data. The display system has flexible internal data manipulation including zoom, scroll, roam, look-up tables, and limited arithmetic capability. A trackball device controls the position of a visual cursor target on the screen; the cursor position can be interrogated or modified by the computer.

The computer software running on the system includes the HP MPE-III operating system, the ESL IDIMS executive, the standard IDIMS library of image processing routines, and special programs written for satellite oceanography applications. A telemetry logging program accepts telemetry data from the IHS, displays it on the monitor, and records it on disk storage. The earth coverage of scanners on the NIMBUS-7, TIROS-N, and NOAA series satellites is determined and displayed in graphical form. This software schedules execution of the logging program to record required data at the correct time. There is a program to convert the raw telemetry data to IDIMS standard internal data format for subsequent processing by the standard IDIMS routines. A list of the general processing functions and display control functions is provided in Appendix C.

REFERENCES

- 2-1. Maul, G., H. Gordon, S. Baig, M. McCaslin, R. DeVivo, An Experiment to Evaluate Skylab Earth Resources Sensors for Detection of the Gulf Stream, NOAA Technical Report ERL-AOML 23, pp. 69, 1976.
- 2-2. Smith, R. and K. S. Baker, The Bio-Optical State of Ocean Waters and Remote Sensing, Scripps Institution of Oceanography, SIO Ref. 77-2, pp. 35, 1977.
- 2-3. Bernstein, R. L., L. Breaker, and R. Whritner (1977), "California Current Eddy Formation: Ship, Air, and Satellite Results," Science, Vol. 195, pp. 353-359.
- 2-4. Logeckis, R., "Long-Waves in the Eastern Equatorial Pacific Ocean; a View From a Geostationery Satellite," Science, Vol. 197, pp. 1179-1181, 1977.
- 2-5. Strong, A. E. and R. J. DeRycke, "Ocean Current Monitoring Employing a New Satellite Sensing Technique," Science, Vol. 182, No. 4111, pp. 482-484, 1973.

APPENDIX A

SATELLITE FACILITY WORKING GROUP DESIGN

RECOMMENDATIONS

The design of this facility is the product of the combined efforts of a number of individuals at Scripps Institution of Oceanography, the Navy Ocean Systems Center in San Diego, and the Jet Propulsion Laboratory:

Robert Bernstein, Scripps Institution of Oceanography
N. A. Renzetti, Jet Propulsion Laboratory
R. H. Evans, Jet Propulsion Laboratory
S. S. Kent, Jet Propulsion Laboratory
J. B. Seidman, Jet Propulsion Laboratory/Image Processing Lab
Norman Ortwein, Navy Ocean Systems Center
Ben McGlamery, SIO/Visibility Lab

This group met intensively over the two-month period January and February 1978, and traveled to NASA centers at Moffett Field, California, and Greenbelt, Maryland, and to the Spaceflight Tracking and Data Network site at Goldstone, California. Existing NOAA/NASA arrangements for handling TIROS-N, NIMBUS-G, and SEASAT-A data were carefully reviewed with personnel in those project offices to seek ways of connecting the SIO facility to these data streams. Since much of the data is in image form, a variety of image processing hardware and software systems was reviewed, and several commercial firms were visited. Evaluation tests were performed employing Ocean Color Scanner data from U-2 aircraft. Discussions were held with representatives of several tracking antenna manufacturers, and with RCA/American (Domestic Satellite Communications).

From this mix of activity and consideration of trade-offs, a firm design for the facility has emerged. It will consist of:

- (1) A 5.0-meter-diameter tracking antenna system with associated equipment for data acquisition. Support is requested from NASA for this portion, in the form of either a long-term loan of an existing system that meets specifications, or monies adequate to purchase a new system. In addition, support is requested from NASA to enable JPL to provide a man-year of cognizant engineering support for this system.
- (2) A commercial turnkey image processing system, the I²S system 101, based around an Hewlett/Packard 3000-II computer. The H/P 3000 will be dedicated to the processing of all satellite data coming into the facility via the antenna, and through telephone lines and magnetic tape exchange. Processing tasks exceeding its capability will be transferred to other systems, most importantly the proposed PRIME 500 to be housed at the Institute of Geophysics and Planetary Physics.

The delivered system cost is \$340,000. Support is requested for this portion from ONR, using the presently pledged \$200,000 in FY78 funds from Codes 480 and 460, combined with a commitment of \$140,000 in FY79 funds as an acceleration of the SIO ONR Omnibus contract.

Maintenance and operation of the facility during its first two years are estimated to require three man-years per year, plus maintenance and expendables for a total cost of \$200,000 per year. Support will be

requested from the NSF/Oceanographic Facilities Support Office and the State of California through the proposed University of California Space Institute.

Figure A-1 is a block diagram of the four major systems composing the facility, each of which, in turn, is expanded to show the basic subsystem components.

The facility will be designed to handle several users simultaneously. Thus the following list might represent activities in progress at any point in a given day:

- (1) User A sits at a simple data terminal, examining a catalog of satellite passes previously collected and available in the data library; he also examines predicted pass locations coming up in the next few days. The user decides to enter a particular request for data into a scheduler routine for the following night.
- (2) A previously made request for data by another user B is being collected via the tracking antenna, and stored on mag tape for subsequent examination.
- (3) User C, sitting at the high-quality color display monitor, reviews previously collected image data and applies image processing and other applications routines.
- (4) User D at another simple data terminal is connected by phone line to FNWC and extracts low-rate SEASAT data.
- (5) User E at another data terminal debugs a new applications routine.

Facility capabilities may be expressed another way, in that a single user over the space of several days may have sessions on the facility that concentrate on a sequence similar to that above. Satellite data collection is requested, performed, and the data is examined and compared with other satellite and conventional ship data. A need for a new ad hoc routine is identified, written, debugged, and applied to the data to obtain a result and complete the analysis sequence. The user can stop work in any session, store the intermediate results, and pick up where he left off at the next session.

The working group is confident that the recommended design would produce a facility with the above capabilities, and that future increased investigator demand for use of the facility could be satisfied through simple additions (such as an array processor or a second color display device) rather than through a completely new design.

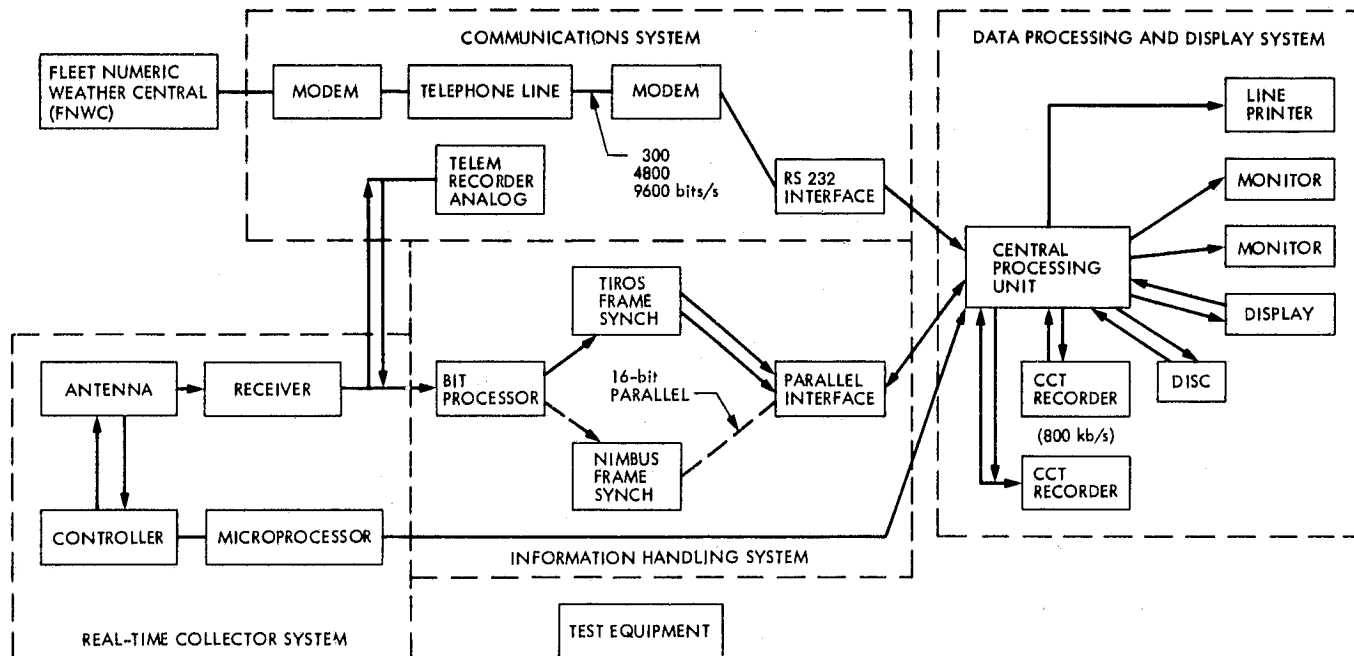


Figure A-1. Remote Sensing Facility Block Diagram

APPENDIX B

SIO PROJECTED REMOTE SENSING FACILITY

USAGE

The pending launch of three ocean-observing satellites, SEASAT-A, TIROS-N, and NIMBUS-G, is attracting the attention of the oceanographic community, and many groups here and elsewhere are preparing to use data from these satellites. The initial work is directed toward understanding the new instruments, but the ultimate goal is to apply them to solving oceanic problems.

At Scripps, the groups who show interest in using satellite data include the NORPAX Program, the California Cooperative Fisheries Investigation, the Climate Program, and the Visibility Laboratory; and already within Scripps various individuals are deeply involved with the development of the satellites.

At the Scripps Visibility Laboratory, under the direction of Jim Harris, several investigators including Rosswell Austin, Ray Smith and Wayne Wilson are presently funded to do research with the NIMBUS-G color scanner, and the variability of ocean color and its relationship to chlorophyll and biological productivity. The Vislab has developed significant capabilities for measuring ocean radiances and correcting for atmospheric effects. In addition, the Vislab maintains a level of expertise in image processing, which is a critically important aspect for much satellite data processing and information extraction.

At Scripps, many investigations take place in the California Current System. The routine hydrographic and biological surveys of the CalCOFI program make conventional data collection easier to accomplish. It now appears that CalCOFI intensive surveys may be performed every year (instead of the recent practice of every third year). Joe Reid is planning renewed experimental interest in the California Current using hydrographic surveys and drifter deployments, and is presently adding two research oceanographers to aid him in this task.

The Food Chain Research Group under R. W. Eppley is an eight-man team involved in a continuing study of the biological oceanography off California. Their phytoplankton studies may be strongly influenced by NIMBUS-G ocean color information.

Walter Munk is leading a research group in developing long-range acoustic transmissions to measure temperature and current along the sound paths. There are major experiments planned for 1978 and 1979 in the California Current. Detailed conventional measurements will be made by ships to provide verification of acoustic results, which may show variations induced by passing mesoscale eddies. Satellite infrared remote sensing data are being employed to simultaneously study these features.

Robert Stewart has for many years been using radio scatter to study the sea surface. His work in this area led him to become a member of the SEASAT-A Science Steering Group and the Synthetic-Aperture Radar team. This year he plans experiments to verify the performance of the SAR, and to characterize the ability of the Scanning Multifrequency Microwave Radiometer to measure oceanic rainfall. Eventually, he hopes to map rainfall over the Pacific for studies of climate, the propagation of microwave signals, and atmospheric dynamics.

Carl Friehe and Douglas Inman are active, funded investigators for the NASA/SEASAT West Coast Experiment, which took place last spring. Aircraft versions of the SEASAT-A instruments were flown repeatedly off Southern California to improve interpretation of the remote sensing data. The X-band and L-band imaging radars appear to be promising sensors for the measurement of high-resolution wave directional spectra. Directional wave measurements in the region west of the borderland islands off Southern California would enhance the usefulness of the existing measurements of energy spectra for the predication of constant wave conditions. Douglas Inman, Clint Winant, and Russ Davis also anticipate the use of wind, sea surface temperature, surf zone color, and surface wave height measurement as background environmental data for their coastal studies.

Robert Pinkel continues his research on internal wave generation in the deep water off California. A major internal wave experiment is being proposed for early 1979. Recent work by Apel (Reference B-1) and by Fett and Rabe (Reference B-2) show that internal wave detection is possible from spacecraft sensors.

Robert Bernstein maintains a strong interest in the bottom topographic forcing of currents and internal instability mechanisms that may generate mesoscale eddies. During 1979, work is proposed to study the influence of the Cape Mendocino Ridge, in collaboration with Bob Smith, OSU, and J. J. O'Brien, FSU. Satellite infrared data were first to point out the strong role topographic forcing exerts there.

Scripps is engaged in a major effort to expand its research in the study of climate, with special emphasis on the role the ocean plays in affecting climate variability. Jerome Namias, Tim Barnett, and John Roads are in the SIO Climate Research Group. The NORPAX project is administratively based at SIO, with major field activities underway in the tropical and mid latitude North Pacific focused on short-term (1 to 5 years), ocean-atmosphere interactions. Charles Keeling and others have worked for many years examining the climatic influence of increasing concentrations of man-made carbon dioxide in the atmosphere, and the ocean's role as a buffer. Accurate and global remote sensing of sea surface temperature, wind and current must invariably have a profound influence on all ocean and climate related research.

The above list of research interests is not intended to be total and comprehensive. It is representative of the mix of continuing activities at Scripps, in which students and faculty are engaged, many with strong field activity aspects.

To complement these oceanographic interests, Scripps looks to remote sensing scientists at JPL to aid in developing methods for extracting oceanographic information from the data. Moustafa Chahine has developed techniques for handling infrared data (Reference B-3) to extract more accurate sea surface temperatures, air-sea temperature differences, and other atmospheric parameters. J. Waters and E. Njoku have concentrated on microwave radiometry. Charles Elachi (Reference B-4) and Omar Shemdin have continuing activities in the interpretation of imaging radar.

Finally the SEASAT-A project at JPL is establishing an algorithm development facility (ADF) there to explore various methods for processing the sensor data from that spacecraft. The SIO remote sensing facility will be connected to it via a telephone Link. The ADF and the programmers who maintain it should serve a very useful role permitting SIO and JPL investigators to interact effectively.

Discussions with the above JPL investigators have included the desirability of having mutually supported graduate and post doctoral students, with individuals spending extended periods of time in both institutions. The ADF will be invaluable for this purpose. The hoped-for outcome will be students who then have strong educational backgrounds in both remote sensing and oceanography.

REFERENCES

- B-1. Apel, J. R., H. M. Byrne, J. Prioni and R. Charnell,
"Observations of Oceanic Internal and Surface Waves From the
Earth Resources Technology Satellite," J. Geophys. Res., Vol. 80,
No. 6, pp. 865-871, 1975.
- B-2. Fett, R. and K. Rabe, "Satellite Observation of Internal Wave
Refraction in the South China Sea," Geophys. Res. Lett. Vol. 4,
No. 5, pp. 189-191, 1977.
- B-3. Chahine, M. T., H. H. Aumann, and F. W. Taylor, "Remote Sounding of
Cloudy Atmospheres. III. Experimental Verifications," J. Atmos.
Sci., Vol. 34, No. 5, pp. 758-765, 1977.
- B-4. Elachi, C., T. W. Thompson and D. King, "Ocean Wave Patterns
Under Hurricane Gloria: Observation With an Airborne Synthetic
Aperture Radar," SCIENCE, Vol. 198, pp. 609-610, 1978.

APPENDIX C

SIO SATELLITE REMOTE SENSING FACILITY

ENGINEERING SPECIFICATION

CONTENTS

1.0	INTRODUCTION -----	C-3
1.1	PURPOSE OF DOCUMENT -----	C-3
1.2	OBJECTIVE OF THE FACILITY -----	C-3
1.3	BACKGROUND -----	C-3
1.4	FACILITY DATA REQUIREMENTS -----	C-3
1.5	FACILITY DESCRIPTION -----	C-4
1.6	DELIVERABLES -----	C-5
2.0°	FACILITY SUBSYSTEMS SPECIFICATIONS -----	C-6
2.1	DIRECT RECEPTION TERMINAL SUBSYSTEM -----	C-6
2.2	INFORMATION HANDLING SUBSYSTEM -----	C-7
2.3	DATA PROCESSING AND DISPLAY SUBSYSTEM -----	C-10

1.0 INTRODUCTION

1.1 PURPOSE OF DOCUMENT

This document provides a technical specification of the proposed Scripps Institution of Oceanography Satellite Remote Sensing Facility. This specification provides a detailed description of all aspects of the facility, except for its Direct Reception Terminal (DRT), which may be found in a separate document.

1.2 OBJECTIVE OF THE FACILITY

The Scripps Satellite Remote Sensing Facility will provide for applications of satellite remote sensing data to serve a wide range of oceanographic investigators at Scripps and other institutions. The facility will receive remote sensing satellite data both directly from a Direct Reception Terminal (DRT), and indirectly by magnetic tape exchange and special common carrier communications links.

Immediate emphasis will be on receiving and processing remote sensing data from the TIROS-N, NIMBUS-G, and SEASAT-A missions of the multispectral ocean emissions and reflectances covering the visible, infrared, and microwave portions of the spectrum. Most important is the near-real-time aspect, permitting investigators to direct ships and aircraft to allow immediate verification of satellite-derived analyses and follow up with more detailed on-site experiments.

1.3 BACKGROUND

Several investigators at Scripps presently are involved in the interpretation of ocean remote sensing signatures from existing aircraft- and satellite-borne sensors. The volume and diversity of available data will increase dramatically during 1978. A facility is required that will provide timely access to these new data and provide processing capabilities for handling them. A flexible facility is required that will be operated by and for researchers, that is relatively straightforward to work with, and that actually encourages students and faculty to begin to utilize remotely sensed information.

1.4 FACILITY DATA REQUIREMENTS

1.4.1 DATA TYPES

A broad multispectral array of sensors producing oceanographically useful data will be distributed over the

scheduled polar orbiter satellites NIMBUS-G, TIROS-N, and SEASAT-A. The specific data of interest are accumulated in 8- to 10-minute passes over the California coast:

- a. NIMBUS-G Coastal Zone Color Scanner (CZCS) data.
- b. TIROS-N Advanced Very High Resolution Radiometry (AVHRR) data, as well as data from all other instruments aboard the spacecraft.
- c. SEASAT-A Scanning Multichannel Microwave Radiometer (SMMR), Scatterometer, and Radar Altimeter (ALT) data.

1.4.2 DATA ACCESS METHOD

Direct access to most of the above sets of data through a radio frequency antenna receiving and tracking systems is the preferred data receiving path. Direct transmission from the given satellite is the best means for insuring timely receipt of data in its original form. This capability is provided by the DRT.

Alternate methods of receiving data are:

- a. Real-time transfer of digital data over common carrier communications links from NASA/NOAA Tracking and Data Acquisition Network Stations.
- b. Near-real-time transfer of computer-compatible data from NASA/NOAA related Mission/Project Operations and Control or Processing Centers over common carrier communications links.
- c. Nonreal time via timely transfer of analog-baseband or computer-compatible tapes from a data acquisition facility having magnetic tape exchange interface.

1.5 FACILITY DESCRIPTION

The facility consists of five subsystems (Figure C-1):

- a. Real-time data collection subsystem, the DRT.
- b. Information handling subsystem (bit and frame synchronizers, magnetic tape recorders).
- c. Communications subsystem (interfaces and modems to telephone lines, teletype system).
- d. Data Processing and Display subsystem (computer and standard peripherals, image display processor).

e. Control subsystem.

Each of these subsystems is described in Section 2.0, with the exception of the DRT, which is described in a separate document.

1.6 DELIVERABLES

1.6.1 The following items are deliverable under this contract:

1. The hardware, as required:
Card extender boards for each style of otherwise inaccessible circuit board. Any other diagnostic hardware needed other than standard items such as voltmeters and oscilloscopes (may be priced as an option).
2. Physical planning data for the hardware:
 - a. Physical size of each box.
 - b. Required clearances beyond box for maintenance areas.
 - c. Power required: voltage, phase, current, connector.
 - d. Heat dissipation in BTU/h. Maximum ambient air temperature. Special ducting if required.
 - e. Cleanliness.
 - f. Other requirements.

Physical planning data should be delivered at least 2 months prior to delivery to allow time for site preparation.

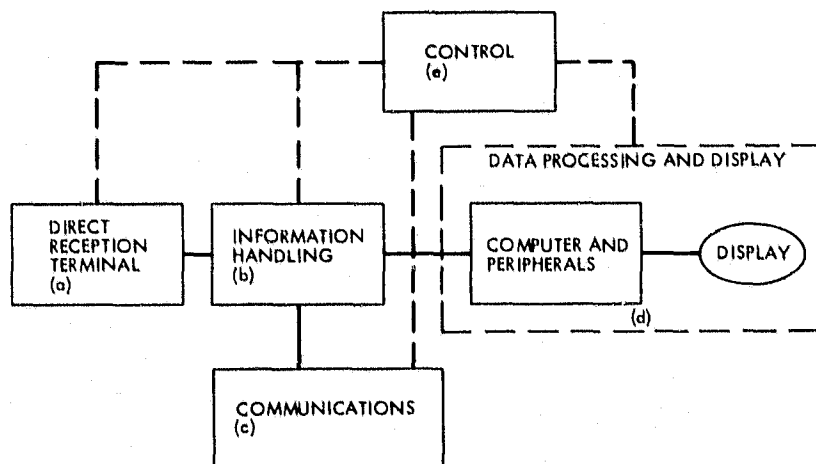


Figure C-1. Remote Sensing Facility Subsystem Block Diagram

3. Documentation on all hardware (2 copies):
 - a. Manual(s) covering operation and maintenance of each piece of equipment, including:
 - Initial set-up
 - Normal operation
 - Calibration
 - Diagnostic tests
 - Theory of operation
 - Preventive maintenance
 - b. Complete drawings:
 - Schematics
 - Logic diagrams
 - Power wiring
 - Wire lists
 - Layout diagrams for circuit boards
 - Mechanical layout and assembly.
4. Program Documentation (Mandatory for all except operating system; desirable for operating system):
 - User guides for each program (10 copies).
 - Programmer's guide, including flowcharts and theory of operations, equations, etc. (2 copies).
 - Source code in machine readable form and listings, with instructions for converting source code to executable code.
5. Software (delivered in executable form, ready to use on disk, or on tape dump of disk):
 - a. Software as required.
 - b. Diagnostic software for checkout and maintenance of hardware.
6. Test and acceptance procedure. The successful bidder must provide a detailed test and acceptance procedure for review and written approval within 60 days after the award date of this contract.
7. On-site installation, checkout, and written certification.

2.0 FACILITY SUBSYSTEMS SPECIFICATIONS

2.1 DIRECT RECEPTION TERMINAL SUBSYSTEM

This subsystem is described in Appendix D.

2.2

INFORMATION HANDLING SUBSYSTEM

The information handling subsystem refers to those functions associated with interconnection of information channels, interfaces, analog tape recorders, a PCM bit synchronizer, two PCM format synchronizers and the necessary equipments to permit interfacing to the CPU of the data processing computer. Figure C-2 is a simplified block diagram depicting the major assemblies and showing the direction of data flow. Specifications are given in Table C-1.

2.2.1

ANALOG RECORDER

The recorder must be capable of recording and reproducing PCM (BIΦ-L) telemetry data at a level of 3 V p-p and at the following rates:

NIMBUS-G	800 kbit/s
TIROS-N	665.4 kbit/s
SEASAT-A	25 kbit/s

The recorder must meet standard IRIG performance requirements while operating in the wideband, direct-record, and reproduce modes. The unit shall be capable of recording and reproduction using standard IRIG 1.27-cm (0.5-in.) tape employing 7 track heads. It must also be capable of reproducing data from IRIG standard 2.54-cm (1-in.) tape employing a 14 track head. No more than 3 tracks will be used for data recording/reproduction; however, any 3 of the 7/14 tracks may be used. Remote/preprogrammed operation of the unit is required. The recorder will include digital programmable control of all tape recorder functions and capability for external loading of program instructions through a standard interface. Change over from 1.27- to 2.54-cm (0.5- to 1-in.) tape capability shall be accomplished in 30 minutes or less.

A typical record time interval will be 15 minutes of data.

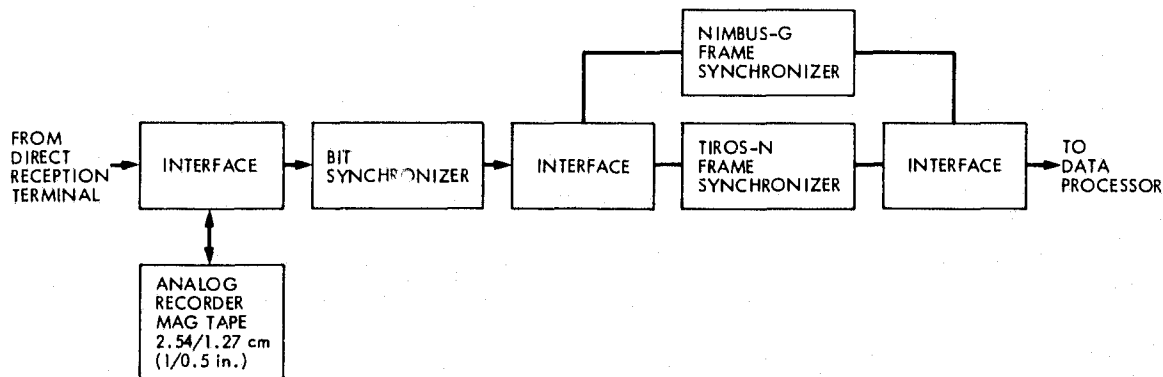


Figure C-2. Information Handling Subsystem

TABLE C-1.

INFORMATION HANDLING COMPONENT SPECIFICATIONS

Bit Synchronizer:	
Control	Local and computer
Inputs (2 each)	BI ϕ - L/H/S
Bit Rate	1 bit/s to 5 Mbit/s
Outputs (2 each)	Serial NRZ-L and 0-deg clock
Loops BWs	Selectable: 0.1, 0.5, 1.0 or 2.0% of selected bit rate

Format Synchronizers (2 required):

1.	TIROS-N	PCH HRPT data format
2.	a. NIMBUS-G	CZCS DATA FORMAT
	b. SEASAT-A	Real-time data format

Analog Recorder:

Tape Width	1 and 0.5 in.
Record/Reproduce Head	7 and 14 Track IRIG
Transport	15, 30, 60, 120 in./s
Data Electronics	Direct record/reproduce
Record/Reproduce	7 and 14 tracks (2 servo)
Bandwidth	400 Hz to 2 MHz
	120 in./s
SNR	20 dB
Flutter (IRIG SPEC)	0.1% at 120 in./s
Speeds	15, 30, 60, 120 in./s
Bandwidth	
152.4 cm/s (60 in./s)	400 Hz to 1.0 MHz
304.8 cm/s (120 in./s)	400 Hz to 2.0 MHz

Interfaces:

Provide required interfaces between the subsystem input, the bit synchronizer, the format synchronizers, and the CPU of the main data processing computer for "On-Line" data gathering and "Off-Line" format programming.

Input Interface:

Number	2 (selectable)
Type	coax
Impedance	75 ohm
Level	0.1-5 V p-p
(Note: up to one mile of coaxial cable will connect DRT to input interface. Purchase and installation of this cable is NOT part of this contract.)	

Output Interface:

Number	2 (in parallel)
Type	coax
Impedance	50 ohms
Level, adjustable	1-3 V p-p

2.2.2

PCM BIT SYNCHRONIZER

The PCM Bit Synchronizer shall accept the detected data (PCM BI ϕ -L codes) from the DRT and reconstruct the data to within 1 dB of its ideal error probability ($SNR \geq 0$ dB). It shall produce a reconstructed data stream in NRZ-L code format along with a coherent 0-deg clock for driving PCM format synchronization equipments. Two outputs each shall be provided for the data stream and the clock.

It is desirable to have a bit rate capacity for all PCM standard codes from 1 bit/s to 5 bit/s. Acquisition shall reliably occur on input signals with $SNR \geq 0$ dB and within 5% of bit rate. Acquisition time shall be within 100 bit periods for signals with 50% transition density and $SNR \geq 5$ dB. (SNR = peak signal to rms noise, where the noise reference bandwidth equals half the bit rate.)

The unit shall be capable of local and external computer control with program storage capability to enable off-line programming.

2.2.3

PCM FORMAT SYNCHRONIZERS

The output of the PCM Bit Synchronizer shall be formatted to agree with the original transmitted format. The formatting data is listed in Table C-2.

It is anticipated that two format synchronizers will be required: 1 for TIROS-N, and 1 for NIMBUS-G and SEASAT-A. The unit for TIROS-N can be fixed programmed to synchronize and decommutate the HRPT Format, as well as the TIP format. The other unit shall be capable of local and computer control with program storage capability to enable off-line programming.

Outputs are:

TIROS-N:

AVHRR	10-bit parallel, start, stop, and word rate timing signals
TIP	16-bit parallel, start, stop, and word rate timing signals
Bit errors	up to 1023 bit errors per sample period of 10^6 bits.

NIMBUS-G and SEASAT-A:

DATA	Word serial NRZ-L; 1 to 10 bits; LSB aligned
ID	Word and frame numbering in binary
STATUS	Sync mode bit slip; frame time. Subframe sync mode and subframe Time supplied with subframe feature

Program verify Multiplexed 8-bit output of register contents.

2.3 DATA PROCESSING AND DISPLAY SUBSYSTEM (DPDS)

The function of the DPDS is to accept raw telemetry data from the Information Handling Subsystem (coming either from the Direct Reception Terminal, or from a recorded magnetic tape copy of the data), perform any of many possible computations on the data, and finally display the processed data to the investigator. Since most data will represent pictures, the standard form of display will be a high-quality color CRT monitor. Other data displays available will be CRT character displays (terminals), a plotter suitable for line drawings and graphs, and a line printer. To add to its flexibility, the DPDS will be able to store and retrieve intermediate, partially processed data on both computer-compatible magnetic tape (CCT) and on digital disk. The heart of the DPDS will be a modern computer CPU capable of rapid computations on data elements which may be 8- or 16-bit integers, or 32-bit floating point (real) numbers.

2.3.1 HARDWARE

Figure C-3 shows a block diagram of the DPDS.

Central Processing Unit:

The CPU will be a general purpose computer CPU with hardware for address relocation (memory mapping). No other specific requirements are placed on the CPU except as implied by other requirements.

TABLE C-2.

FORMAT DATA

Parameter	PROJECT		
	NIMBUS-G	TIROS-N	SEASAT-A
Bit Rate, kbit/s	800	665.4	25
Bits/word	8	10	8
Minor frame			
Words	825	11,090	124
Rate, words/s	121.2121	6	25.2016
Major frame			
Words	12,375	33,270	3100
No. of Rate words/s	8.08081	2	1.0081
minor frames	15	3	25

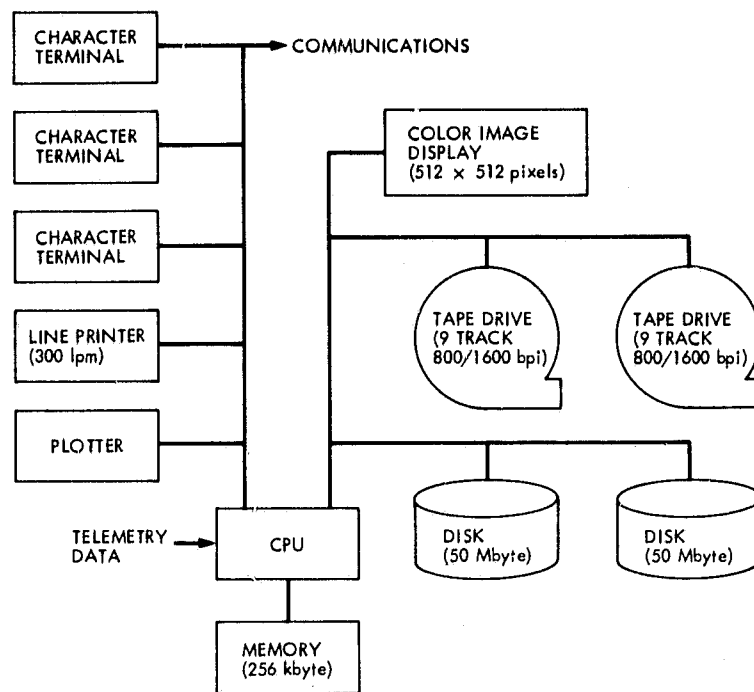


Figure C-3. Data Processing and Display Subsystem Hardware Block Diagram

Memory:

A minimum of 256 kbytes of main memory is necessary to support the kinds of processing functions that will be performed, after allowing space for a general purpose operating system.

Disk:

Two disk drives of capacity 50 Mbytes each are provided for rapid, direct access data storage of raw and intermediate processed data. At least one of the drives will handle a removable disk pack, allowing each user to remove his own data when not using the system. The other disk drive, which need not be removable, will contain the software used by all users, including the operating system and general-purpose data processing software. Options providing for additional disk storage capacity will be of interest.

Tape Drives:

Two dual density (800 and 1600 bpi), 125 IPS tape drives are provided for bulk data storage and for interfacing with the outside world. Telemetry data received in real time will be stored on magnetic tape for later retrieval. Data or software received from or sent to other facilities or institutions are most efficiently put on magnetic tape. Finally, storage of large amounts of processed data is most economically done using magnetic tape. Two units are provided for redundancy, to allow tape copying, and to

support real-time data logging when the volume exceeds the capacity of one reel of tape. Options providing for replacement of one (or both) of the drives with a 6250/1600 bpi, 75-125 ips drive will be of interest and considered on the basis of cost and reliability.

Line Printer:

A 300-line/minute line printer is provided to produce permanent hard copy of character data at reasonable speeds. For example, a complete record of the data processing steps performed will be made on the line printer for later off-line reference. Complete listings of large amounts of numerical data may be produced. The development of software is facilitated by making complete listing of source code.

Character Terminal:

Three character terminals are provided for computer users to interactively command the DPDS. Due to hardware limits, only one user will be able to perform image processing at any given time. However, it will be possible for up to two additional concurrent users to perform less demanding functions such as program development or text file editing or inspection. These terminals are of high speed (960 characters/s) and have CRT displays.

Plotter:

A plotter is provided for generating graphs or other line-drawing hardcopy output. The plotter will be either a pen plotter or an electrostatic raster plotter.

Telemetry Data:

The DPDS will have a direct interface to the satellite telemetry data. Details are covered in another section.

Color Image Display:

The DPDS will have the capability to display a color image (red-green-blue) on a high-resolution color CRT. The display will consist of a raster of 512 lines by 512 samples per line, with a diagonal screen size of 25 inches. The CRT will be refreshed at 30 frames per second from a dedicated solid-state digital memory. The refresh memory will be organized into 4 "video" channels of 512 by 512 pixels each, each pixel containing 8 bits. It will be possible to update the entire memory from the computer in 10 seconds. Any of the 4 channels may be selected under computer control to be displayed in black and white. Three of the 4 channels may be selected under computer control to be displayed in color, each channel corresponding to one of the three primary colors. Under computer control, it will be possible to select one of the 4 channels for color display using a "pseudo color" mode in which groups of the possible pixel values are mapped to unique colors. The color mapping function will be computer

controllable, independent of the data stored in the refresh memory. In addition to the color mapping function, there will be computer-controllable look-up tables at the output of each channel which will map the stored data to new arbitrary values before display.

In addition to the 8-bit video channels, there will be 4 graphics channels of 512 by 512 pixels each, each pixel containing one bit. Under computer control, any combination of graphics channels may be superimposed on the image delivered to any of the three CRT primary colors.

A cursor may be superimposed on the CRT display. The cursor is a small symmetric graphical position indicator. Its shape, visibility, and location are computer controlled. Its position is also controllable by means of the trackball. When the trackball is controlling the cursor position, the position may be read into the computer at any time.

As an adjunct to the display, a mechanical position controller (trackball) will be provided. Motion of the trackball can be read into the computer. Associated with the trackball will be several special function keys or buttons whose position can be read at the computer for control of special operations.

Options that enhance the capability of the display unit will be of interest and considered on the basis of cost. One such option would be the capability to provide a "feedback" loop on the refresh memory hardware.

Communications:

The DPDS will have communications interface for transmitting and receiving data directly to and from other facilities, through dial-up or dedicated telephone lines. Associated modems are not part of this contract.

2.3.2

SOFTWARE

Three types of software will be provided.

Operating System:

A general purpose multiuser operating system will control the computer. The operating system will provide to each of several users concurrent usage of "sharable" resources (disk, memory, CPU) and to protect each user's nonsharable resources (disk tracks, memory cells, tapes) from other users. The operating system will provide to each user an interactive computer system that appears as much like the basic hardware as possible, consistent with the sharing of resources. A rapid interactive response to user commands will be provided. A batch processing capability will also be available.

The operating system provides commonly used functions to all users: file management, language processors, utility programs, as well as an easy-to-use flexible command language for invoking these functions or other more special-purpose programs.

The operating system will also include a FORTRAN compiler, plus an assembler or its equivalent, to process symbolic code allowing control of all registers, memory locations, and input/output registers.

Image Processing Executive:

For maximum flexibility, the image processing software is modularized by being broken up into a number of "application programs," each performing a well-defined primitive function. A complete task is performed by invoking a specific sequence of such primitive functions or programs. An image processing executive is used to control the execution of the application programs, based on commands entered by the user. A flexible, easy-to-use control language is required, preferably including a macro facility allowing sequences of commands to be saved and later simply invoked with parameter substitution.

Application Programs:

Each application program performs a well-defined data processing function on one or more image data files. The files normally are stored on disk. However, some programs may operate on files stored on tape, or in the refresh memory of the display. An example of a primitive function is "generate a classification map from 4 images representing 4 spectral bands." All programs will operate on arbitrary size images. Each program will automatically determine the image size and process it correctly. It will be possible for the user to specify any rectangular segment to be processed, instead of the full image.

There will be a few necessary application programs that do not fall in the category of image processing. These will be written to run apart from the image processing executive if necessary. An example is the real-time program that accepts the telemetry data and stores it on tape or disk in a format compatible with the image processing programs.

An exhaustive list of all available application programs will not be given, but rather a list of specific required functions. The exact way in which these will be accomplished via hardware and/or software is not known at present.

2.3.3

DPDS FUNCTIONAL CAPABILITIES

The DPDS will be capable of a wide variety of image processing functions. Not all available functions will be listed here. However, certain functions are either known to be required, or are functions commonly applied to remotely sensed multispectral data. They are as follows:

Telemetry Logging:

Telemetry data in frame-synchronized format will be read from the telemetry interface, converted to a format compatible with the image processing programs, and stored on tape or disk or both as desired. Concurrently, the received image data will optionally be displayed in scroll mode on the color image display, allowing immediate verification of proper system operation and initial viewing for scientific purposes. Identification and certain auxiliary information concerning the file will be stored in the data catalog.

Processing History:

A record will be kept of the processing steps that have been used to go from a set of raw data to a processed image file. The record will be complete enough to permit the processing to be duplicated. Processing history need not be retained for files that have been deleted. The user may display the complete history for any existing image file.

Orbital Predict:

For each of the satellites NIMBUS-G, TIROS-N, and SEASAT-A, the user will be able to determine certain information about the orbital path and sensor field of view, based on orbital elements and sensor characteristics. The user may specify the time period and earth coordinates of interest. He may determine the time of each closest approach of the satellite, and its minimum distance. For any desired satellite pass, he may obtain on the plotter a diagram of the sensor coverage areas superimposed with a geographic coordinate system.

Data Catalog:

A catalog of archived data will be maintained and may be inspected by a user. The catalog will be updated automatically whenever an archival file is created by any program. A means for manually updating the file will be provided as a back-up and to correct errors.

For each archival file, the catalog will contain the satellite and sensor identifications, date and time of first and last (chronologically) data, tapes and file numbers where the data is to be found, a geographic coordinate description of the coverage area, and solar azimuth and elevation and phase angle at the limits of coverage. Some descriptive text may be included if desired by a user for any given file. The user can inspect the catalog in various ways. He can create a list of catalog entries meeting one or more criteria that he specifies, such as beginning and ending times for a given sensor, or a geographical area of interest specified by latitude and longitude limits.

Image Display and Edit:

The user may display any section of any image that fits in the 512 x 512 display raster. If the image size exceeds 512 x 512, it may be displayed in its entirety by subsampling

in either or both line and sample directions. When viewing only a segment of a larger image, the user may easily vary the location in the larger image from which the segment is taken. In one mode, the user may scroll the image across the screen to view selected areas as desired. When an area of interest has been identified, the user may cause a new file to be created containing only that segment. The size of the segment is arbitrary.

If the image being displayed has more than one spectral band, the user may display it in color by selecting three of the bands to be assigned to the red, green, and blue display primary colors. When the new file is created containing the subsequent display, it will contain the proper segment for each spectral channel. During display, the user may designate any desired point in the image using the cursor under track-ball control. The geographic coordinates, (latitude - longitude) of the point will be displayed. The user may also specify a set of geographic coordinates, and cause a cursor to be displayed over the image at that location.

Radiometric Correction:

The raw sensor data contains a number of "distortions" due to imperfections in the sensor or inherent in its design. One of the most important is radiometric distortion. The DPDS will be capable of correcting (calibrating) the raw sensor data by making the digital value of each sample proportional to surface radiance averaged over the resolution cell of the pixel. The proportionality will hold over an entire image, and in the case of multispectral data, over all channels. The constant of proportionality will be reported to the user and will be included in the history log for the resulting image file.

Multispectral Classification:

Multispectral classification is an automated way for identifying areas of a multichannel image based on the similarity of their spectral "signatures." The DPDS will provide a number of algorithms for this function that have previously proved useful in classifying multispectral data.

Image Ratio:

The DPDS will have the capability to produce an image, each pixel of which has the value of the ratio of the pixels in the corresponding positions in each of two input images. The ratios of various spectral channels, taken pairwise, is a useful device for discriminating subtle color variations. It is less costly in computer time than more complex multispectral classification algorithms.

Parallelepiped Classification:

The DPDW will perform multispectral classification using a "parallelepiped" algorithm. It will process an arbitrary number of classes and spectral channels. A convenient interactive procedure will be provided for the user to designate training areas, and to measure and edit training statistics for the classifier.

Maximum Likelihood Classification:

The DPDS will perform multispectral classification using a maximum likelihood algorithm. It will process an arbitrary number of classes and spectral channels. A convenient interactive procedure will be provided for the user to designate training areas, and to measure and edit training statistics for the classifier.

Geometric Registration:

To correlate images of a given area from different instruments or different satellite passes, they must first be registered to a common raster format. That is, a given pixel location (line-sample) must correspond to the same location on the earth in each image. The DPDS will have a semiautomated means of doing this. The user will be able to display the common area of overlap of the two images side by side using half the display area for each. Using the trackball, he will position the cursor to points in each image corresponding to a single ground point. Optionally, local areas surrounding the designated points will be cross-correlated to improve the precision of correlation. After designating a number of points, geometric transformation coefficients will be computed that map one of the images to the other such that the previously designated pairs of points now coincide. The user may limit the degrees of freedom of the transformation to force only translation, only translation and rotation, or only a general linear transformation. After computing the transformation coefficients, one of the pair of images is geometrically transformed. In the case of multichannel data, each channel is transformed. Intensity interpolation may optionally be nearest-neighbor, bilinear, or cubic convolution.

Spatial Filtering:

The DPDS will be capable of linear spatial filtering operations using Fourier transform and convolution techniques. An image can be convoluted with an arbitrary rectangular array specified by the user. An image can be Fourier-transformed into (two-dimensional) spatial frequency components, which constitute a complex-valued array. Other than having dimensions that are powers of two, the DPDS will be capable of applying the fast Fourier transform (FFT) to arrays of arbitrary size. The array size will specifically not be limited by CPU memory size. The inverse Fourier-transform operation may be applied to convert the spatial-frequency array back into image space. The FFT will be capable of handling both real and complex valued arrays. Operations will be incorporated permitting merging of two real arrays to form one complex-valued array, and to obtain the (real valued) modulus and phase arrays of a given complex array.

Any two arrays may be multiplied, divided, added, or subtracted, element by element, for the cases where both arrays are complex, both are real, or when one is real and the other complex.

A starting set of filtering functions will be provided, including Gaussian, sine, sine squared, Bessel sine, with the ability to add more functions easily.

All the above functional capabilities are required under this specification, with the following exceptions: orbit predict, radiometric correction, earth-image coordinate transformation. These capabilities are, however, highly desirable so that system users can overlay satellite imagery with map coordinates, coastlines and other geographic reference information.

APPENDIX D

SIO SATELLITE REMOTE SENSING FACILITY

DIRECT RECEPTION TERMINAL

1.0 INTRODUCTION

1.1 PURPOSE OF DOCUMENT

This document provides a technical specification of the Scripps Institution of Oceanography Satellite Remote Sensing Facility's Direct Reception Terminal (DRT). The terminal subsystem of the Facility is defined in this specification; however, reference to the entire Facility is frequently made to explain its intended use.

2.0 DELIVERABLES

2.1 The hardware deliverables under this contract are:

- a. Antenna/mount.
- b. Antenna controller.
- c. RF components.
- d. Strip chart recorder.
- e. Signal generator.
- f. Test feed.
- g. Spectrum analyzer.

2.2 The documentation deliverables under this contract are:

- a. Maintenance plan.
- b. Installation plan and instructions.
- c. Terminal operation and maintenance manual.
- d. Schematic drawings.
- e. Wire drawings.
- f. Test plan and procedures.
- g. Certification of readiness for acceptance testing.

2.3 Other deliverables are:

- a. On-site installation.
- b. On-site training.
- c. On-site support.

3.0 DIRECT RECEPTION TERMINAL SPECIFICATIONS

3.1 GENERAL DESCRIPTION

The real-time data collection subsystem, or DRT, consists of an automatic tracking antenna, a low-noise RF preamplifier, a single-channel telemetry and tracking receiver, the proper demodulators and the necessary mounting and interface components. Figure D-1 is a simplified diagram of the subsystem. Table D-1 contains the DRT subsystem specification.

TABLE D-1.

Direct Reception Terminal Subsystem Specifications

G/T	14 dB/K minimum
Operating Frequency Range	1690 to 2300 MHz (nominal)
Angle Tracking Range	All az/el with elevation greater than 15 deg
Special Accuracy	Overhead passes Necessary to maintain G/T
Data Rates	25, 665, and 800 kbit/s
Modulation Type	
NIMBUS-G & TIROS-N	PSK(BI ϕ -L), PCM/PSK
SEASAT-A	PSK(BI ϕ -L), PCM/PSK/PM 1.6-MHz subcarrier
External Environmental	
Shock and Vibration	As experienced in normal transportation
Wind	
Operating	40 mph
Survival	100 mph
Temperature	0 to 120°F
Relative Humidity	To 100% including condensation
Rain	To 4 in./hour
Environment	Wind blown sand and dust, salt spray as experi- enced in coastal areas
Internal Environment	Normal non-air-conditioned working spaces

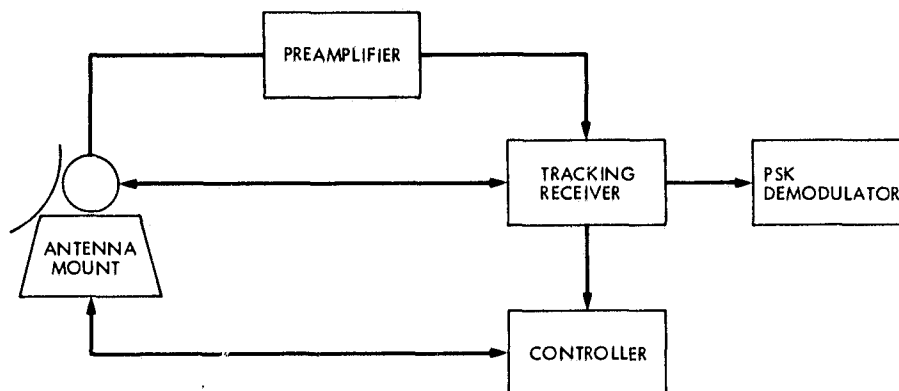


Figure D-1. Real-Time Data Collection Subsystem Block Diagram

3.1.1 PRIMARY SPECIFICATION

It is specifically intended to automatically track and receive telemetry data from the NIMBUS-G, SEASAT-A, and TIROS-N satellites employing right-hand circularly polarized signals at S-band frequencies. Sufficient G/T ratio is provided to enable tracking the NIMBUS-G satellite at an elevation angle of 15 deg above the local horizon. This G/T ratio will be more than adequate to provide the same coverage for SEASAT-A and TIROS-N.

3.1.2 LOCATION

- 3.1.2.1 The antenna and low-noise amplifier will be located up to 200 feet from the rest of the equipment. This arrangement permits location of the antenna some distance from the telemetry and tracking receiver.
- 3.1.2.2 The entire DRT will be located up to 1/2 mile from the other portions of the Facility. Initial operation of the subsystem is not fully automatic, and is expected to require one operator for the receiver and antenna controller manual operations. However, future plans for the terminal call for a remote "normal" operation of the DRT from the Facility control. Therefore, the DRT design should make maximum provision for this capability whenever feasible.

3.2 COMPONENT SPECIFICATIONS

3.2.1 THE ANTENNA/MOUNT

Antenna/mount specifications for candidate systems to meet the general requirements are given in Table D-2.

TABLE D-2.

Antenna Specifications

Tracking Feed	
Type	Autotrack
Polarization	RHCP
Antenna Gain, Nominal	38 dB at 2300 MHz
Reflector	
Type	Parabola
Diameter	5.0 meters
Travel if az/el	
Azimuth	± 270 deg
Elevation	0 to 90 deg
Travel if X-Y	180 deg each
Mount Structure	
Height of Upper Axis	3 meters (minimum)
Contents	Drive motors Gear boxes Power amplifiers

3.2.2 ANTENNA CONTROLLER

- 3.2.2.1 General: The controller section receives manual command inputs, digital inputs, and analog inputs and provides the output signals to the drive units in the antenna. It contains subsystem status indicators, position displays, and automatic switching and control logic. Specifications are summarized in Table D-3.
- 3.2.2.2 Modes of Operation: The operating modes shall be mutually exclusive. The indicator lights of the active mode shall be incorporated in the lighted pushbuttons which activate the mode. The lighting of the indicator shall be an indication of the actual mode, not the commanded one.
- 3.2.2.3 Indicators and Displays: Normal control indicators shall be provided. The position display shall include a digital display with precision of 0.1 degree and an accuracy of better than 0.1 degree. The Servo Error display shall indicate Velocity Lag in degrees. The use of a meter display is adequate. The System Ready light shall indicate that the terminal will begin autotracking if activated. The Autotrack/Acquired light shall indicate that the terminal is autotracking within specifications.

3.2.2.4 Acquisition: Acquisition shall be automatic in autotrack mode.

3.2.2.5 Inputs/Outputs: The indicated inputs/outputs shall be provided on separate plugs at the rear of the chassis.

3.2.3 RF COMPONENTS

These items provide for amplification, filtering, and demodulation of the received signal. The track receiver also provides for decommutating the autotrack signals and providing signals to the antenna controller. The pre-amplifier effective noise temperature is crucial in determining the system G/T. Table D-4 lists the specifications.

TABLE D-3.

Antenna Controller Specifications

Modes of Operations (Exclusive)	Standby Manual Auto Remote
Indicators and Displays	
Position (az/el)	Digital display
Position Resolution	0.1 degrees az/el
Servo Error	Meter
Limit/Stow	Lights
Modes	Lights
Operation/Maintenance	Lights
System Ready	Light
Autotrack/Acquired	Light
Inputs	
Track Receivers Drive	Az/el or X-Y
Position Commands	Manual and digital Digital signal lines
Outputs	
Drive Signals	DC to power amplifiers
Position	Digital az/el (BCD)
Mode Status	Exclusive signal lines
System Ready	Signal line
Autotrack/Acquired	Signal line

Note: This specification allows various axis configurations. However, the digital inputs, displays, and outputs shall be in the local azimuth/elevation coordinate system.

TABLE D-4.

RF Component Specifications

Preamplifiers	
Type	GaAs FET
Noise Temperature	120 K
1-dB Compression	-60 dBm
Gain	40 dB
Track Receiver	
Type	Phase-locked loop
Bandwidth	100 Hz
Noise Figure	5 dB maximum
IF Bandwidth	5 MHz
Telemetry Output	PM Data, 4 V p-p 75-ohm load
Telemetry Bandwidth	1 khz to 2.0 MHz
Signal Level Output	AGC voltage
Scan Code	Generation/demodulation
PSK Demodulator	
Type	Coherent
Output	4 V peak-peak, 75-ohm load

3.2.4 MAINTENANCE

- 3.2.4.1 The hardware preventive maintenance includes routine equipment checks, calibration, replacement of mechanical wearing parts, interface continuity checks, and replacement of marginal components. This routine will be developed by the contractor and a maintenance plan provided with the DRT.
- 3.2.4.2 Test Equipment
An important aspect of this work will be the built-in test equipment and other test equipment dedicated to the Facility. The primary equipment shall consist of a signal generator, a feed on the dish edge, and a simple spectrum analyzer with a special display of the received signals. They may be an integral part of the antenna tracking receiver. They are listed in Table D-5. They are deliverables under this contract and are an integral portion of the DRT.

TABLE D-5.

Test Equipment

Recorder	
Type	Strip chart (paper)
Signals	Analog
	Event pen
Frequency Response	30 Hz
Speeds	6 inches per hour
	6 inches per minute
	60 inches per minute
Signal Generator	
Frequency	1690 to 2300 Mhz
Modulation	PSK
Test Feed	
Mounting	Edge of dish
Frequency	1690 to 2300 MHz
Spectrum Analyzer	
Frequency	Intermediate frequency
Display/Monitoring	CRT (2-inch minimum)
Amplitude Accuracy	3 dB
Frequency Range	Scanable throughout receiver bandwidth (downconverted)

4.0 DOCUMENTATION

4.1 OPERATION AND MAINTENANCE MANUAL

The contractor shall provide three copies of an operation and maintenance manual, or a set of manuals adequate for use by an engineer to operate, maintain, and repair the DRT.

4.2 INSTALLATION PLAN

The contractor shall supply installation plans and instructions if not contained in the operation and maintenance manuals.

4.3 OTHER

The contractor shall supply schematic drawings of the supplied equipment and components. Wire diagrams at the chassis level shall be supplied. Manuals on test equipment shall be supplied.

5.0 INSTALLATION

- 5.1 The contractor shall supply installation plans and drawings indicating the requirements for mounting, cabling, power, size, weight, and other such requirements as crane capability.
- 5.2 Scripps Institution of Oceanography shall prepare the site for installation.
- 5.3 The contractor shall ship the equipment to the site, install it, and certify it ready for final acceptance tests.
- 5.4 The contractor shall provide on-site hands-on training of SIO engineers in operation and maintenance of the system. This shall not exceed two working days.
- 5.5 The contractor shall provide an on-site engineer during acceptance testing, not to exceed five working days.

6.0 TESTING

- 6.1 The contractor shall supply, 60 days after contract award, a test plan and the test procedures necessary to demonstrate conformance to these specifications. Scripps Institution of Oceanography (SIO) (University of California) shall approve or reject them within 30 days. No other action shall constitute approval. In addition to functional testing, the procedures shall include inspection of the documentation.
- 6.2 Acceptance Tests: Final acceptance shall be made after installation at Scripps Institution of Oceanography, San Diego.
- 6.3 Engineering Tests: The contractor may elect to conduct such tests as desired prior to delivery. These tests shall NOT constitute acceptance testing. However, SIO may elect to insert data collected during them into the acceptance tests if it was witnessed by their representative, and no change was made from the time of the tests and final acceptance.
- 6.4 Test Results: The acceptance test results shall be the property of SIO.

APPENDIX E

SIO SATELLITE REMOTE SENSING FACILITY

PROGRAM PLAN

CONTENTS

1.0	INTRODUCTION -----	E-3
1.1	PURPOSE -----	E-3
1.2	PLAN OBJECTIVE -----	E-3
1.3	REFERENCES -----	E-3
1.4	CHANGE CONTROL -----	E-3
2.0	PROGRAM MANAGEMENT -----	E-3
2.1	ORGANIZATION OF REMOTE SENSING FACILITY DEVELOPMENT PROJECT --	E-3
2.2	PROCEDURES -----	E-3
2.3	FINANCIAL PROCESSES -----	E-4
2.4	CONTRACTING -----	E-4
2.5	LIBRARY -----	E-4
2.6	DOCUMENTATION -----	E-4
2.7	OPERATING INSTRUCTIONS -----	E-4
3.0	PROGRAM DEFINITION -----	E-5
3.1	GENERAL -----	E-5
3.2	PRESENT PROGRAM -----	E-5

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to define the Remote Sensing Program Plan as envisioned for the Scripps Institution of Oceanography Remote Sensing Facility. It is intended to evolve, providing the vehicle to document the ongoing plans for the Facility.

1.2 PLAN OBJECTIVE

The objective of this plan is to provide guidance in developing the SIO Remote Sensing Facility and establishing operating principles. It is intended, as it develops, to define the processes and procedures of management, maintain updated time schedules, and consolidate information of general interest.

1.3 REFERENCES

To be supplied at a later date.

1.4 CHANGE CONTROL

Changes to this document will be made by memo indicating changes or including pages to be replaced or added. Each new page will have the change number and date in the upper right-hand corner. Changes must be approved and issued by the SIO Remote Sensing Program manager.

2.0 PROGRAM MANAGEMENT

2.1 ORGANIZATION OF REMOTE SENSING FACILITY DEVELOPMENT PROJECT

This project is intended to develop and operate the Facility for a broad range of users. The organization of those participating in the development is given in Figure 2-1. It does not include the users of the Facility. This project constitutes the entire organization effort for the program at the present time.

2.2 PROCEDURES

Procedures will be developed in a semiformal manner to establish a coordinated effort by all participants. Documents, reports and correspondence will be routed through the Program Manager for technical control, program coordination and record keeping.

Travel plans and meetings will be coordinated through the office.

2.3 FINANCIAL PROCESSES

All financial actions will be in accordance with SIO procedures. Financial status reports will become the property of the Program Office for retention.

2.4 CONTRACTING

All procurement and contracting actions shall be in accordance with SIO procedures. Copies of all contracts and orders are to be filed in the Program Office.

2.5 LIBRARY

A Remote Sensing Library will be developed. This will be composed of three sections: (a) documents, (b) unprocessed data tapes and, (c) processed data tapes. Procedures for the various library sections will be established as required.

2.5.1 Document Section

A document library will be established to retain all documents pertaining to the facility or remote sensing. This section will be available to all interested persons.

2.5.2 Unprocessed Data Tape Section

A data tape library will be established. Procedures for its access will be established.

2.5.3 Processed Data Tape Section

A repository for processed data will be established.

2.6 DOCUMENTATION

Experiments conducted with the Facility will be documented in accordance with SIO policy. cursory information will be provided in the station log for operating and system usage information.

2.7 OPERATING INSTRUCTIONS

Operating instructions and procedures will be established for use of the Facility.

3.0 PROGRAM DEFINITION

3.1 GENERAL

This program is intended to provide to the associated projects the necessary management, develop a real-time receiving capability, provide for a processing capability, provide information displays, allow for data replay, develop the necessary support facilities for easy use of the terminal and provide a viable facility for research at SIO.

3.2 PRESENT PROGRAM

The present program is a project to:

- a. Develop the facility requirements.
- b. Establish system specifications.
- c. Develop a short-term acquisition plan.
- d. Establish funding.
- e. Establish working relationships with agencies.
- f. Acquire real-time subsystem.
- g. Acquire processing/display subsystem.
- h. Integrate and start operation.