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NOAA Technical Memorandum NESS 116



MODIFIED VERSION OF THE TIROS N/NOAA A-G SATELLITE
SERIES (NOAA E-J) - ADVANCED TIROS N (ATN)

Washington, D.C.
February 1982

**U.S. DEPARTMENT OF
COMMERCE**

National Oceanic and
Atmospheric Administration

National Earth Satellite
Service

NOAA TECHNICAL MEMORANDUMS

National Earth Satellite Service Series

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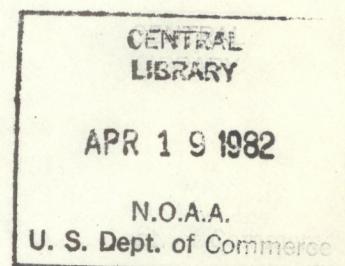
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Arthur Schwalb

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DEPARTMENT OF COMMERCE
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Preface

The material presented within this Technical Memorandum describes a satellite system that is being built. It has been assumed throughout the text that the NOAA polar orbiting satellite system consisted of a two satellite constellation, with the selected orbital planes phased approximately ninety degrees apart. Recent budgetary constraints have placed this concept under increasing pressure. At this writing (December 15, 1981), it is uncertain whether the NOAA System will retain two in-orbit satellites or be reduced to only one, with the potential for periods when no spacecraft will be operational. The satellites and payloads described herein are being built and are expected to fly. The question is when, not if. Should we be forced to adopt a one-satellite system, the assignment of instruments among the satellites (Table 1) will likely be modified.

ADVANCED TIROS-N/NOAA E-J SUMMARY SHEET

Spacecraft: Total Weight - 1,009 Kg (2,220 lbs)
(Excludes expendibles)

Payload: Weight, including tape recorders - 386 Kg (850 lbs)

Instrument Complement: Advanced Very High Resolution Radiometer (AVHRR/2)
High Resolution Infrared Radiation Sounder (HIRS/2)
Stratospheric Sounder Unit (SSU)
Microwave Sounder Unit (MSU)
Data Collection System - ARGOS (DCS)
Space Environment Monitor (SEM)
Search and Rescue (SAR) Satellite Aided Tracking
(SARSAT)
Solar Backscatter Ultra Violet Radiometer (SBUV/2)
- NOAA F and on -
Earth Radiation Budget Experiment (ERBE)-NOAA F and G
only

Spacecraft Size: 3.71 meters in length (165 inches)
1.88 meters in diameter (74 inches)

Solar Array: 2.37 m x 4.91 m: 11.6 square meters
(7.8 ft x 16.1 ft: 125 square feet)

515 watts, end of life at worst solar angle
(violet, high efficiency solar cells)

Power Requirement: Full operation - 475 watts
Reserved - 40 watts

Attitude Control System: 0.2° all axes
0.14° determination

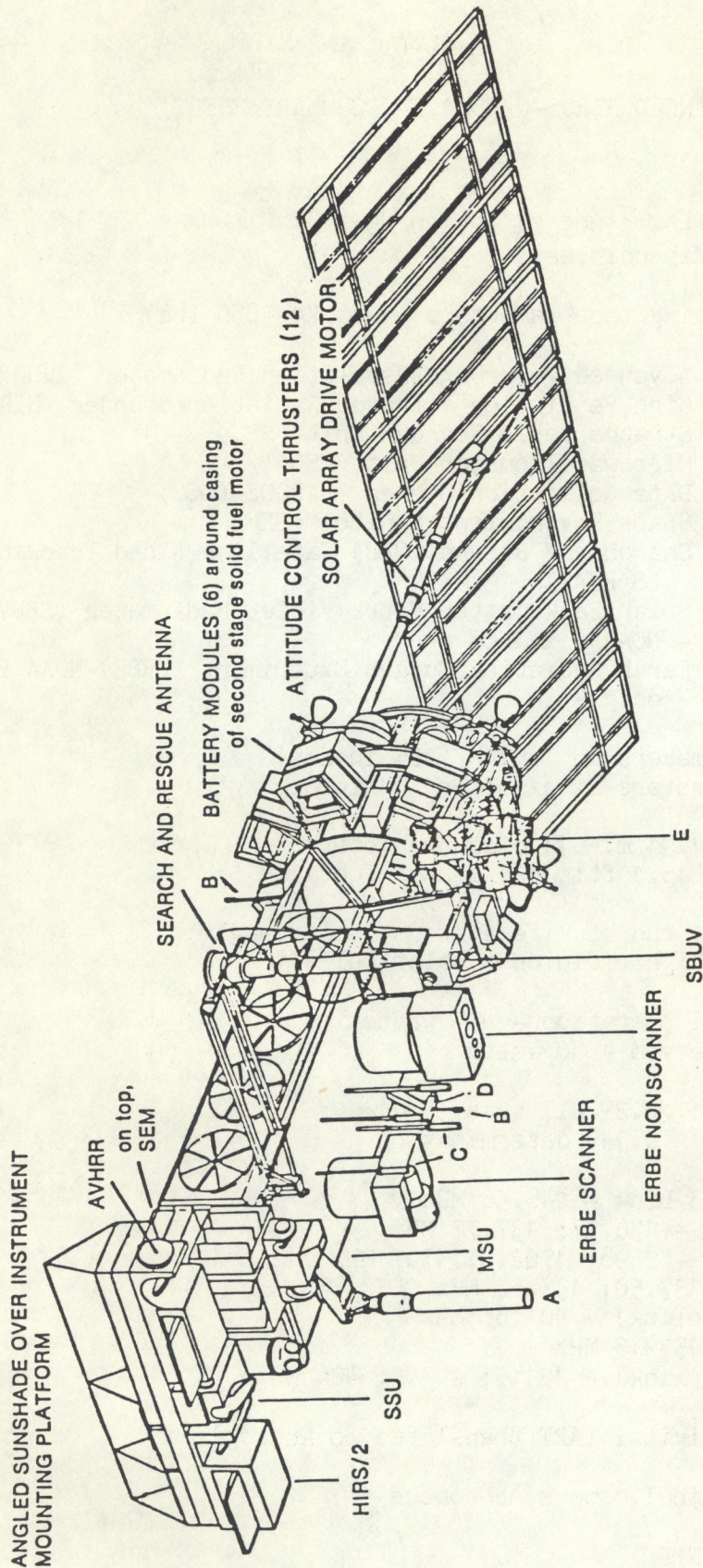
Communications: Command Link - 148.56 MHz
Beacon - 136.77; 137.77 MHz
S-Band - 1698; 1702.5; 1707 MHz
APT - 137.50; 137.62 MHz
DCS (uplink) - 401.65 MHz
SAR - 1544.5 MHz
SAR (uplink) - 121.5; 243.0; 406 MHz

Data Processing: All digital (APT translated to Analog)

Orbit: 833; 870 Km nominal, sun synchronous

Launch Vehicle: Atlas E/F

Lifetime: 2 years planned



Antennas Identified by letters:

- A—UHF for the DCS.
- B—S-band omni antennas.
- C—Four S-band antennas.
- D—Beacon command antenna.
- E—VHF real-time antenna.

Figure 1
Advanced TIROS-N Satellite

MODIFIED VERSION OF THE TIROS N/NOAA A-G SATELLITE SERIES
(NOAA E-J) - ADVANCED TIROS N (ATN)

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ABSTRACT: The TIROS N/NOAA A-G satellites described in NOAA Technical Memorandum NESS 95 have been modified to add payload capacity without changing the basic environmental mission of the series. Three additional satellites are being added to the initial procurement to extend the lifetime of the program to the end of the decade. Incrementally added to the payload will be a Search and Rescue Demonstration System, an Earth Radiation Budget Experiment and an operational Solar Backscatter Ultraviolet Radiometer which will monitor the distribution of ozone in the atmosphere. Characteristics of the real time data links (APT, HRPT and DSB) will not be changed by the addition of these instruments.

This Technical Memorandum is being issued to supplement the information presented in Technical Memorandum NESS 95 and delineates changes to the system already described. No attempt has been made to repeat the information already presented, except in a very general manner.

1. INTRODUCTION

The TIROS N/NOAA A-G satellite series was introduced with the launch of the protoflight satellite TIROS N on October 13, 1978. This NASA funded satellite was followed into orbit by NOAA 6 (NOAA A, before launch) on June 27, 1979 and NOAA 7 on June 23, 1981. The two satellite system has been considered operational since that time. NOAA, as an agency, has been receptive to requests from other agencies to use a national resource (NOAA satellites) to further space research as long as the primary environmental mission of the satellite was not impacted. In 1975, NASA asked NOAA to permit them to modify three satellites in the NOAA A-G series to carry Search and Rescue (SAR) demonstration hardware. NOAA concurred in this request recognizing the potential advantages of using a space platform in a cost effective approach to meeting high seas and terrestrial search and rescue, distress, alerting and location activities. The system to be flown on the NOAA satellites will provide the data base necessary to evaluate this potential. The SAR program is a cooperative effort of the United States, Canada and France. The USSR will join the demonstration by launching a satellite equipped with compatible equipment.

A NASA experiment aimed at making long-term global determinations of the components of earth's incoming and outgoing radiation will fly on the NOAA F and G satellites. Flight of these Earth Radiation Budget Experiment (ERBE) instruments in sun synchronous orbit will be in conjunction with flight of duplicate instruments on a dedicated NASA research and development satellite in an orbit that is not sun synchronous.

NOAA will add an instrument for operational long-term monitoring of the global distribution of ozone with a first flight likely on NOAA G. This instrument, the Solar Backscatter Ultraviolet Radiometer/2 (SBUV/2) is an adaptation of a similar instrument flown on Nimbus satellites.

The primary sensors for the NOAA E-J satellites are:

- o A TIROS Operational Vertical Sounder (TOVS). The TOVS is a three instrument system consisting of:

- a. The High Resolution Infrared Radiation Sounder (HIRS/2) - a 20-channel instrument making measurements primarily in the infrared region of the spectrum. The instrument is designed to provide data that will permit calculation of 1) temperature profile from the surface to 10 mb; 2) water vapor content in three layers in the atmosphere; and 3) total ozone content. The design is based on the HIRS instrument flow on the Nimbus satellite. It is identical to the instruments flown on TIROS N and NOAA A-D satellites.

- b. The Stratospheric Sounding Unit (SSU) - employing a selective absorption technique to make measurements in three channels. The spectral characteristic of each channel is determined by the pressure in a carbon dioxide gas cell in the optical path. The amount of carbon dioxide in the cells determines the height of the weighting function peaks in the atmosphere. Programmatic constraints will limit the flight of this instrument to eight (possibly nine) of the satellites planned for the TIROS-N, NOAA A-J series.

- c. The Microwave Sounding Unit (MSU) - a 4-channel Dicke radiometer, making passive measurements in the 5.5 mm oxygen band. This instrument, unlike those making measurements in the infrared region, is little affected by clouds.

Data from the TOVS will be available locally as a part of the HRPT transmission and on the spacecraft beacon transmission, frequently referred to as the Direct Sounder Broadcast (DSB).

- o The Advanced Very High Resolution Radiometer (AVHRR) - a 5-channel (4 channels on five satellites of the NOAA A-G series) scanning radiometer sensitive in the visible, near infrared and infrared window regions. This instrument will provide data for central processing, APT, and HRPT outputs. HRPT data (all spectral regions) will be transmitted at full resolution (1.1 km); APT (two selectable spectral regions) will have reduced resolution (4 km).

- o The Space Environment Monitor (SEM) data will also be included in the HRPT and beacon transmissions. The SEM consists of two (TIROS N and NOAA A-C had three) separate instruments and a data processing unit. The components are:

- a. The Total Energy Detector (TED): measures a broad range of energetic particles from 0.3 KeV to 20 KeV in 11 bands.

- b. The Medium Energy Proton and Electron Detector (MEPED): senses protons, electrons and ions with energies from 30 KeV to several tens of MeV.

c. The High Energy Proton and Alpha Detector (HEPAD)-Through NOAA C: senses protons and alphas from a few hundred MeV up through relativistic particles above 840 MeV. This instrument is now flying on the NOAA, Geostationary Operational Environmental Satellite (GOES). First flight was GOES 4 in 1980.

As is true of the SSU, programmatic constraints will limit the flight of the SEM to eight of the planned satellites in this series.

- o The Data Collection System (DCS): a random access system to acquire data from fixed and free-floating terrestrial and atmospheric platforms. Platform location will be possible by ground processing of the doppler measurements of the carrier frequencies. Data collected from each platform will include identification, as well as environmental measurements. These data are also included in the HRPT and beacon transmissions.

- o The Solar Backscatter Ultraviolet Radiometer (SBUV/2) starting with NOAA G. The SBUV/2 is a non spatial-scanning, nadir viewing instrument designed to measure scene radiance in the spectral region from 160 nanometers (nm) to 400 nm. The data gathered will be used to determine the vertical distribution of ozone in the earth's atmosphere, total ozone in the atmosphere and solar spectral irradiance.

- o The Search and Rescue (SAR) system: a random access system to acquire data from Emergency Locator Transmitters (ELT) and Emergency Position Indicating Radio Beacons (EPIRB) carried on general aviation aircraft and some classes of marine vessels. The received data are transmitted (directly) to the ground where they are processed to locate the origin of the distress signal. These data will be transmitted to the ground using a special radio frequency allocated for this purpose. SAR data will not be included within the conventional meteorological data real time transmission.

- o The Earth Radiation Budget Experiment (ERBE): The ERBE is a two-part instrument consisting of:

- a. A fixed field-of-view instrument with four earth viewing radiometers and one shuttered sun viewing radiometer. The earth viewing radiometers consist of pairs of broadband (0.2 to 50+ micrometer wavelength) and shortwave (0.2 to 5 micrometer) monitors.

- b. A scanning instrument comprising three earth scanning channels differing only in spectral response characteristics. The "total" radiation channel sensitive to 0.2 to 50 micrometers; the shortwave channel sensitive to 0.2 to 5 micrometers; and the longwave channel sensitive to 5 to 50 micrometers. The instantaneous field-of-view of these channels will be approximately three degrees.

The ERBE is planned for flight as an experiment on NOAA F and NOAA G satellites.

The projected payload complement for each of the satellites in this series is shown in Table 1. These allocations are subject to continuing reassessment based on in-orbit experience and updated requirements.

TABLE 1

PROJECTED PAYLOAD COMPLEMENT FOR NOAA C-J SATELLITES

SPACECRAFT	C	D	E	F	G	H	I	J
<u>Instrument</u>								
AVHRR	*/2	*/1	/2	/1	/2	/2	/2	/2
HIRS/2	YES	YES	YES	YES	YES	YES	YES	YES
SSU	YES	DUMMY	YES	DUMMY	YES	DUMMY	YES	DUMMY
MSU	YES	YES	YES	YES	YES	YES	YES	YES
DCS	YES	YES	YES	YES	YES	YES	YES	YES
SAR	NO	NO	YES	YES	YES	YES	YES	YES
SBUV/2	NO	NO	BALLAST	BALLAST	YES	YES	YES	YES
ERBE SCANNER	NO	NO	BALLAST	YES	YES	DUMMY	DUMMY	DUMMY
ERBE NON-SCANNER	NO	NO	BALLAST	YES	YES	DUMMY	DUMMY	DUMMY
SEM TED	YES	DUMMY	YES	DUMMY	YES	DUMMY	YES	DUMMY
MEPED	YES	DUMMY	YES	DUMMY	YES	DUMMY	YES	DUMMY
HEPAD	YES	DUMMY	NO	NO	NO	NO	NO	NO

NOTE: Ballast denotes addition to balance spacecraft center of gravity. Dummy denotes a physical simulation model with proper weight, thermal characteristics and appropriate electrical terminations.

*/2 - Represents AVHRR/2 - The 5-channel version of the AVHRR.

*/1 - Represents AVHRR/1 - The 4-channel version of the AVHRR.

2. THE SPACECRAFT

The NOAA E-J spacecraft, henceforth called the Advanced TIROS-N (ATN), will be similar to the NOAA A-D satellites that precede them with the exception that the Equipment Support Module (ESM) has been stretched 48 centimeters (19 inches) to allow integration of the new payload. The data system and transmission characteristics of the real time data links (APT, HRPT, DSB) are unchanged with the exception that spare word locations of the low bit rate data system (TIP) have been used for data from the ERBE and SBUV/2 instruments. The Search and Rescue system will be independent, utilizing a special frequency for transmission of data to the ground.

2.1 Structure

As described in NOAA Technical Memorandum NESS 95, "The spacecraft structure consists of four components: 1) the Reaction System Support Structure (RSS); 2) the Equipment Support Module (ESM); 3) the Instrument Mounting Platform (IMP); and 4) the Solar Array (SA). Instruments are located on both the IMP and the ESM. With the exception of the SEM, all instruments face the earth when the satellite is in mission orientation."

The ATN satellite, including the injection motor assembly, is approximately 3.71 meters (13 ft. 9 in.) in length and 1.88 meters (6 ft. 2 in.) in diameter. Exclusive of expendables consumed during the launch phase, the satellite is expected to weigh 2,220 lbs. Of this weight, approximately 850 lbs. will be used for the payload or kept in reserve for future growth instruments.

2.2 Power System

The Advanced TIROS N (ATN) power system will be a modified version of the TIROS N/NOAA system augmented to provide the additional power needed for the added payload requirements. Major changes are:

- o Use of high-efficiency, violet solar cells rather than "standard cells."
- o The addition of a third battery.
- o Modification of the electronics to accommodate the increased power capability.

Total orbit average power at the end of 2 years in-orbit is expected to be about 515 watts.

2.3 Reaction Control Equipment (RCE)

The RCE for the ATN is essentially unchanged from that flown on previous satellites in the series.

2.4 Attitude Determination and Control (ADACS)

The ADACS for the ATN will function in the same manner as that flown on previous satellites of the series. Modifications required for the larger satellite will be invisible to the ground, since control functions will be essentially unchanged. Attitude control will be maintained within the ± 0.2 degree (3) specification; determination (as computed on-board the satellite) will be accurate to ± 0.14 degrees. No hardware changes have been made.

2.5 Thermal System

Addition of 48 centimeters (19 inches) to the Equipment Support Module (ESM) will permit a fourth set of thermal "pin wheel" louvers to be added. The thermal control system otherwise remains functionally unchanged.

2.6 Data Handling System

The data handling system is only slightly changed from previous satellites in the series; the APT/HRPT/DSB formats will be identical. System changes are limited to:

- o Use of the spare word locations within the TIP data format for SBUV and ERBE outputs.
- o Change in the content of the subcommutated housekeeping telemetry used for satellite and instrument evaluation purposes. These changes are of no consequence to users of real time data transmissions.
- o Addition of Search and Rescue data to the information stored on board the satellite for global data processing.
- o Addition of a new processor for receipt, processing (and rebroadcast) of Search and Rescue data.

The Search and Rescue data are handled in a manner independent of the environmental data. This may be seen in Figure 2. Data from the 121.5 MHz Emergency Locator Transmitters (ELT) and the 243 MHz Emergency Position Indicating Radio Beacons (EPIRB) and experimental 406 MHz ELT's/EPIRB's are received by the spaceborn receiver which retransmits the data directly to the ground on the SAR frequency of 1544.5 MHz. With the exception of frequency translation, these data are essentially unchanged by the satellite.

Data from the experimental 406 MHz beacons are also processed by the on-board hardware. The processor measures the doppler shifted frequency, and formats this information along with decoded data from the platform and time tag. These data are transmitted in near real time with the 121.5/243/406 MHz data on the 1544.5 MHz channel. In addition, these experimental processed data are stored on-board the satellite for later transmission to the ground and further processing at a central location.

Detailed information concerning SAR data processing, message content and data utility are contained in Search and Rescue Satellite Aided Tracking (SARSAT) documentation issued by the SARSAT Project.

2.7 Command and Control

The Command and Control System has been changed to accommodate requirements imposed by addition of the new payload components. The primary changes are these necessary to provide a command capability for the added payload. The Central Processing Unit (CPU) memory has been increased to accommodate the additional computational requirements associated with the enlarged satellite and a Controls Interface Unit annex has been added to interface with the new payload.

2.8 Communications System

The seven TIROS-N primary communications links have been augmented by addition of four links necessary to support the Search and Rescue mission. Characteristics of the original links have been changed only to the extent that antenna patterns are somewhat different because of the changed satellite configuration and the necessity to change the position of the antennas; data format, transmitting frequencies and equipment are unchanged. Characteristics of the new links are shown in Table 2. Detailed information may be obtained from the SARSAT Project (see page 13).

Table 2

<u>Link</u>	<u>Carrier Frequency</u>	<u>Information Signal</u>	<u>Baseband Bandwidth</u>	<u>Modulation</u>
ELT	121.5 MHz	ELT uplink		AM
EPIRB	243 MHz	EPIRB uplink		AM
Experimental ELT	406.025 MHz	ELT uplink	400 bps	Split phase
SAR Downlink	1544.5 MHz	Realtime SAR transmission		PM

3. LAUNCH AND ORBIT

Orbits for the ATN series of satellites are subject to the same constraints as previous satellites in the series. Operational priorities will likely result in the afternoon (ascending node) satellite being launched early within its design "window" and the morning (descending node) satellite being separated by 6 to 7 hours from the afternoon orbit.

4. ACTIVATION AND EVALUATION

Checkout of the environmental instruments following launch of a satellite is expected to require 2 to 3 weeks. Once engineering evaluations have been completed, the instruments are planned to remain in operational mode, continuously. The SAR system on NOAA E will require approximately 3 months of engineering evaluation before entering the demonstration phase. Routine operation is expected to follow the engineering evaluation.

5. INSTRUMENTS

Characteristics of the AVHRR/2, HIRS/2, MSU, SSU, SEM, and DCS are unchanged from that described in NESS 95.

5.1 Solar Backscatter Ultraviolet Radiometer (SBUV/2)

The Solar Backscatter Ultraviolet Radiometer (SBUV/2) design is based upon the technology developed for the SBUV/TOMS flown on the Nimbus 7 satellite; the NOAA instrument is being built by the Ball Corporation, Aerospace Systems Division (BASD), Boulder, Colorado.

The instrument is being designed to provide data from which it will be possible to compute the vertical distribution of ozone in the earth's atmosphere. From these data, global maps of ozone concentration can be constructed and from continuous monitoring, long-term trends estimated.

To collect this information, two separate measurements in the 160 to 400 nanometer spectral range are made by the SBUV/2 instrument. These are: 1) The spectral radiance of the solar ultraviolet radiation backscattered from the strong ozone absorption band of the earth's atmosphere and 2) The direct solar spectral irradiance.

The SBUV/2 instrument is divided into two components, separating the electronics and logic and the sensor/detector modules. The earth viewing sensors are mounted on the exterior surface of the Equipment Support Module of the satellite (Figure 1) while the electronics/logic module is located within.

The basic components of the sensor module are:

- o A scanning double monochromator
- o A cloud cover radiometer
- o A diffuser plate
- o Detectors

The SBUV/2 instrument measures backscattered solar radiation in an 11.3 degree field-of-view in the nadir direction at 12 discrete, 1.1 nanometer (nm) wide, wavelength bands between 252.0 and 339.8 nm. The solar irradiance is determined at the same 12 wavelength bands by deploying, upon command, a diffuser which will reflect sunlight into the instrument field-of-view. The atmospheric radiance measurement, relative to the solar irradiance, is the significant factor being determined.

The SBUV/2 instrument can also measure the solar irradiance or the atmospheric radiance with a continuous spectral scan from 160 nm to 400 nm in increments nominally 0.148 nm. These measurements provide data on photochemical processes in the atmosphere.

A separate narrowband filter photometer channel, called the Cloud Cover Radiometer (CCR), continuously measures the earth's surface brightness at 380 nm, i.e., outside the ozone absorption band. The Cloud Cover Radiometer is located in the same structure as the monochromator. The CCR field-of-view is the same size (11.3 Degree x 11.3 degree) as, and is co-aligned with, the monochromators field-of-view.

The instrument operates in five distinct modes:

- o Discrete Mode. The instrument sequentially measures scene radiance and solar spectral irradiance in 12 discrete spectral bands.
- o Sweep Mode. The instrument will sense input energy as the spectral band pass is "swept from" 160 nm to 400 nm in a continuous manner. Each measurement will have an equal integration time and be equally spaced across the spectral band. Either the scene spectral radiance or solar spectral irradiance may be measured in this mode.
- o Wavelength Calibration Mode. This is equivalent to the discrete mode, but the spectral wavelengths scanned will be equal to those of the onboard calibration lamp.
- o Monochromator Stop Mode. In this mode, the spectral scan is interrupted with the grating fixed in position at the time of command receipt.
- o Monochromator Caged Mode. In this mode, the monochromator is caged for launch at a predetermined position.

The sequencing for each monochromator mode is controlled from either a fixed, ground-programmable memory or from a random access memory programmable by command. The desired memory is selected by command.

Each monochromator mode defines a unique wavelength sequence and a data sampling sequence. The wavelengths are always scanned from the long wavelengths to the short wavelengths. This is followed by a rapid retrace to the long wavelength and a wait for the start of the next 32 second TIROS Information Processor (TIP) major frame. During this time, the preamplifiers are switched out and up to ten precision voltage levels are inserted into the electronics for calibration of the analog electronics and the voltage-to-frequency converters.

Beginning at the start of the first major frame following a "Discrete Mode" command, the gratings sequentially move to and dwell at the 12 discrete wavelengths. The signal at each wavelength is integrated for 1.25 seconds. An additional 0.75 second is allowed for moving to and settling at the next wavelength. Thus, the 12 discrete wavelengths are covered in 24 seconds. This allows eight seconds for returning to the first discrete wavelength, electronic calibration, and waiting for the start of the next major frame.

Beginning at the start of the first major frame following receipt of a "Sweep Mode" command, the wavelength range from 400 nm to 160 nm is scanned in nominally 0.074 nm steps. The monochromator signal is integrated for 0.1 second resulting in nominally 0.148 nm sample increments. Therefore, approximately 1631 spectral measurements are made between 400 nm and 160 nm. This takes about 164 seconds. The grating drive then retraces to 400 nm and waits for the start of the next major frame. Thus, the total cycle time for the Sweep Mode is 192 seconds. Electronic calibration takes place during the time period between 164 seconds and 192 seconds.

The "Wavelength Calibration Mode" is functionally very similarly to the "Discrete Mode." Beginning at the start of a major frame, it moves to and dwells at 12 separate wavelengths, each separated by nominally 0.296 nm, around any desired line source. At each wavelength, data is integrated for 1.25 seconds.

The SBUV/2 will not be turned on after launch until it is believed that all deleterious outgassing of the satellite and payload has been completed. This may take up to 30 days after injection into orbit.

5.2 Earth Radiation Budget Experiment (ERBE)

The Earth Radiation Budget Experiment (ERBE) instrument is being built to gather data which will permit a better understanding of climate and its potential predictability. It is planned to determine, for at least one year, the monthly average radiation budget on regional, zonal and global scales and to determine the equator to pole energy transport gradient. A second objective is to determine average diurnal variations in radiation budget.

There are two ERBE instrument packages which together provide the data required. One instrument package containing wide and medium field-of-view channels viewing in a fixed mode, is called the Non-Scanner. The second package consisting of narrow field-of-view channels is referred to as the Scanner. TRW is the prime industrial contractor for these instruments with the scanning motor-optical head-mount assembly of the Scanner subcontracted to the Barnes Engineering Company.

ERBE Non-Scanner

The Non-Scanner instrument consists of five channels, four of which have, as a primary function, the viewing of the earth. Of these channels, two are wide field-of-view (view the total earth disc beneath the satellite) and two are medium field-of-view (31.8 degree field-of-view, equivalent to a 10 degree earth central angle beneath the satellite). These four channels are mounted on a

single axis gimble which when activated by command (in the appropriate orbital location) allows these channels to view the sun for periodic calibration. The fifth channel is not gimbled but is so located as to periodically view the sun and provide a measurement of the solar constant. The five sensors differ in spatial and spectral scales of their measurements as shown in Table 3 below:

Table 3

ERBE NON-SCANNER CHARACTERISTICS

<u>Channel</u>	<u>Spectral Interval (μm)</u>	<u>Filter</u>	<u>Field-of-View</u>
1 (Wide FOV)	0.2 - 50+	None	Limb-to-Limb
2 (Wide FOV)	0.2 - 5	Suprasil-W Dome	Limb-to-Limb
3 (Medium FOV)	0.2 - 50+	None	10° ECA*
4 (Medium FOV)	0.2 - 5	Suprasil-W Dome	10° ECA
5 (Solar)	0.2 - 50+	None	18° Conical

*Earth Central Angle

The detectors are essentially cavity radiometers which have a broadband spectral response of from about 0.2 micrometers to 50 micrometers. The detectors of one wide field-of-view and one medium field-of-view channel are placed beneath a Suprasil-W hemispheric dome filter which provides spectral isolation since the filter does not transmit above 5 micrometers. Hence, one of each size channel makes broadband or total radiation measurements and the other measurements of the shortwave spectral band characterized by the filter. For both sets of channels, the earth emitted longwave radiation component is determined by subtracting the shortwave (earth reflected radiation) channel measurements from the total measurement.

The solar channel is a narrow field-of-view cavity radiometer measuring the total solar spectral range.

The Non-Scanner instrument package is estimated to weigh 32 kg and require 20 watts orbit average power. Data output is 160 bits per second.

Scanner

The Scanner instrument is being designed to scan an essentially continuous pattern from horizon-to-horizon in a direction normal to the orbit plane. The instantaneous field-of-view is 3 degrees by 4.5 degrees. The mechanical system is configured to provide the same capability for viewing earth and sun as does the Non-Scanner instrument.

As shown in Table 4 below, there are three wavelength regions of operation for the scanning channels - a long wavelength band (5 - 50 μm), a short wavelength band (0.2 - 5 μm) and a total band (0.2 - 50 μm).

Table 4

ERBE SCANNER CHARACTERISTICS

<u>Channel</u>	<u>Spectral Interval (μm)</u>	<u>Filter</u>	<u>Instantaneous Field-of-View</u>
6	0.2 - 5	Suprasil-W	$3^{\circ} \times 4.5^{\circ}$
7	5 - 50	Diamond plus short-wave cut-off	$3^{\circ} \times 4.5^{\circ}$
8	0.2 - 50	None	$3^{\circ} \times 4.5^{\circ}$

The scanner assembly is a lightweight, compact, three-bearing, mechanical configuration which is scanned in sawtooth fashion across the ground track of the spacecraft.

The scanner instrument package is estimated to weigh 29 kg and to require 25 watts orbit average power. The data output is 960 bits per second.

NASA, Langley Research Center is responsible for procurement of the ERBE instruments and for data management for the mission. They will process the data received from the NOAA satellites and from the dedicated ERBE satellite. For further information concerning the ERBE instruments, the reader is referred to:

ERBE Project Manager
Mail Code 158
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

5.3 Search and Rescue Satellite Aided Tracking (SAR-SARSAT)

The SARSAT system consists of space and ground components. The key elements are:

- o A satellite borne receiver, frequency translation repeater (provided by the Department of Communications, Canada) for both existing and experimental Emergency Locator Transmitter (ELT)/Emergency Position Indicating Radio Beacons (EPIRB) bands (121.5, 243 and 406 MHz). This system is used for regional coverage/alerting.

- o Local User Terminal (LUT) which receive the relayed ELT/EPIRB signals and process the doppler data to earth locate the transmitting platform.

- o Operational and experimental ELT and EPIRB systems.

o A satellite borne receiver and processor for the experimental (406 MHz) ELT/EPIRB transmissions (provided by Centre National d'Etudes Spatiales (CNES) France). The unit is analogous to and in many ways equivalent to the Data Collection System (DCS) also provided by CNES and is used to provide experimental data for regional and global purposes.

o Mission Control Centers for coordinating activities, processing global experimental data and coordinating search activity support.

The Spacecraft Repeater System: When an emergency occurs to a vehicle carrying an ELT or EPIRB, the unit is activated either automatically or manually. The weak (100 mwatt) signal transmitted, used for homing by search forces, is amplitude modulated so that it can be recognized by listening to an ordinary communications receiver. With the SARSAT system, the signal is received by the satellite when within range of the transmitter. The signal is then translated and rebroadcast to any Local User Terminal (LUT) within view of the satellite. Because of the relative velocity difference between satellite and platform the signals received at the satellite are Doppler shifted. At the LUT, special processing of the received signals after time tagging allows the weak transmission of the Doppler shifted signal to be processed to determine the position of the transmitter. This information is then provided to a Rescue Coordination Center for use in their operations. This data flow is shown in Figure 2.

The Experimental 406 MHz System: This system works in the same manner as the DCS. The relatively strong signal (5w transmitter) is transmitted on a periodic basis. The Doppler shifted frequency received on the satellite is measured and time tagged. This information is both transmitted in real time at 1544.5 MHz and stored on board the satellite so that regional and global coverage are obtained. The data received either at the LUT or, through the NOAA ground complex, at the Mission Control Center is processed to determine platform location and through its coded transmission, platform identification. This information is also to be sent to the Rescue Coordination Center for use in their operations.

Detailed information about the SARSAT system characteristics may be obtained by writing to:

SARSAT Project Manager
National Aeronautics and Space Administration
Goddard Space Flight Center, Code 480
Greenbelt, Maryland 20771

APPENDIX A FOR ADVANCED TIROS-N (ATN)

Beacon Transmission Characteristics (Direct Sounder Broadcast - DSB)

The ATN beacon transmission will be identical to that of previous satellites in the series with two exceptions: a) Nineteen of the twenty spare word locations within the TIP will be used for SBUV/2 and ERBE data when those instruments are included in the payload, b) The satellite telemetry included within words 12 and 13 of the TIP format will be changed. There will be no changes to the other transmission characteristics such as radiated power, data rate, information content or data location. Users not desiring to obtain data from the new instruments will, therefore, find their operation unaffected as a result of these changes.

Table 5 defines the location of data within the ATN data format. Figure 3 shows similar information in graphic form.

1 BIT CV STATUS
2 BIT TIP STATUS
3 BIT MAJOR FRAME COUNTER

0	1	2	3	4	5	6	7	8	9	10	11
24 BIT SYNC					9 BIT SUBCOM COUNTER	COMMAND VERIFICATION	DIG B SUBCOM (3.2 SEC)	ANALOG SUBCOM (32 SEC)	ANALOG SUBCOM (16 SEC)	ANALOG SUBCOM (1 SEC)	
12 DIG B SUBCOM (3.2 SEC)	13 ANALOG SUBCOM (16 SEC)	14 HIRS/2	15 HIRS/2	16	17 SSU	18	19 ERBE SCANNER	20	21 SEM	22 HIRS/2	23
24 MSU	25	26	27 HIRS/2	28	29 ERBE SCANNER	30	31 HIRS/2	32	33 SSU	34	35 HIRS/2
36 SBUV/2	37	38	39 HIRS/2	40	41 MSU	42	43 HIRS/2	44	45 ERBE SCANNER	46	47 CPU-A-TLM
48	49	50	51	52	53 ERBE NON SCANNER	54	55 HIRS/2	56	57 DCS	58	59 HIRS/2
60	61 ERBE SCANNER	62	63 HIRS/2	64	65 DCS	66	67 HIRS/2	68	69	70	71 HIRS/2
72	73 ERBE SCANNER	74	75 HIRS/2	76	77 SSU	78	79 HIRS/2	80	81 SBUV/2	82	83 HIRS/2
84	85 HIRS/2	86	87 ERBE SCANNER	88	89 HIRS/2	90	91 DCS	92	93 HIRS/2	94	95 DCS
96	97	98	99	100	101	102	103	104	105	106	107
CPU-A-TLM						DCS		2 BIT CPU DATA STATUS			
CPU-B-TLM						DCS		6 BIT EVEN PARITY			

NOTES:

NUMBER IN UPPER LEFT HAND CORNER INDICATES MINOR FRAME WORD NUMBER.
TIME CODE DATA SHALL APPEAR DURING MINOR FRAME "O" WORD LOCATIONS 8 THRU 12
////, WORD LOCATIONS ARE SPARE AND CONTAIN CODE 01010101

FIGURE 3 - TIP MINOR FRAME FORMAT

Table '5 --TIP Minor Frame Format

Function	Number of Words	Word Position	Bit Number 1 2 3 4 5 6 7 8	Plus Word Code and Meaning	
Frame Sync & S/C ¹ ID ²	3	0	1 1 1 0 1 1 0 1	The last 4 bits of word 2 are used for spacecraft Identification	
		1	1 1 1 0 0 0 1 0		
		2	0 0 0 0 A A A A		
Status	1-	3	Bit 1:	Cmd ³ Verification Status; 1=CV ⁴ update word present in frame; 0=no CV update in frame.	
			Bits 2&3 :		TIP status; 00=orbital mode, 10=CPU ⁵ memory Dump Mode, 01=Dwell Mode; 11 Boost Mode.
			Bits 4-6 :		
Dwell Mode Address	1+	3	Bits 7&8	9 bit dwell mode address of analog channel that is being monitored continuously	
		4	Bits 1-7		
			0 0 0 0 0 0 0 0 = Analog chan 0 1 0 1 1 1 0 1 0 1 = Analog chan 383		MSB6 is first
Minor Frame Counter	1+	4	Bit 8	0 0 0 0 0 0 0 0 = Minor Frame 0 1 0 0 1 1 1 1 1 = Minor Frame 319 MSB is first	
		5	Bits 1-8		
Command Verification	2	6	Bits 9 through 24 of each received command word are placed in the 16 bit slots of telemetry words 6 and 7 on a one-for-one basis		
		7			
1/S/C: Spacecraft Z/ID : Identification			3/Cmd: 4/CV :	5/CPU: Central Processor Unit 6/MSB: Most Significant Bit	

Table 5 --TIP Minor Frame Format (Con't)

Function	Number of Words	Word Position	Bit Number								Plus Word Code and Meaning
			1	2	3	4	5	6	7	8	
Time Code	5	8, 9 9 9, 10, 11, 12	9 bits of Binary Day Count, MSB first bits 2-5: 0 1 0 1, Spare bits 27 bits of Binary millisec of Day Count, MSB first.								
Time code is inserted in word location 8-12 only in minor frame 0 of every major frame. The data inserted is referenced to the beginning of the first bit of the minor frame sync word of minor frame 0.											
Digital B Subcom	1	8	A subcommutation of Discrete Inputs collected to form 8 bit words. 256 Discrete inputs (32 words) can be accommodated. It takes 32 minor frames to sample all inputs once (sampling rate = once per 3.2 sec). A major frame contains 10 complete Digital B subcommuted frames.								
32 Sec Analog Subcom	1	9	A subcommutation of up to 192 analog points sampled once every 32 seconds plus 64 analog points sampled twice every 32 seconds (once every 16 seconds). Bit 1 of each word represents 2560 mv while Bit 8 represents 20 mv.								
16 Sec Analog Subcom	1	10	These two subcoms are under PROM ² control. A maximum of 128 analog points can be placed in the 169 slots; supercommutation of some selected analog channels will be done in order to fill the 169 time slots. The 170th slot is filled with data from the analog point selected by command. The slot is word number zero of the one second subcom. The analog point may be any of the 384 analog points available. Bit 1 of each word represents 2560 mv while bit 8 represents 20 mv.								
1 Sec Analog Subcom	1	11									

¹/mv: milli volts ²/PROM: Programmed, Read Only Memory

Table 5 --TIP Minor Frame Format (Con't)

Function	Number of Words	Word Position	Bit Number								Plus Word Code and Meaning
			1	2	3	4	5	6	7	8	
DIG B ¹ Digital Subcom (3.2 sec)	1	12	Spacecraft status telemetry in subcommutated form for analysis by ground satellite controllers.								
Analog Telemetry (16 sec)	1	13	Analog housekeeping telemetry points converted to digital values for ground controller analysis.								
Spares	2	68, 69	01010101								
SBUV/2	2	36, 37 80, 81	8 bit words are formed by the SBUV/2 instrument and are read out by the telemetry system at an average rate of 40 words per second.								
ERBE-NS ²	2	52, 53	8 bit words are formed by the ERBE-Non Scanner instrument and are read out by the telemetry system at an average rate of 20 words per second.								
ERBE-S ³	12	18, 19, 28 29, 44, 45 60, 61, 72 73, 86, 87	8 bit words are formed by the ERBE-Scanner instrument and are read out by the telemetry system at an average rate of 120 words per second.								
HIRS/2	36	14, 15, 22 23, 26, 27 30, 31, 34 35, 38, 39 42, 43, 54 55, 58, 59 62, 63, 66 67, 70, 71 74, 75, 78 79, 82, 83 84, 85, 88 89, 92, 93	8 bit words are formed by the HIRS/2 instrument and are read out by the telemetry system at an average rate of 360 words per second.								

¹/DIG B Digital (B) Telemetry
²/Non Scanner
³/Scanner

Table 5 --IIP Minor Frame Format (Con't)

Function	Number of Words	Word Position	Bit Number								Plus Word Code and Meaning
			1	2	3	4	5	6	7	8	
SSU	6	16, 17, 32 33, 76, 77	8 bit words are formed by the SSU instrument and read out by the telemetry system at an average rate of 60 words per second.								
SEM	2	20, 21	8 bit words are formed by the SEM sensor and read out by the telemetry system at an average rate of 20 words per second.								
MSU	4	24,25,40, 41	8 bit words are formed by the MSU experiment and read out by the telemetry system at an average rate of 40 words per second.								
DCS	9	56,57,64 65,90,91 94,95,102	8 bit words are formed by the DCS experiment and read out by the telemetry system at an average rate of 90 words per second								
CPU A TLM ¹	6	46,47,48 49,50,51	A block of three 16 bit CPU words is read out by the telemetry system every minor frame.								
CPU B TLM	6	96,97,98, 99,100,101	A second block of three 16 bit CPU words is read out by the telemetry system every minor frame.								
CPU Data Status	1 ⁻	103	Bits 1&2: 00 = All CPU data received 01 = All CPU-A data received; CPU-B incomplete 10 = All CPU-B data received; CPU-A incomplete 11 = Both CPU-A and CPU-B incomplete								

¹/TLM: Telemetry

Table 5 --TIP Minor Frame Format (Con't)

Function	Number of Words	Word Position	Bit Number								Plus Word Code and Meaning
			1	2	3	4	5	6	7	8	
Parity	1-	103									
			Bit 3:	Even	parity	check	on	words	2	through	18
			Bit 4:	Even	parity	check	on	words	19	through	35
			Bit 5:	Even	parity	check	on	words	36	through	52
			Bit 6:	Even	parity	check	on	words	53	through	69
			Bit 7:	Even	parity	check	on	words	70	through	86
			Bit 8:	Even	parity	check	on	words	87	through	bit
				7	of	word	103.				

APPENDIX B FOR ATN

APT Transmission Characteristics

The APT system for the ATN satellites will be unchanged from that described in NOAA Technical Memorandum NESS 95. Search and Rescue Data will not be included in the APT transmission.

APPENDIX C FOR ATN

HRPT Transmission Characteristics

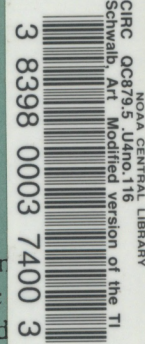
The HRPT system for the ATN satellites will be unchanged from that described in NOAA Technical Memorandum NESS 95 with the exception of changes within the TIP portion of the data described in Appendix A. Search and Rescue will not be included within the HRPT transmission.

(Continued from inside front cover)

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- NESS 90 Lake Erie Ice: Winter 1975-76. Jenifer H. Wartha, August 1977, 68 pp. (PB-276-386/AS)
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- NESS 92 Publications and Final Reports on Contracts and Grants, 1976. Catherine M. Frain (Compiler), August 1977, 11 pp. (PB-273-169/AS)
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NOAA SCIENTIFIC AND TECHNICAL PUBLICATIONS

The National Oceanic and Atmospheric Administration was established as part of the Department of Commerce on October 3, 1970. The mission responsibilities of NOAA are to assess the socioeconomic impact of natural and technological changes in the environment and to monitor and predict the state of the solid Earth, the oceans and their living resources, the atmosphere, and the space environment of the Earth.



The major components of NOAA regularly produce various types of scientific and technical information in the following kinds of publications:

PROFESSIONAL PAPERS — Important definitive research results, major techniques, and special investigations.

CONTRACT AND GRANT REPORTS — Reports prepared by contractors or grantees under NOAA sponsorship.

ATLAS — Presentation of analyzed data generally in the form of maps showing distribution of rainfall, chemical and physical conditions of oceans and atmosphere, distribution of fishes and marine mammals, ionospheric conditions, etc.

TECHNICAL SERVICE PUBLICATIONS — Reports containing data, observations, instructions, etc. A partial listing includes data serials; prediction and outlook periodicals; technical manuals, training papers, planning reports, and information serials; and miscellaneous technical publications.

TECHNICAL REPORTS — Journal quality with extensive details, mathematical developments, or data listings.

TECHNICAL MEMORANDUMS — Reports of preliminary, partial, or negative research or technology results, interim instructions, and the like.

