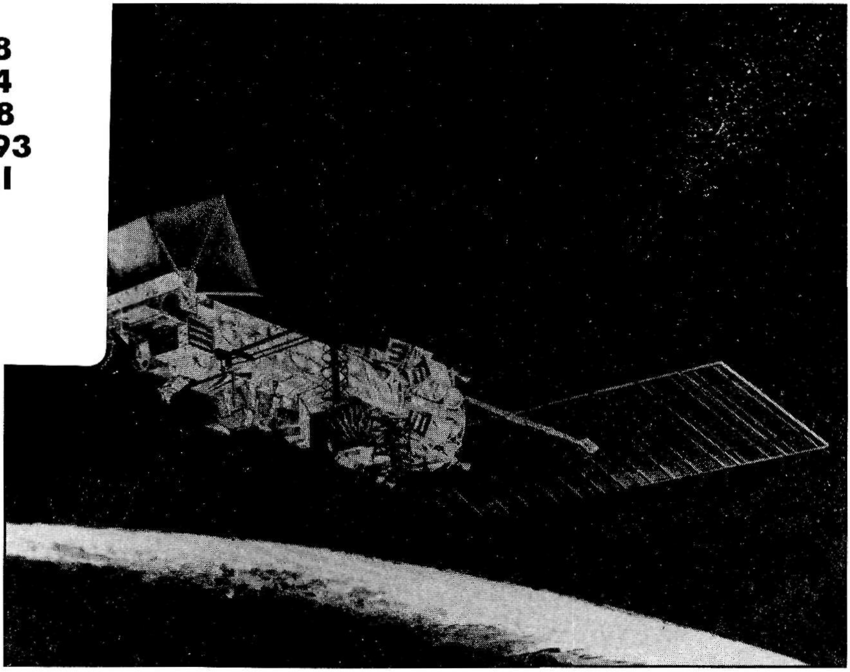
ADVANCED TIROS-N (ATN)

NOAA-I



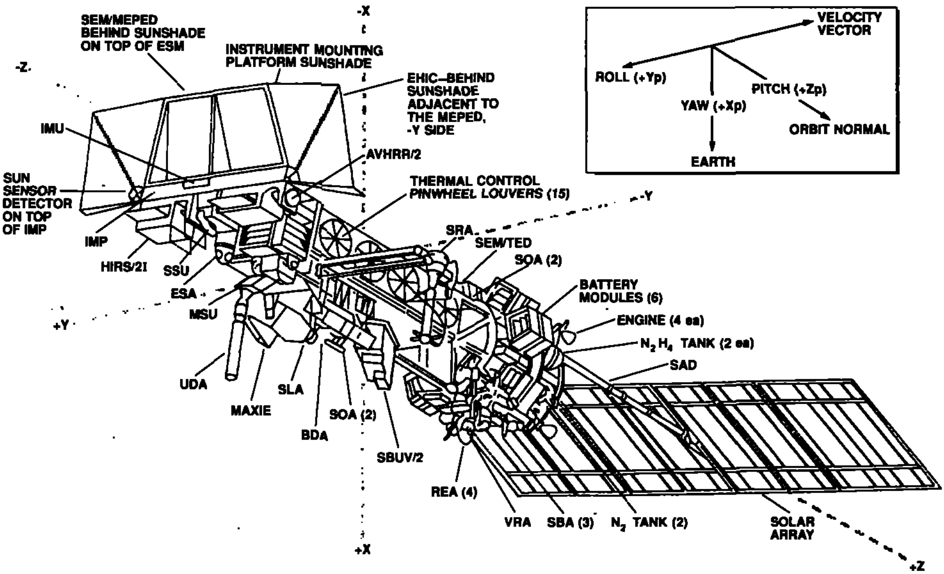
NASA

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

**National Environmental
Satellite, Data, and
Information Service
Suitland, Maryland**



LEGEND

AVHRR/2	Advanced Very High Resolution Radiometer	**SLA**	Search-and-Rescue Transmitting Antenna (L-Band)
BDA	Beacon/Command Antenna	**SOA**	S-Band Omni Antenna
ESA	Earth Sensor Assembly	**SRA**	Search-and-Rescue Receiving Antenna
HIRS/2I	High-resolution Infrared Sounder	**SSD**	Sun Sensor Detector
IMP	Instrument Mounting Platform	**SSU**	Stratospheric Sounding Unit
IMU	Inertial Measurement Unit	**UDA**	Ultra-High-Frequency Data Collection System Antenna
MSU	Microwave Sounding Unit	**VRA**	Very-High-Frequency Real-Time Antenna
REA	Reaction Engine Assembly		
SAD	Solar-Array Drive	**SEM**	Space Environment Monitor
SBA	S-Band Antenna	**EHIC**	Energetic Heavy Ion Composition Experiment
SBUV/2	Solar Backscatter Ultraviolet Spectral Radiometer	**MAXIE**	Magnetospheric Atmospheric X-Ray Imaging Experiment

NOAA-I Spacecraft with Major Features Identified

TIROS PROGRAM

INTRODUCTION

The Advanced Television Infrared Observation Satellite (TIROS)-N (ATN) program is an extension of the TIROS Program. The ATN provides for additional instruments such as the SAR and instruments of opportunity, i.e., the Energetic Heavy Ion Composition Experiment (EHIC) and Magnetospheric Atmospheric X-Ray Imaging Experiment (MAXIE) for NOAA-I. These are described later in this document. The program is a cooperative effort between the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the United Kingdom (UK), and France for providing day and night global environmental and associated data for regular daily operations. Elements of the Search and Rescue (SAR) system are provided by Canada and France. General Dynamics Space Systems Division (GDSSD) is the prime contractor for the Atlas launch vehicle and is under contract to the U.S. Air Force (USAF) Systems Command Headquarters—Space Systems Division, which provides launch vehicle management and launch services. The USAF Space Command, 2nd Space Launch Squadron, is responsible for flight vehicle processing and launch operations.

TIROS-N was launched October 13, 1978, at 11:23 Z into a 470-nmi orbit and was the first in the series of a fourth-generation operational environmental satellite system. TIROS-N was a research and development spacecraft serving as a protoflight for the operational follow-on series, NOAA-A through M spacecraft.* Advanced instruments measure parameters of the Earth's atmosphere, its surface and cloud cover, solar protons, positive ions, electron-flux density, and the energy spectrum at the satellite altitude. As a part of its mission, the spacecraft also receives, processes, and retransmits data from Search and Rescue beacon transmitters, free-floating balloons, buoys, and remote automatic observation stations distributed around the globe. General Electric/Astro Space Division (GE/ASD) is the prime contractor for the spacecraft. The operational system consists of two satellites in Sun-synchronous orbits, one in a morning orbit at 450 nmi and one in an afternoon orbit at 470 nmi.

NOAA-A (6) was launched June 27, 1979, at 15:51:59 Z into a 450-nmi orbit. The satellite greatly exceeded its 2-year lifetime and was deactivated on March 31, 1987 after nearly 8 years of operational service.

*Redesignated NOAA-6 through 11 after launch—Note: NOAA-B did not receive a number because it did not achieve a useful orbit due to a launch-vehicle anomaly. Therefore, NOAA-C became NOAA-7 in orbit. NOAA-D was launched on May 14, 1991, and became NOAA-12. The expected launch date for NOAA-I is February 1992. NOAA-I, J, K, L, and M will receive numbers after they are successfully in orbit.

National Oceanic and Atmospheric Administration TIROS Satellites and Satellite Meteorology

ERRATA NOTICE

NOAA-B was launched May 29, 1980, at 10:53 Z and failed to achieve a usable orbit because of a booster engine anomaly.

NOAA-C (7), launched June 23, 1981, at 10:52:59 Z into a 470-nmi orbit, was deactivated in June 1986 following failure of the power system.

NOAA-E (8) was launched March 28, 1983, at 15:51:59.95 Z into a 450-nmi orbit. It was the first of the ATN spacecraft and included a stretched structure which provides growth capability, and it also included the first SAR package. The redundant crystal oscillator (RXO) failed after 14 months in orbit. The RXO recovered from its failure, finally locking up on the RXO backup side in May 1985. The spacecraft was stabilized and declared operational by NOAA on July 1, 1985. The satellite was finally lost on December 29, 1985, following a thermal runaway which destroyed the battery.

NOAA-F (9) was launched December 12, 1984, at 10:41:59.8 Z into the 470-nmi afternoon orbit and is currently in standby operation. Digital Tape Recorder (DTR) 1A/1B failed 2 months after launch. The Earth Radiation Budget Experiment (ERBE)-Scanner stopped outputting science data in January 1987. The Advanced Very High Resolution Radiometer (AVHRR) has at times exhibited anomalous behavior in its synchronization with the Manipulated Information Rate Processor (MIRP), Microwave Sounding Unit (MSU) channels 2 and 3 have failed, and the power system is degraded. A Solar Backscatter Ultraviolet (SBUV/2) instrument is also aboard, and it is operating satisfactorily. The satellite is collecting, processing, and distributing SBUV/2 and ERBE-Nonscanner (NS) data. It is also providing real-time SAR data.

NOAA-G (10) was launched September 17, 1986, at 15:52 Z into the 450-nmi morning orbit, and it is currently transmitting data for local weather analysis directly to users around the world. All instruments and subsystems are performing well except the ERBE-Scanner, which has exhibited a scan sticking anomaly that is apparently generic to the instrument, and the SAR Processor (SARP) 406 MHz receiver, which has failed.

NOAA-H (11) was launched September 24, 1988, at 10:02:00.385 Z into a 470-nmi afternoon orbit with a 1:40 p.m. ascending node crossing time. It is currently transmitting data for local weather analysis directly to users around the world. All instruments are operational. The NOAA-H had been modified for a 0° to 80° Sun angle and includes fixed and deployable sunshades on the Instrument Mounting Platform (IMP) and the capability for a deployable Medium Energy Proton and Electron Detector (MEPED). The increase of maximum Sun angle from 68° to 80° allows an afternoon nodal crossing closer to noon to enhance data collection. Two gyros have failed, however, and attitude control is being maintained through the use of new reduced gyro flight software. In addition, before the NOAA-D launch, a gyroless flight software package was installed on NOAA-11 which will provide attitude control, at expected reduced accuracy, should the X gyro fail.

NOAA-D (12) was launched into a 450-nmi morning orbit on May 14, 1991, at 15:52: .035Z and is functioning well. It replaced NOAA-G (10) in orbit. However it does not contain a SAR package.

NOAA-I (13) will be launched into a 470-nmi afternoon orbit. Air Force instruments of opportunity, the Energetic Heavy Ion Composition Experiment (EHIC) and the Magnetospheric Atmospheric X-Ray Imaging Experiment (MAXIE), will fly on NOAA-I.

The operational ground facilities include the Command and Data Acquisition (CDA) stations in Fairbanks, AK and Wallops Island, VA, the Satellite Operations Control Center (SOCC) and Data Processing Services Subsystem (DPSS) facilities in Suitland, MD, and a data-receiving location in Lannion, France. The U.S. SAR operational ground system consists of a Search and Rescue Satellite Aided Tracking (SARSAT) U.S. Mission Control Center at Suitland, MD, and three Local User Terminals (LUT's) ground stations at Scott Air Force Base, IL; Point Reyes, CA; and Kodiak, AK. During the NOAA-I post-launch period, new LUTs with expanded real-time coverage are expected to be commissioned by NOAA. These LUTs will increase the coverage further into the Pacific and Atlantic Oceans. In addition to U.S. SAR ground facilities, many other cooperating nations operate additional LUTs and Mission Control Centers (MCCs) of their own, and have other MCCs networked to the U.S. MCC.

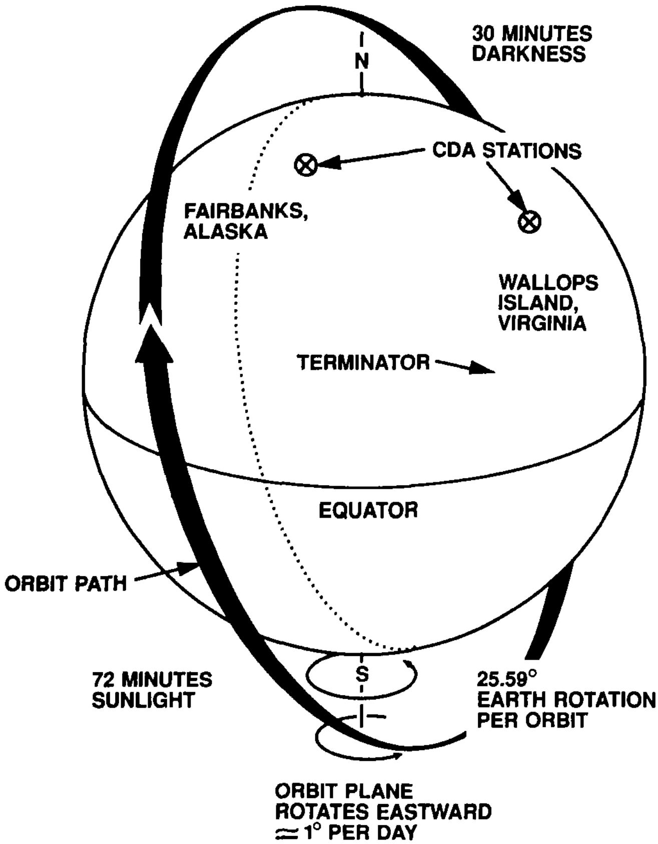
PHYSICAL CHARACTERISTICS

The physical characteristics of the NOAA-I spacecraft are—

- Main body: 4.18 m (13.7 ft) long, 1.88 m (6.2 ft) in diameter.
- Solar array: 2.37 by 4.91 m (7.8 by 16.1 ft), 11.6 m^2 (125 ft^2).
- Weight: At liftoff, 1,712 kg (3,775 lb); on orbit, 1,030 kg (2,288 lb).
- Power: Orbit average end of life—593 W for gamma angle = 0°, 533 W for gamma angle = 80°.
- Lifetime: Greater than 2 years.

ORBIT

NOAA-I is a three-axis-stabilized spacecraft that will be launched into an 870-km (470 nmi) circular, near-polar orbit with an inclination angle of 98.86° (retrograde)



ORBITAL CHARACTERISTICS	
Apogee	870 km (470 nmi)
Perigee	870 km (470 nmi)
Minutes per orbit	102.12
Degrees inclination	98.86

NOAA-I Orbit

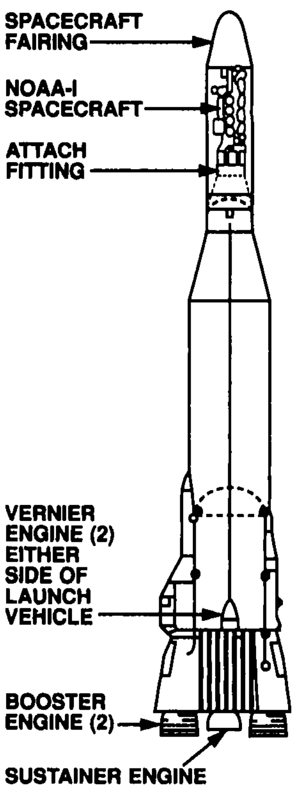
to the Equator. The total orbital period will be approximately 102.12 minutes. The sunlight period will average about 72 minutes, and the Earth shadow time will average about 30 minutes. Because the Earth rotates 25.59° during each NOAA-I orbit, the satellite observes a different portion of the Earth's surface during each orbit.

The nominal orbit is planned to be Sun-synchronous and precesses (rotates) eastward about the Earth's polar axis 0.986° per day (the same rate and direction as the Earth's average daily rotation about the Sun). This precession keeps the satellite in a constant position with reference to the Sun for consistent illumination throughout the year. NOAA-I will be launched so that it will cross the Equator at about 1:40 p.m. northbound and 1:40 a.m. southbound local solar time.

The circular orbit permits uniform data acquisition by the satellite and efficient command control of the satellite by CDA stations located near Fairbanks, AK, and Wallops Island, VA.

LAUNCH VEHICLE

The spacecraft will be launched from the Air Force Western Space and Missile Center (WSMC) at Vandenberg Air Force Base, CA, by an Atlas-E launch vehicle. The standard Atlas launch vehicle consists of an E-series Atlas ballistic missile that has been refurbished and modified to a standard configuration for use as a launch vehicle for orbital missions. It is capable of launching a spacecraft into a variety of low Earth orbits. The launch vehicle is manufactured and refurbished by GDSSD, under contract to the USAF.



Atlas-E Launch Vehicle

The vehicle is 28.7 m (94 ft) tall and 3.05 m (10 ft) in diameter. The fairing is 7.42 m (24.3 ft) long and 2.13 m (7 ft) in diameter. At liftoff, it carries 70 kiloliters (kL) (18,457 gal) of liquid oxygen and 43 kL (11,351 gal) of RP-1 fuel, a highly refined kerosene. Sea level engine data are presented in Table 1.

An airborne autopilot programmer in the launch vehicle flight control system provides preprogrammed steering and backup discrete commands. The GE Radio Tracking System (GERTS) ground station acquires the vehicle at approximately liftoff +85 sec and performs the guidance function by means of the launch vehicle's pulse beacon decoder.

TABLE 1: Atlas-E Sea Level Engine Data

	Booster	Sustainer	Vernier
No. Of Engines	2	1	2
Thrust per engine (lb) Thrust per engine (N) Thrust duration from liftoff (sec)	165,000 733,920 121	60,000 266,880 310	1,000 4,448 329

The vehicle is powered by one sustainer, two boosters, and two vernier engines using liquid oxygen and liquid hydrocarbon propellants. A 0.97-m (38-in) diameter attach fitting fastens the NOAA-I spacecraft to the launch vehicle. The fairing attached to the forward face of the launch vehicle protects the spacecraft during the boost flight.

APOGEE KICK MOTOR (AKM)

Apogee maneuver is accomplished by use of a Thiokol Corporation, Elkton Division, STAR 37S solid propellant motor. This 94-cm (37-in.) spherical rocket motor, which has flown on all previous TIROS-N type missions to date, provides an average 42.77 kN (9,542 lbf) of thrust during a motor burn time of 43.5 sec. The STAR 37S motor, which is attached to the NOAA spacecraft, remains with the spacecraft after burnout.

NOAA-I INSTRUMENTATION

The instrument systems provide both direct readout (real time) and onboard recording (playback) of environmental data during day and night operation. The NOAA-I spacecraft carries the following primary instruments (*manufacturer in italics*):

ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

ITT

The AVHRR is a radiation-detection imager used for remotely determining cloud cover and the surface temperature. This scanning radiometer uses five detectors that collect different bands of radiation wavelengths as shown in Table 2. Measuring the same view, this array of diverse wavelengths, after processing, will permit multispectral analysis for more precisely defining hydrologic, oceanographic, and meteorological parameters. One channel will monitor energy in the visible band, and another channel will monitor energy in the near-infrared portion of the electromagnetic spectrum to observe vegetation, clouds, lakes, shorelines, snow, and ice. Comparison of data from these two channels can indicate the onset of ice

TABLE 2: Advanced Very High Resolution Radiometer (AVHRR)

Characteristics	Channels				
	1	2	3	4	5
Spectral range (micrometers)	0.58 to 0.68	0.725 to 1.0	3.55 to 3.93	10.3 to 11.3	11.4 to 12.4
Detector Material	Si	Si	InSb	HgCd Te	HgCd Te
Resolution (km at nadir)	1.1	1.1	1.1	1.1	1.1
Instantaneous field of view (IFOV)(milliradians squared)	1.3	1.3	1.3	1.3	1.3
Signal-to-noise ratio at 0.5 albedo	>3:1	>3:1	-	-	-
Noise-equivalent temperature difference at (NEΔT) 300 K	-	-	<0.12 K	<0.12 K	<0.12 K
Scan angle (degrees)	±55	æ55	±55	±55	±55

Optics—8-in diameter afocal Cassegrainian telescope with refractive focusing optics.
Scanner—360-rpm hysteresis synchronous motor with beryllium scan mirror.
Cooler—Two-stage radiant cooler, infrared detectors controlled at 105 or 107 K.
Data output—10-bit binary, simultaneous sampling at 40-kHz rate.

and snow melting. The other three channels operate entirely within the infrared band to detect the heat radiation from and hence, the temperature of, land, water, and sea surfaces and the clouds above them.

SOLAR BACKSCATTER ULTRAVIOLET SPECTRAL RADIOMETER, MOD 2 (SBUV/2)

Ball Aerospace

The SBUV/2 instrument is a spectrally scanning ultraviolet radiometer. Similar instruments were flown on NOAA-F and NOAA-H.

The SBUV/2 is capable of measuring solar irradiance and scene radiance (backscattered solar energy) over the spectral range 160 to 400 nanometers. The objectives of this instrument are—

- To make measurements from which total ozone concentration in the atmosphere can be determined to an absolute accuracy of 1 percent.

- To make measurements from which the vertical distribution of atmospheric ozone can be determined to an absolute accuracy of 5 percent.
- To measure the solar spectral irradiance from 160 to 400 nanometers.

TIROS OPERATIONAL VERTICAL SOUNDER SYSTEM (TOVS)

The TOVS system consists of three instruments: the HIRS/2I, the SSU, and the MSU. All three instruments measure radiant energy from various altitudes of the atmosphere, and the data are used to determine the atmosphere's temperature profile from the Earth's surface to the upper stratosphere. Pertinent information appears in the following sections.

Stratospheric Sounding Unit (SSU)

MARCONI/UK

Temperature measurements in the upper stratosphere are derived from radiance measurements made in three channels using a pressure-modulated gas (CO_2) to accomplish selective bandpass filtration of the sampled radiances. The gas is of a pressure chosen to yield weighting functions peaking in the altitude range of 25 to 50 km where atmospheric pressure is from 15.5 to 1.5 mbar, respectively. This gas is contained in three cells, one of which is located in the optical path of each channel. Table 3 summarizes the SSU instrument characteristics.

High Resolution Infrared Radiation Sounder (HIRS/2I)

ITT

This instrument detects and measures energy emitted by the atmosphere to construct a vertical temperature profile from the Earth's surface to an altitude of about 40 km. Measurements are made in 20 spectral regions in the infrared band. (One frequency lies at the high frequency end of the visible range.) Table 4 summarizes the HIRS/2I instrument characteristics.

Microwave Sounding Unit (MSU)

JPL

This unit detects and measures the energy from the troposphere to construct a vertical temperature profile to an altitude of about 20 km. Measurements are made by radiometric detection of microwave energy divided into four frequency channels as shown in Table 5. Each measurement is made by comparing the incoming signal from the troposphere with the ambient temperature reference load. Because its data are not seriously affected by clouds, the unit is used along with the HIRS/2I to remove measurement ambiguity when clouds are present.

TABLE 3: Stratospheric Sounding Unit (SSU)

Characteristics	Channels		
	1	2	3
Spectral range (cm^{-1})	669.99	669.63	669.36
Equivalent bandwidth (cm^{-1})	2.0	1.0	0.4
Detector	TGS* pyroelectric	TGS* pyroelectric	TGS* pyroelectric
Resolution (km at nadir)	147.3	147.3	147.3
IFOV (degrees) circular	10	10	10
NEΔT at 273 K	0.25	0.5	1.25
Scan width from nadir (degrees)	±40	±40	±40
Weighting function peak (atmospheric pressure in mbar)	15	5	1.5
Optics—No collecting optics, 2-in aperture. Scanner—10° stepper for 360° when in automatic calibration mode. Data output—12-bit binary sampled at 0.48-kbps rate.			

* *TGS = triglycine sulfate*

Space Environment Monitor (SEM)
LORAL/NOAA SEL

The SEM is a multichannel, charged-particle spectrometer that measures the population of the Earth's radiation belts and the particle precipitation phenomena resulting from solar activity (both of which contribute to the solar/terrestrial energy interchange). The SEM consists of two separate sensor units and a common DPU. The sensor units are the TED and the MEPED. The lower-energy sensors (TED, plus the proton and electron telescopes of MEPED) have pairs of sensors with different orientations because the direction of the particle fluxes is important in characterizing the energy interchanges taking place.

Objectives:

- To determine the energy deposited by solar particles in the upper atmosphere.
- To provide a solar storm warning system.

TABLE 4: High Resolution Infrared Radiation Sounder (HIRS/2I)

Characteristics	Channels		
	1 - 12	13 - 19	20
Spectral range (micrometers)	6.72 - 14.95	3.76 - 4.57	0.69
Detector	HgCd Te	InSb	Si
Resolution (km at nadir)	20.4	20.4	20.4
IFOV (milliradians)	24	24	24
(NEΔN)	0.03 to 0.96	0.003 0.0002 to 0.001	—
Scan width from nadir (degrees)	±49.5	±49.5	±49.5

Optics—5.9-in diameter Cassegrainian telescope.
Scanner—1.8° stepper, 56 scan steps then retrace.
Cooler—Two-stage radiant cooler, infrared detectors controlled at approximately 105 K.
Data output—13-bit binary, channels sampled sequentially at 2.88-kbps rate.

TABLE 5: Microwave Sounding Unit (MSU)

Characteristics	Channel			
	R_1	R_2	R_3	R_4
Frequency (GHz)	50.30	53.74	54.96	57.95
RF bandwidth (MHz)	220	220	220	220
Resolution (km at nadir)	105	105	105	105
NEΔT (K)	0.3	0.3	0.3	0.3
Dynamic range (K)	0–350	0–350	0–350	0–350
Scan width from nadir (degrees)	±47.4	±47.4	±47.4	±47.4
Antenna beamwidth (degrees)	7.5	7.5	7.5	7.5
Antenna beam efficiency (%)	>90	>90	>90	>90

Optics—Two scanning reflector antennas.
Scanner—9.5° stepper through 360° scan.
Data output—12-bit binary at a 0.32-kbps rate.

Technique:

- TED cylindrical electrostatic analyzer and spiraltron.
- MEPED solid-state detector telescopes and omnidetectors.

Electrical characteristics:

- Logarithmic digital data and 32-sec subcommutation of housekeeping in two 8-bit words per minor frame.
- Twelve commands.
- Fifteen analog housekeeping parameters.
- Fifteen digital discrete telemetry functions.

Performance:

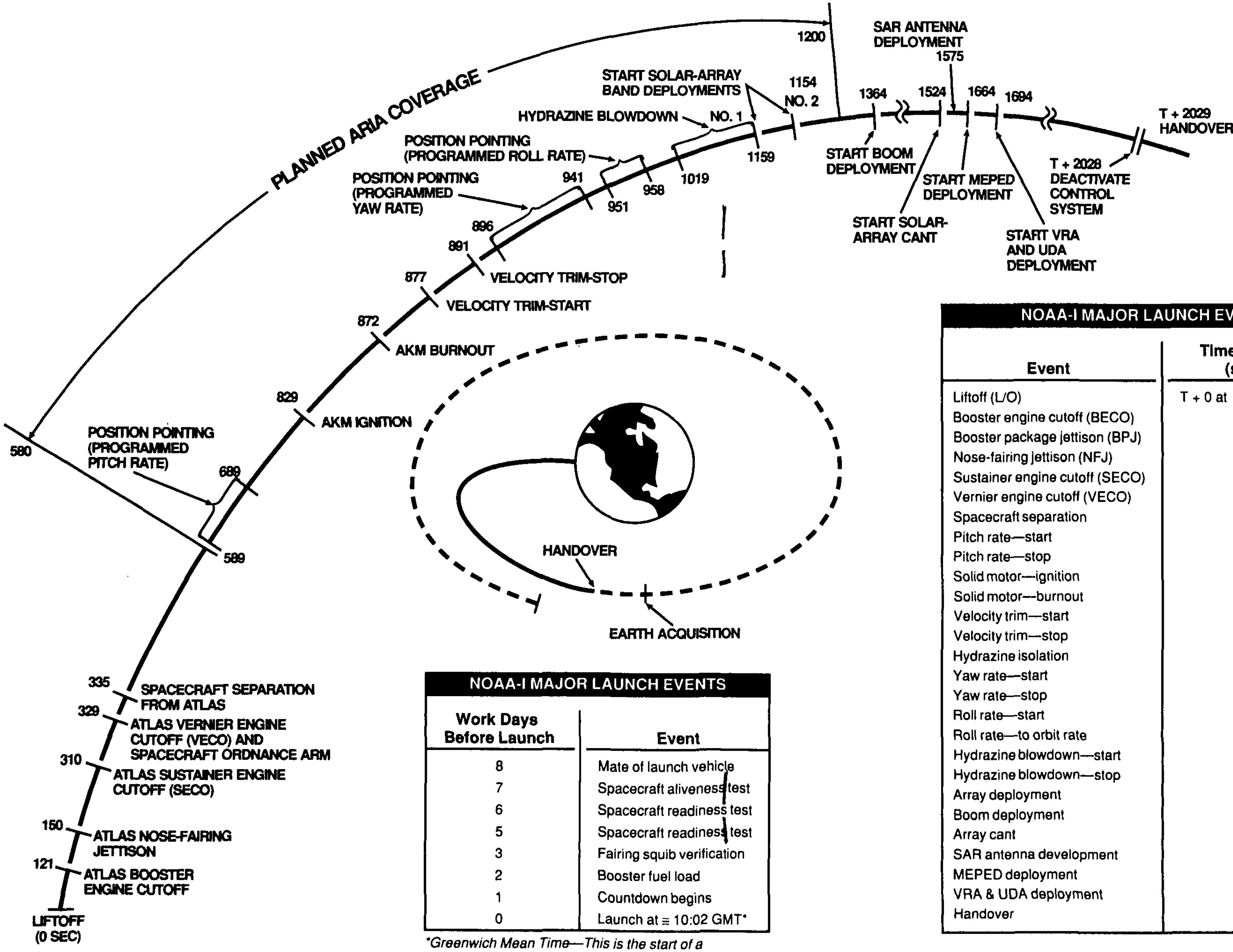
- TED: Proton: 0.3 to 20 keV in 11 bands.
  Electron: 0.3 to 20 keV in 11 bands.
- MEPED: Proton: 30 to 2500 keV in 5 bands.
  Electron: >30 to >300 keV in 3 bands.
  Ions: >6 MeV.
  Omniproton: >16 MeV, >36 MeV, >80 MeV.

SEARCH AND RESCUE (SAR) INSTRUMENTS
SAR REPEATER (SARR) *CRC/CANADA*
SAR MEMORY (SARM) *CNES/FRANCE*

The SAR instruments consist of a 3-band (121.5, 243, and 406.05 MHz) repeater SARR and a 406.025-MHz processor SARM. The SARR down link is at 1544.5 MHz and, besides the three repeated bands, also includes the 2,400 bps bit stream SARM output. GE ASD provided the antennas and interfaces and integrates the SARR and SARM into NOAA-I. The 121.5- and 406-MHz bands are also serviced by two Union of Soviet Socialist Republics (USSR) COSPAS satellites which, together with the NOAA satellites, provide improved timeliness of response.

The 121.5- and 243-MHz bands service emergency beacons are required on many aircraft, with a smaller number carried on maritime vessels. The 406-MHz band presently services the U.S. fishing fleet, which is required to carry emergency beacons, and large international ships, which soon will be required to carry them. The beacons also are carried by some aircraft and smaller vessels and are being used by terrestrial carriers.

The 406-MHz emergency beacon signals are immediately processed and stored on board the satellite and are transmitted to the ground from a continuous memory dump,



NOAA-I MAJOR LAUNCH EVENTS

Work Days Before Launch	Event
8	Mate of launch vehicle
7	Spacecraft aliveness test
6	Spacecraft readiness test
5	Spacecraft readiness test
3	Fairing squib verification
2	Booster fuel load
1	Countdown begins
0	Launch at ≅ 10:02 GMT*

**Greenwich Mean Time—This is the start of a 10-minute window.*

NOAA-I MAJOR LAUNCH EVENTS

Event	Time from Liftoff (seconds)
Liftoff (L/O)	T + 0 at 10:02 GMT
Booster engine cutoff (BECO)	121.5
Booster package jettison (BPJ)	124.6
Nose-fairing jettison (NFJ)	150.0
Sustainer engine cutoff (SECO)	310.5
Vernier engine cutoff (VECO)	329.6
Spacecraft separation	335.6
Pitch rate—start	589.3
Pitch rate—stop	689.3
Solid motor—ignition	829.2
Solid motor—burnout	872.7
Velocity trim—start	877.7
Velocity trim—stop	891.3
Hydrazine isolation	891.8
Yaw rate—start	896.3
Yaw rate—stop	946.3
Roll rate—start	951.3
Roll rate—to orbit rate	958.3
Hydrazine blowdown—start	1019.3
Hydrazine blowdown—stop	1159.3
Array deployment	1159.3
Boom deployment	1364.3
Array cant	1524.3
SAR antenna development	1564.3
MEPED deployment	1664.3
VRA & UDA deployment	1694.3
Handover	2029.3

Liftoff To Handover Launch Sequence

providing complete worldwide coverage. Around the world, ground station LUTs acquire the processed data and unique beacon identification and send these located and identified alerts to MCCs which forward the alerts to appropriate Rescue Coordination Centers for action. The 406-MHz beacons are designed to work well with the satellite, and the system nominally provides better than 4-km accuracy, 90 percent ambiguity resolution on first pass, and better than 90 percent location probability on one pass.

The 121.5/243-MHz emergency beacons, whose use predates the satellite system, have not been specified to work with the satellite; consequently the results are variable, depending on the quality of the beacon. Nominally, location accuracy is about 20 km. All the processing is accomplished within the LUT, and because the satellite does not store these data, only beacons with mutual view of the satellite and LUT will be detected. No identification is included with the 121.5/243-MHz transmissions; consequently, many non-beacon sources are also detected as beacons, increasing the difficulty of using these alerts. Even with these problems, the large number of these beacons in the field have provided an impressive performance history. More than 1,700 people have been saved by the SAR forces using satellite-derived locations, and for more than 300 of these people, the satellite provided the only means of alert.

ARGOS/DATA COLLECTION SYSTEM (DCS)

CNES/FRANCE

The ARGOS/DCS assists NOAA in its overall environmental mission. Platforms (buoys, free-floating balloons, and remote weather stations) collect relevant data and transmit them to the satellite. The onboard DCS receives the incoming signal, measures both the frequency and relative time of occurrance of each transmission, and the spacecraft retransmits these data via the CDA stations through SOCC to the central processing facility. The DCS information is decommutated and sent to the ARGOS processing center where it is processed, distributed, and stored on magnetic tape for archival purposes. The NOAA-I and J series DCS data rate has increased to 1,200 bits per second.

Characteristics of the DCS are—

- **System Specifications:**
  - Minimum platform/satellite elevation angle of visibility . . . . 0°
  - Number of platforms requiring location/velocity and four sensor channel, within the satellite visibility circle 520
  - Percentage of platforms with four good Doppler measurements per day . . . . >85 percent
  - Measured location accuracy 350m

➪ Data bits available . . . . 32 to 256

□ **Platform:**

➪ Nominal frequency emitted . . . . 401.65 MHz

➪ Oscillator stability drift (15 min) . . . . 0.5×10^{-9}/min

➪ Jitter . . . . 2×10^{-9}

➪ Power emitted . . . . 1 to 5 W

➪ Message

Repetition rate . . . . 90 sec for location, >200 sec for data collection

Coding: biphase, ... ±1.1 ±0.1 rad

Bit rate . . . . 400 bps

□ **Satellite.**

➪ Receiver

Noise factor: . . . . 3 deciBels (dB)

Bandwidth: . . . . ±12 kHz

➪ Data recovery units

Number 4

Frequency measurement accuracy . . . . 350 mHz rms

Time tagging accuracy . . . . better than 1 millisecond (ms)

➪ Interface to satellite telemetry system periodically interrogated buffer, average-bit rate . . . . 1,200 bps

ENERGETIC HEAVY ION COMPOSITION EXPERIMENT (EHIC)

UNIVERSITY of CHICAGO and the CANADIAN NRC HIA

The EHIC is designed to measure the chemical and isotopic composition of energetic particles between hydrogen and nickel over the energy range of 0.5 to 200 MeV/nucleon. The experiment will measure energetic solar flare particles in the polar regions where the Earth's magnetic field connects to the interplanetary field carried in the solar wind and will also measure trapped energetic particles in the magnetosphere. The primary scientific objective for the EHIC is to obtain elemental and isotopic composition data, which can be used to test models for solar flare ion acceleration, ion transport in interplanetary space, ion entry into the magnetosphere, and nucleosynthetic processes leading to the elemental and isotopic mix found at the Sun. The EHIC will provide data on the fluxes and energy spectra of heavy ions, which can cause single-bit upsets and damage to integrated circuits, found in the Sun-synchronous orbits used by NOAA and other environmental satellites.

MAGNETOSPHERIC ATMOSPHERIC X-RAY IMAGING EXPERIMENT (MAXIE)

LOCKEED MISSILES and SPACE COMPANY'S PALO ALTO RESEARCH LABORATORY with the ASSISTANCE of the AEROSPACE CORPORATION and NORWAY'S UNIVERSITY of BERGEN.

The MAXIE maps the intensities and energy spectra of x rays produced by electrons that precipitate into the atmosphere. With mechanical scanning, the MAXIE will obtain new high-resolution x-ray imaging data on auroral and substorm processes with a temporal resolution and repetition rate that has not previously been available. By repeated scans of the atmosphere, the MAXIE will provide the opportunity to study temporal variations on a fast time scale that has yet to be accomplished.

COMMUNICATIONS AND DATA HANDLING

The communications subsystem uses 10 separate transmission links to handle communications between the satellite and the ground stations. Table 6 summarizes the communications links.

Communications and data handling characteristics are—

- TIROS Information Processor (TIP):
  - Flexible low-rate data formatter and telemetry processor.
  - Boost, orbit, and dwell modes.
  - 8,320 bps (orbit).
  - 16,640 bps (boost).
- MIRP:
  - High-rate data formatter and processor.
  - Performs multiplexing, formatting, resolution reduction, and geometric correction functions.
  - Analog Automatic Picture Transmission (APT): Global Area Coverage (GAC) data (66.54 kbps); High-Resolution Picture Transmission (HRPT) data (665.4 kbps); Local Area Coverage (LAC) data (665.4 kbps) outputs.
- DTR:
  - Five digital data recorders.

Table 6: Communications and Data Handling

Link	Carrier Frequency	Information Signal	Baseband	Modulation	Subcarrier Frequency
Command*	148.56 MHz	Digital commands	1 kbps	Ternary frequency-shift keyed (FSK/AM)	8, 10, and 12 kHz
Beacon	137.77 and 136.77 MHz	HIRS, SSU, MSU, SBUV/2 SEM, DCS data, spacecraft attitude data, time code, housekeeping telemetry, memory verification; all from TIP	8,320 bps	Split-phase phase-shift keyed (PSK)	
VHF real time	137.50 and 137.62 MHz	Medium-resolution video data from AVHRR	2 kHz	AM/FM	2.4 kHz
S-band real time	1,698 or 1,707 MHz	High-resolution video and TIP data	665.4 kbps	Split-phase PSK	
S-band playback	1,698, 1,702.5, or 1,707 MHz	High-resolution AVHRR data from MIRP, medium-resolution AVHRR data from MIRP; all TIP outputs	2.6616 Mbps	Randomized nonreturn-to-zero/PSK	
Data collection (uplink)	401.65 MHz	Earth-based platforms and balloons	400 bps	Split-phase PSK	
S-band playback to European ground station	1,698, 1,702.5, or 1,707 MHz	TIP data recovered from tape recorders	332.7 kbps	Split-phase PSK	
S-band contingency and launch	2,247.5 MHz	Boost during ascent and real-time TIP in orbit	Boost 16.64 kbps TIP in orbit 8.32 kbps	Split-phase PCM/BPSK	1,024 MHz
SAR L-band downlink	1,544.5 MHz	Data transmission from SARR and SARP to ground LUTs	250 kHz	PM 2 rad peak	
SAR uplinks	SARR 121.5 MHz 243 MHz 406.05 MHz SARP 406.025 MHz	From ground ELT/EPIRBs/PLBs to spacecraft	(video) 25 kHz for 121.5 MHz 45 kHz for 243 MHz 400 bps for 406 MHz	PM for 121.5/243 MHz FM for 406 MHz	

**Uplink to the satellite*

HIGH-RESOLUTION RADIOMETRY

One of the objectives of high-resolution radiometry is to provide timely day and night sea-surface temperature and ice, snow, and cloud cover information to diverse classes of users. The AVHRR is used to obtain these data. Requirements include—

- Worldwide direct readout to ground stations of the APT class, at low resolution (4 km).
- Worldwide direct readout to ground stations of the HRPT class (1-km resolution).
- GAC data at relatively low resolutions (4 km) for central processing.
- LAC data from selected portions of each orbit at high resolution (1 km) for central processing.

DATA TRANSMISSION

The sounder system data along with radiometry data will be telemetered through the TIP telemetry system on NOAA-I. Data will be transmitted at full resolution in the following modes:

- Worldwide direct TIP data transmission (beacon link).
- Worldwide direct TIP data multiplexed with HRPT.
- TIP data multiplexed with low-resolution AVHRR data stored and played back GAC.
- TIP data multiplexed with full-resolution AVHRR data stored and played back LAC.
- TIP-only data stored and played back during blind orbits.

COMMAND

The CDA stations control the operation of the satellite by programmed commands transmitted to the satellite on a 148-MHz radio signal. The following is a list of command characteristics:

- Command-link bit rate: 1,000 bps.
- Stored commands.
  - Table capacity: 1,800 commands at launch and on orbit. (Table capacity reduced to accomodate the new MACRO command capability)
  - Time tag: 1.0-second granularity, 36-hour clock.

GROUND SYSTEM

A principal operating feature of the ATN system is the centralized remote control of the satellite, through the CDA stations, by the NOAA National Environmental Satellite Data and Information Service (NESDIS) SOCC. The ground system is made up of the Polar Acquisition and Control System (PACS) and the central processing system, designated the Data Processing Services Subsystem (DPSS): The SAR ground system consists of LUTs and MCC.

NATIONAL ENVIRONMENTAL SATELLITE DATA AND INFORMATION SERVICE (NESDIS) SATELLITE OPERATIONS CONTROL CENTER (SOCC)

The central operations and control center for satellite operations is located at Suitland, MD. SOCC is responsible for operational control of the entire ground system and for the following areas:

CDA Stations—The primary command and data acquisition stations are located at Fairbanks, AK, and Wallops Island, VA. Through a cooperative agreement between NOAA/NESDIS and the Etablissement d'Etudes et de Recherches Meteorologiques (EERM) in France, stored and real-time TIP data can be relayed from the Lannion Centre de Meteorologie Spatiale (CMS) via the Geostationary Operational Environmental Satellite (GOES) satellite.

The CDA stations transmit command programs to the satellite and acquire and record meteorological and engineering data from the satellite. All data are transmitted between CDA and Suitland via commercial communications links. Commands are transmitted between SOCC and CDA via commercial communications links.

Ground Communications—The ground communications links for satellite operations are provided by the Satellite Communications Network (SATCOM) and NASA Communications Network (NASCOM). NASCOM provides any launch-unique communications links for satellite launch. This support is defined in the Network Operations Support Plan (NOSP) and the NASA Support Plan (NSP). SATCOM provides all voice and data links between the SOCC and the CDA stations after launch. SATCOM is provided and operated by NESDIS.

NESDIS Data Processing Services Subsystem (DPSS)—DPSS acquires data from the CDA stations via SOCC and is responsible for data processing and the generation of meteorological products on a timely basis to meet the TIROS program requirements. NOAA provides all hardware and software for DPSS. NOAA will provide ephemeris data and strip out SAR data from MIRP/GAC data dumps and transmit them to U.S. and Canadian SAR MCCs.

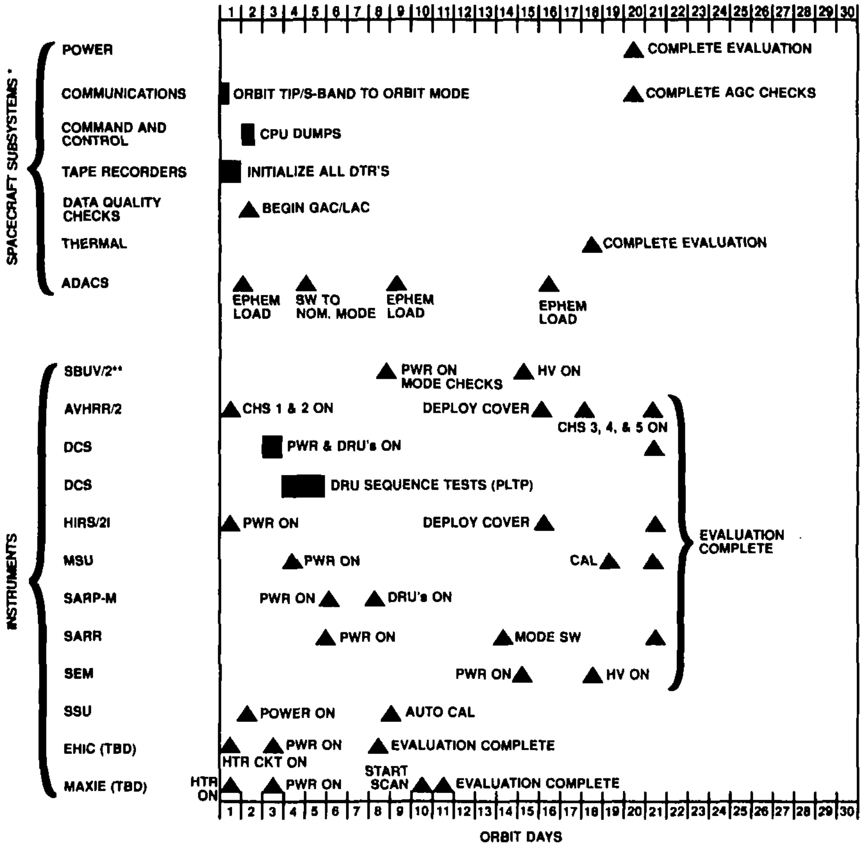
SAR Ground System(LUTs and MCCs)—The U.S. LUTs are located at Scott Air Force Base, Belleville, IL; Point Reyes, CA; and Kodiak, AK. Additional LUTs are being procured for expanded ocean area coverage. The LUTs receive the SAR data from the satellite, determine the distress location, and forward the data to the MCC at Suitland, MD. The MCC determines the proper Rescue Coordination Center and forwards the distress location data after removing redundant information. There are also MCCs and LUTs in Canada, France, the USSR, Norway, the UK, and many other cooperating countries. All MCCs cooperate in forwarding data to provide rapid global delivery of distress locations received through the satellites.

GSFC Facility Support—The Office of Space Tracking and Data Systems (OSTDS) associated support is requested through the Support Instrumentation Requirements Document (SIRD), with other support as described in Memoranda of Understanding.

During launch and early orbit (approximately 24 hours), special VHF support for telemetry reception and contingency commanding is being provided by Santiago, Chili, on an as-available and best-effort basis. Santiago is required to provide emergency support for TIROS spacecraft if requested during their operational lifetime, provided NASA funding for site support continues.

The North American Air Defense Command (NORAD) has prime responsibility for orbit determination, which includes establishing the initial orbit solution and providing updated orbital parameters routinely throughout the life of the mission. NORAD provides the orbital information through the NASA/Goddard Space Flight Center (GSFC) communications to NOAA/SOCC. NASA/GSFC provides nominal prelaunch orbital and prediction information, special support for initial orbit estimation, and initial quality-control checks of the NORAD orbital data. All ground attitude determination is to be accomplished by the NOAA central data processing facility.

Launch and Contingency Downlink—An S-band downlink operating at 2,247.5 MHz is used during satellite ascent to recover TIP boost telemetry through WSMC tracking sites and the Advanced Range Instrumentation Aircraft (ARIA). During in-orbit operations, orbit mode TIP will be available on this link to provide early-orbit and contingency support through the ground tracking network operated by the Air Force Satellite Control Network (AFSCN) in Sunnyvale, CA.



*Subsystem baseline evaluation and operational configuration complete on Day 4

**SBUV/2 - Completion of SBUV: load flex memory Day 35; open lamp assembly Day 40; begin wavelength calibration Day 47; checkout complete Day 52

NOAA-I Activation and Evaluation Timeline

GLOSSARY

ADACS Attitude Determination and Control Subsystem

AFSCN Air Force Satellite Control Network

AKM Apogee Kick Motor

AM Amplitude Modulation

APT Automatic Picture Transmission

ARGOS French Data Collection System

ARIA Advanced Range Instrumentation Aircraft

ATN Advanced TIROS-N

AVHRR Advanced Very High Resolution Radiometer

BASD Ball Aerospace Division

bps bits per second

BPSK biphase shift key

Cd Cadmium

CDA Command and Data Acquisition

CHS channels

cm centimeter(s)

CMS Centre de Meteorologie Spatiale

CNES Centre National d'Etudes Spatiales

CRC DOC Communications Research Center

dB decibel(s)

DCS Data Collection System

DOC Department of Communications (Canada)

DPSS Data Processing Services Subsystem

DPU data processing unit

DRU Data Recovery Unit

DTR Digital Tape Recorder

EERM Etablissement d'Etudes et de Reserches Meteorologiques

EHIC Energetic Heavy Ion Composition Experiment

ELT Emergency Locator Transmitter

EPHEM ephemeris

EPIRB Emergency Position Indicating Radio Beacon

ERBE Earth Radiation Budget Experiment

ERBE-NS Earth Radiation Budget Experiment-Non Scanner

FM frequency modulation

FSK frequency shift keyed

ft feet

GAC Global Area Coverage

gal gallon(s)

GDSSD General Dynamics Space Systems Division

GE-ASD General Electric-Astro Space Division

GERTS General Electric Radio Tracking System

GHz gigahertz

GOES Geostationary Operational Environmental Satellite

GSFC Goddard Space Flight Center

Hg mercury

HIA Herzberg Institute for Astrophysics

HIRS High Resolution Infrared Sounder

HRPT High-Resolution Picture Transmission

HV high voltage

IFOV instantaneous field of view

IMP Instrument Mounting Platform

In Indium

In inch(es)

ITT International Telephone and Telegraph

K kelvin temperature in degrees

kbps thousand bits per second

keV kiloelectronvolts

kg kilogram(s)

kHz kilohertz

kl kiloliter(s)

km kilometers

LAC Local Area Coverage

lb pound(s)

LUT Local User Terminal

m meter(s)

MARCO Command System for Space Test Program Instruments

MAXIE Magnetospheric Atmospheric X-Ray Imaging Experiment

MCC Mission Control Center

MEPED Medium-Energy Proton/Electron Detector

MeV megaelectronvolt(s)

mHz megahertz

mHz millihertz

min minute(s)

MIRP Manipulated Information Rate Processor

ms millisecond(s)

MSU Microwave Sounding Unit

N newton

NASA National Aeronautics and Space Administration

NASCOM NASA Communications

NEΔT Noise Equivalent Radiance

NESDIS National Environmental Satellite Data and Information Service

nm nanometer(s)

NOAA National Oceanic and Atmospheric Administration

NOM nominal

NORAD North American Air Defense Command

NOSP Network Operations Support Plan

NRC National Research Council

NSP NASA Support Plan

OSTDS Office of Space Tracking and Data Systems

PACS Polar Acquisition and Control Subsystem

PCM pulse code modulation

PLB Personal Locator Beacon

PLTP platform test procedure

PM phase modulated

PSK phase shift keyed

RXO Redundant Crystal Oscillator

SAR Search and Rescue

SARM SAR Processor with Memory

SARR SAR Repeater

SARSAT Search and Rescue Satellite Aided Tracking

SATCOM Satellite Communications Network

Sb Antimony (Stibium)

SBUV Solar Backscatter Ultraviolet Radiometer

sec second(s)

SEL Space Environmental Lab

SI Silicon

SOCC Satellite Operations Control Center

SSU Stratospheric Sounding Unit

SW shortwave/switch

Te Tellurium

TED Total-Energy Detector

TGS triglycine sulfate

TIROS Television Infrared Observation Satellite

TIP TIROS Information Processor

TOVS TIROS Operational Vertical Sounder

UDA Ultra-High-Frequency Data Collection System Antenna

UK United Kingdom

USAF U.S. Air Force

USSR Union of Soviet Socialist Republics

VDA VHF collection system antenna

VHF very high frequency

VRA VHF real-time antenna

W watt(s)

WOMS NESDIS CDA Station, VA

WSMC Western Space and Missile Center