NOAA-N

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

U.S. Department of Commerce
National Oceanic and
Atmospheric Administration
National Environmental Satellite,
Data, and Information Service
Suitland, Maryland

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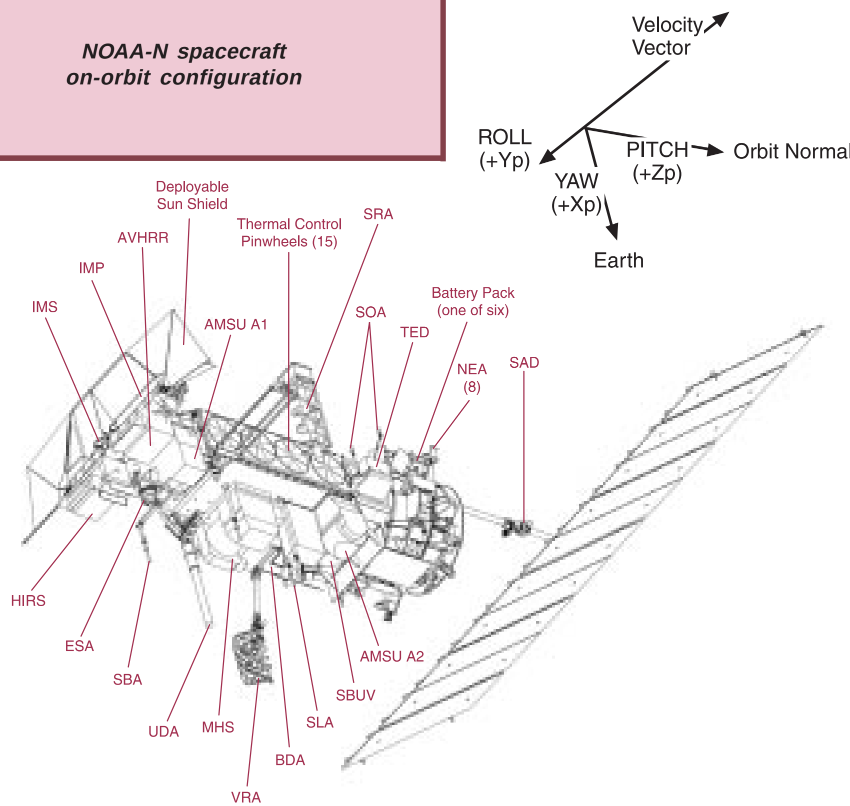
NOAA-N spacecraft on-orbit configuration



LEGEND

AMSU	Advanced Microwave Sounding Unit
AVHRR	Advanced Very High Resolution Radiometer
BDA	Beacon Dipole Antenna
*DCS	Data Collection System
ESA	Earth Sensor Assembly
HIRS	High Resolution Infrared Radiation Sounder
IMP	Instrument Mounting Platform
IMS	Inertial Measurement System
*MEPED	Medium Energy Proton/Electron Detector
MHS	Microwave Humidity Sounder
NEA	Nitrogen Engine Assembly
SAD	Solar Array Drive
*SAR	Search and Rescue
SBA	S-Band Antenna
SBUV	Solar Backscatter Ultraviolet Radiometer
SLA	Search and Rescue Transmitting Antenna (L-Band)
SOA	S-Band Omni Antenna (2 of 6 shown)
SRA	Search-and-Rescue Receiving Antenna
TED	Total Energy Detector
UDA	Ultra High Frequency Data Collection System Antenna
VRA	Very High Frequency Real-time Antenna

*Not shown in this view

POES PROGRAM

The NOAA Polar-Orbiting Satellites

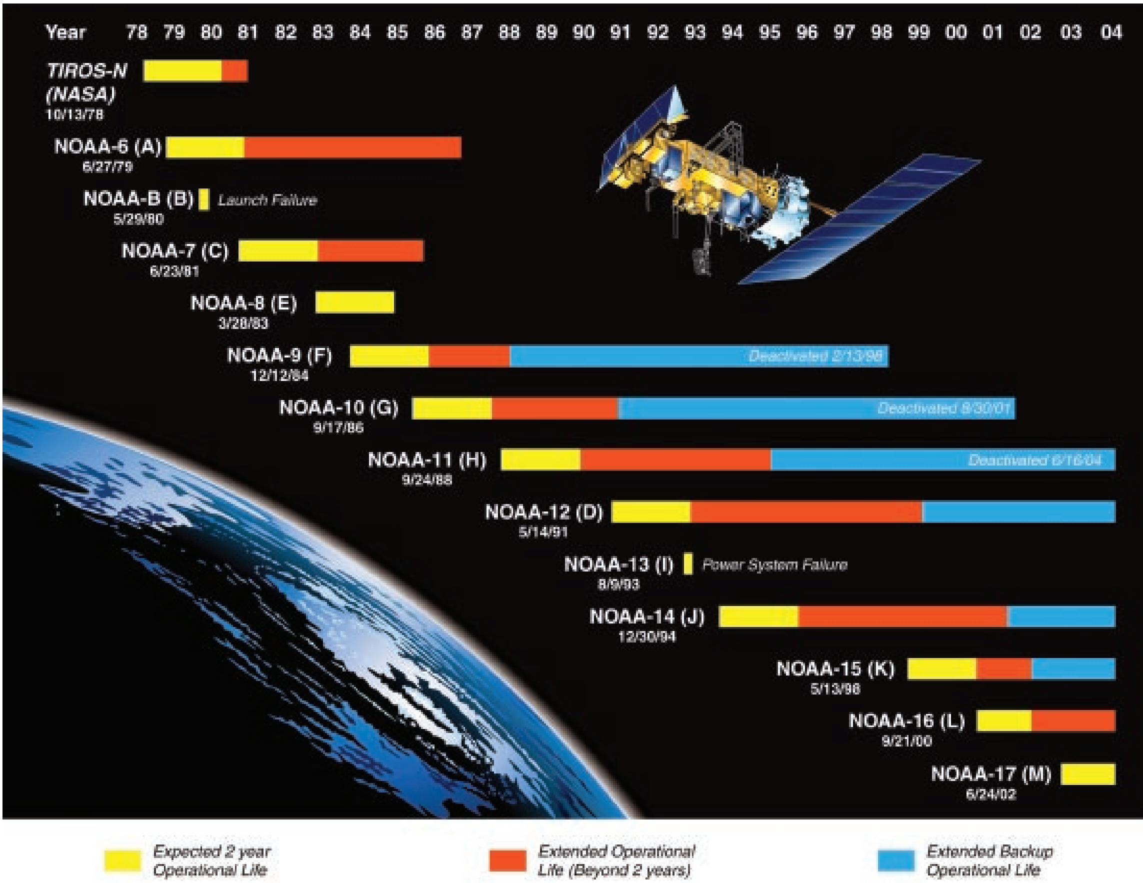
The National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) have jointly developed a valuable series of Polar Operational Environmental Satellites (POES). These Advanced TIROS-N (ATN) spacecraft, named after the prototype satellite, TIROS-N (Television Infrared Observation Satellites), have been flying since 1978.

The system consists of a pair of satellites, which ensures that every part of the Earth is regularly observed at least twice every 12 hours. The satellites provide global coverage of numerous atmospheric and surface parameters, furnishing quantitative measurements for input to global atmospheric and surface forecast models. As users around the world have learned how to exploit this quantitative radiometric satellite data routinely, the consistency and accuracy of predictions of potentially catastrophic environmental events have improved significantly. Better prediction of these events allows emergency managers to activate plans to reduce their effect and protect life and property. In addition, this continuous overlapping source of satellite data has provided the foundation for extensive climate and research programs. In many developing countries and over much of the oceans, satellite data is the only source of quantitative information on the state of the atmosphere and of the Earth's surface, and is an invaluable source of real-time information about severe weather, critical for safety in these remote areas.

The satellites also support an international search and rescue program. Since 1982, this program is credited with saving more than 17,000 lives by detecting and locating emergency beacons from ships, aircraft, and people in distress.

Initial Joint Polar-Orbiting Operational Satellite System

The launch of NOAA-N inaugurates a new era of international cooperation and introduces a new model for future polar-orbiting environmental satellite systems. On November 19, 1998, the Administrator of NOAA and the Director-General of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) signed an agreement creating the Initial Joint Polar-Orbiting Operational Satellite (IJPS) System. The primary mission of the IJPS is to collect and exchange polar satellite environmental data between NOAA and EUMETSAT and to disseminate this data to users worldwide in support of continued and improved operational meteorological and environmental forecasting and global climate monitoring. These services have been furnished largely by NOAA since 1960 with the assistance of a few international partners



This figure summarizes the operational and extended lifetimes of the TIROS satellites.

who have provided additional instruments to complete the satellites' sensor suites. This agreement commits NOAA to provide the NOAA-N and -N' satellites for launch into an afternoon orbit (the satellites will cross the Equator northbound in the afternoon), carrying the EUMETSAT-provided Microwave Humidity Sounder (MHS) along with the NOAA-provided suite of instruments. EUMETSAT, in turn, agrees to provide and launch two European-built meteorological satellites, Metop-1 and Metop-2, into a morning orbit carrying the NOAA payload as well as several new sensors developed by EUMETSAT. Additionally, both NOAA and EUMETSAT will upgrade their ground systems to receive, process, and distribute data from each other's satellites and will back up each other in the event of anomalies. The launch of the first Metop satellite will follow the NOAA-N launch by about a year and pick up coverage of the morning orbit now provided by NOAA-17. When NOAA-N and Metop-1 need replacing, NOAA-N' and the second Metop satellite will be placed into service in their respective orbits.

NOAA-N

Lockheed Martin Space Systems Company

NOAA-N is the latest satellite in the ATN series built by Lockheed Martin Space Systems Company (LMSSC). This spacecraft will continue to provide a polar-orbiting platform to support (1) environmental monitoring instruments for imaging and measuring the Earth's atmosphere, its surface and cloud cover, including Earth radiation, atmospheric ozone, aerosol distribution, sea surface temperature, and vertical temperature and water profiles in the troposphere and stratosphere; (2) measurement of proton and electron flux at orbit altitude; (3) data collection from remote platforms; and (4) the Search and Rescue Satellite-Aided Tracking (SARSAT) system. Additionally, NOAA-N is the fourth in the series to support dedicated microwave instruments for the generation of temperature, moisture, surface, and hydrological products in cloudy regions where visible and infrared (IR) instruments have decreased capability.

NOAA-N CHARACTERISTICS

Main body:	4.19 m (13.75 ft) long, 1.88 m (6.2 ft) diameter
Solar array:	2.73 by 6.14 m (8.96 by 20.16 ft); 16.76 m^2 (180.63 ft^2)
Weight:	At lift-off ~1419.8 kg (3130 lb); weight includes 4.1 kg (9 lb) of gaseous nitrogen
Lifetime:	Greater than 2 years
Load Power Requirements	833 W for 0° Sun angle, 750 W for 80° Sun angle

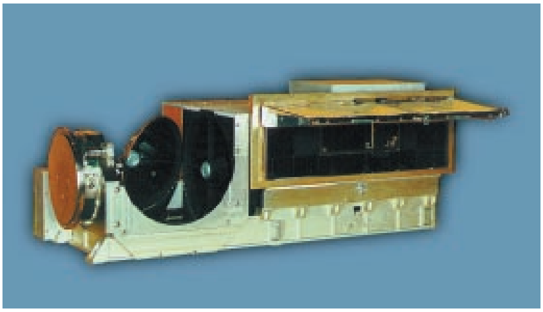
NOAA-N INSTRUMENTS

The NOAA-N primary instruments—the Advanced Very High Resolution Radiometer (AVHRR), High Resolution Infrared Radiation Sounder (HIRS), and the Advanced Microwave Sounding Unit (AMSU-A)—have all been designed for a three-year mission. Detailed information on each of these instruments, as well as for the Solar Backscatter Ultraviolet Radiometer (SBUV/2), designed for a two-year mission, and the Microwave Humidity Sounder (MHS), designed for a five-year mission, is found in Appendix A.

The NOAA-N spacecraft carries the following instruments (manufacturers are shown in italics).

ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR/3)
ITT A/CD

The AVHRR/3 is a six-channel imaging radiometer that detects energy in the visible and IR portions of the electromagnetic spectrum. The instrument measures reflected solar (visible and near-IR) energy and radiated thermal energy from land, sea, clouds, and the intervening atmosphere. The instrument has an instantaneous field of view (IFOV) of 1.3 milliradians, providing a nominal spatial resolution of 1.1 km (0.69 mi) at nadir. A continuously rotating elliptical scan mirror provides the cross-track scan, scanning the Earth from ±55.4° from nadir. The mirror scans at six revolutions per second to provide continuous coverage.

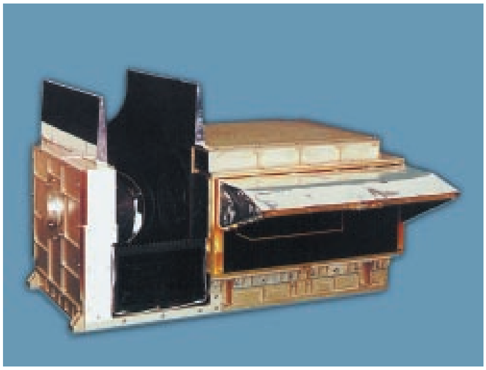


AVHRR/3

The AVHRR/3 provides spectral and gain improvements to the solar visible channels that provide low light energy detection. Channel 3A, at 1.6 micrometers (μm), provides snow, ice, and cloud discrimination. Channel 3A is time-shared with the 3.7-μm channel, designated 3B, to provide five channels of continuous data. The hysteresis scan mirror motor has been replaced with a Brushless DC motor for the NOAA-N spacecraft. This motor is more reliable and operates with significantly less jitter.

HIGH RESOLUTION INFRARED RADIATION SOUNDER (HIRS/4)
ITT-A/CD

The HIRS/4 is an atmospheric sounding instrument that provides multispectral data from one visible channel (0.69 μm), seven shortwave channels (3.7–4.6 μm), and 12 longwave channels (6.7–15 μm) using a single telescope and a rotating filter wheel containing 20 individual spectral filters. The IFOV for each channel is approximately 0.7° that, from a spacecraft altitude of 870 km (470 nmi), encompasses a circular area of 10 km (6.2 mi) in diameter at nadir on Earth. This is an improvement in resolution over the 20-km (12.4-mi) HIRS/3 instrument that was flown on the NOAA-KLM series. An elliptical scan mirror provides a cross-track scan of 56 steps of 1.8° each. The mirror steps rapidly, then holds at each position while the optical radiation passing through the 20 spectral filters is sampled. Each Earth scan takes 6.4 seconds and covers



HIRS/4

±49.5° from nadir. IR calibration of the HIRS/4 is provided by views of space and the internal warm target, each viewed once per 38 Earth scans.

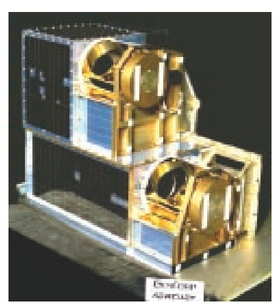
The instrument measures scene radiance in the IR spectrum. Data from the instrument is used, in conjunction with the AMSU instruments, to calculate the atmosphere's vertical temperature profile from the Earth's surface to about 40 km (24.9 mi) altitude. The data is also used to determine ocean surface temperatures, total atmospheric ozone levels, precipitable water, cloud height and coverage, and surface radiance.

ADVANCED MICROWAVE SOUNDING UNIT-A (AMSU-A)

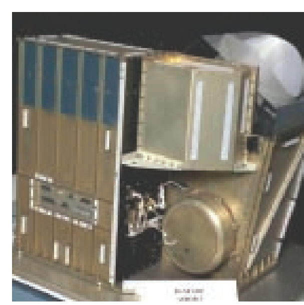
Northrop Grumman Electronic Systems

The AMSU-A measures scene radiance in the microwave spectrum. The data from this instrument is used in conjunction with the HIRS to calculate global atmospheric temperature and humidity profiles from the Earth's surface to the upper stratosphere, approximately a 2-millibar pressure altitude (48 km or 29.8 mi). The data is used to provide precipitation and surface measurements including snow cover, sea ice concentration, and soil moisture.

The AMSU-A is a cross-track scanning total power radiometer. It is divided into two physically separate modules, each of which operates and interfaces with the spacecraft independently. Module A-1 has 13 channels, and Module A-2 has two channels.



AMSU-A1



AMSU-A2

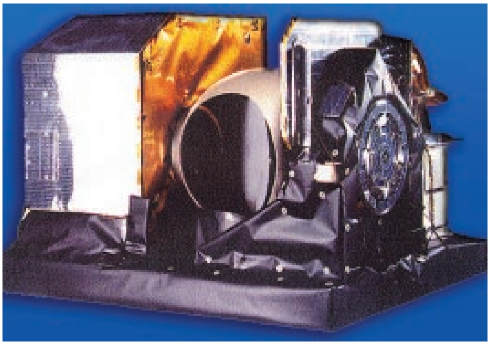
The instrument has an IFOV of 3.3° at the half-power points, providing a nominal spatial resolution at nadir of 48 km (29.8 mi). The antenna provides a cross-track scan, scanning ±48.3° from nadir with a total of 30 Earth fields of view per scan line. The instrument completes one scan every 8 seconds.

MICROWAVE HUMIDITY SOUNDER (MHS)

EADS Astrium Ltd via EUMETSAT

The MHS is a new instrument for the NOAA series of satellites. It is a five-channel microwave instrument intended primarily to measure profiles of atmospheric humidity. It is also sensitive to liquid water in clouds and so measures cloud liquid water content. Additionally, it provides qualitative estimates of the precipitation rate.

Because of the high variability of atmospheric water, the MHS has a higher resolution than the AMSU-A, with an approximate 16-km (10-mi)-diameter circular field of view at nadir. Ninety such fields of view are measured in each cross-track scan. The instrument has approximately the same swath width as AMSU-A but scans across-track in one-third the time so as to keep the two instruments synchronized. By this means, arrays of 3 x 3 MHS samples will overlay each AMSU-A sample, facilitating synergistic use of these instruments.



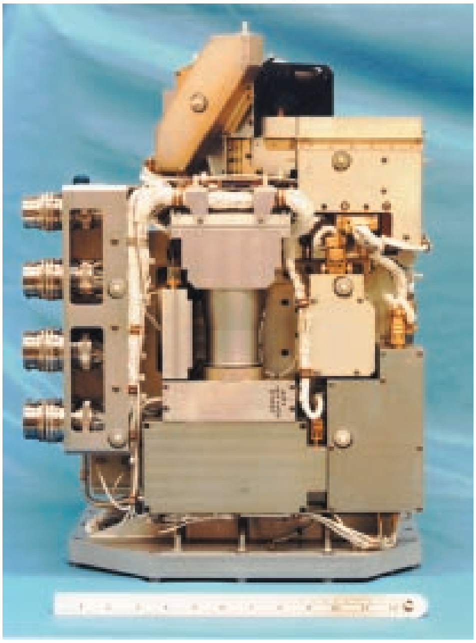
MHS

MHS has four humidity sounding channels in the 157–190-GHz range. As with AMSU-A, it also has a surface-viewing window channel at 89 GHz, partly to ensure cross-registration of the two sounding instruments.

SOLAR BACKSCATTER ULTRAVIOLET RADIOMETER (SBUV/2)

Ball Aerospace

The SBUV/2 is a nadir-pointing, nonspatial, spectrally scanning, ultraviolet radiometer carried in two modules. The two modules are the Sensor Module, with optical elements/detectors, and the Electronics Module. The overall spectral resolution is approximately 1 nanometer (nm). Two optical radiometers form the heart of the instrument: a monochrometer and a Cloud Cover Radiometer (CCR). The monochrometer measures the Earth radiance directly and the Sun selectively when a diffuser is deployed. The CCR measures the 379-nm wavelength and is co-aligned to the monochrometer. The output of the CCR represents the amount of cloud cover in a scene and is used to remove cloud effects in the monochrometer data.



SBUV/2

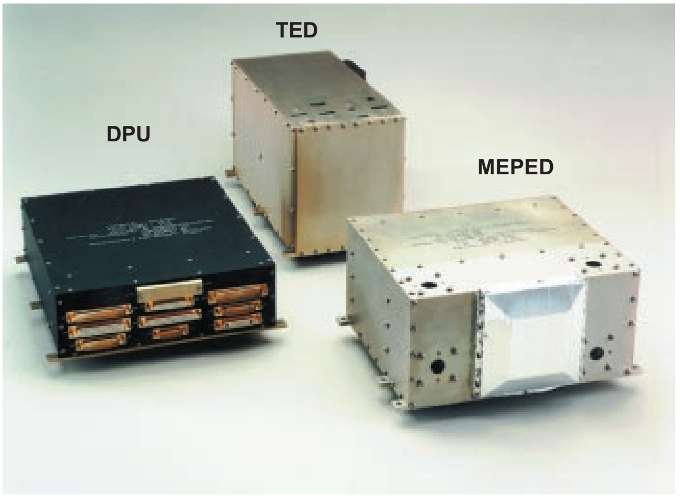
The SBUV/2 measures solar irradiance and Earth radiance (backscattered solar energy) in the near ultraviolet spectrum (160–400 nm). The following atmospheric properties are measured from this data:

- The global ozone concentration in the stratosphere to an absolute accuracy of 1 percent.
- The vertical distribution of atmospheric ozone to an absolute accuracy of 5 percent.
- The long-term solar spectral irradiance from 160–400 nm.
- Photochemical processes and the influence of “trace” constituents on the ozone layer.

SPACE ENVIRONMENT MONITOR (SEM-2)

Panametrics via NOAA Space Environment Center

The SEM-2 provides measurements to determine the intensity of the Earth’s radiation belts and the flux of charged particles at satellite altitude. It provides knowledge of solar terrestrial phenomena as well as warnings of solar wind occurrences that may impair long-range communications and high-altitude operations, damage satellite circuits and solar panels, or cause changes in drag and magnetic torque on satellites.



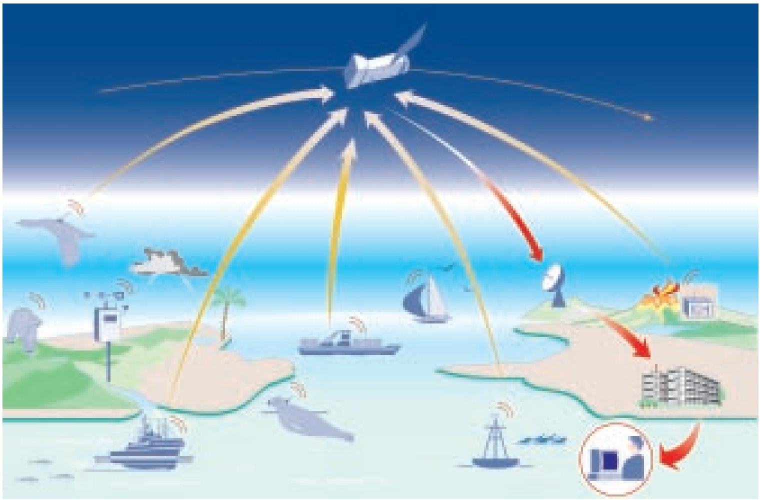
Space Environment Monitor

The SEM-2 consists of two separate sensor units and a common Data Processing Unit (DPU). The sensor units are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED).

The TED senses and quantifies intensity in the sequentially selected energy bands. The particles of interest have energies ranging from 0.05–20 keV. The MEPED senses protons, electrons, and ions with energies from 30 keV to levels exceeding 6.9 MeV.

DATA COLLECTION SYSTEM (DCS/2)
CNES/France/Thales

A wide variety of data collection platforms dedicated to environmental study and protection collect and transmit data within the 401.610-MHz to 401.690-MHz DCS/2 receiver bandwidth. These platforms consist mainly of drifting and moored buoys, subsurface floats, remote weather stations that serve meteorological and oceanographic applications, fishing vessels for fishing resource management, and tracking animals for biological and species protection purposes. The platforms relay data such as atmospheric pressure, sea surface temperature and salinity, surface and subsurface ocean currents, sea and river levels, vessel positions, and animal temperature and activity. The DCS onboard the satellite collects the messages transmitted by the platforms and measures its received frequency. The data is transmitted in real time along with the High Resolution Picture Transmission (HRPT) data and is also stored onboard for later transmission from the satellite.



Data Collection System

The stored data is transmitted to the ground once per orbit to NOAA Command and Data Acquisition (CDA) stations at Wallops Island, Virginia, and Fairbanks, Alaska, and then relayed to Argos ground processing centers in Largo, Maryland, and Toulouse, France, for data processing and dissemination.

DCS Processing Centers

The ground processing centers process the frequencies measured onboard the satellite and locate the mobile platforms using the Doppler effect. Location accuracies range from 150–1000 m (492–3281 ft) on average. For special applications, Global Positioning System fixes included in the messages sent by the platforms also help obtain better accuracy for regular and frequent locations.

SEARCH AND RESCUE (SAR) INSTRUMENTS

Search and Rescue Repeater (SARR) Canada/EMS
Search and Rescue Processor (SARP) CNES/France/Thales

The SAR instruments are part of the international COSPAS-SARSAT system designed to detect and locate Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs), and Personal Locator Beacons (PLBs) operating at 121.5 MHz, 243 MHz, and 406 MHz. The NOAA spacecraft carry two instruments to detect these emergency beacons: the Search and Rescue Repeater (SARR) provided by Canada and the Search and Rescue Processor (SARP-2) provided by France. Similar instruments are carried by the Russian COSPAS polar-orbiting satellites.

The SARR transmits the signals of 121.5-MHz, 243-MHz, and 406-MHz emergency beacons on a 1544-MHz downlink frequency. However, these beacon signals are detected on the ground only when the satellite is in view of a ground station known as a Local User Terminal (LUT). The SARP detects signals only from 406-MHz beacons and retransmits them to a LUT as described above. In addition, the SARP stores the information for subsequent downlink to a LUT; thus, global detection of 406-MHz emergency beacons is provided by the SARP.

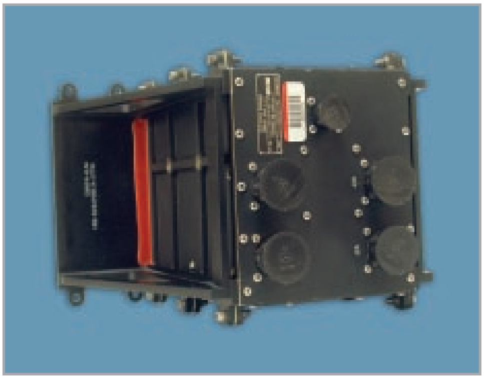
After receipt of information from a satellite's SARP or SARR, a LUT locates the beacons by Doppler processing. The 121.5-MHz and 243-MHz beacons are located with an accuracy of approximately 20 km (12.4 mi), whereas the 406-MHz beacons are located with an accuracy of approximately 4 km (2.5 mi). The LUT forwards location information to a corresponding Mission Control Center (MCC) that, after further processing, forwards the information to an appropriate Rescue Coordination Center (RCC) that effects search and rescue.

The U.S. fishing fleet is required to carry 406-MHz emergency beacons. The 406-MHz beacons are also carried on most large international ships, some aircraft and pleasure vessels, and are available for personal use as well. The 121.5-MHz and 243-MHz beacons are required on many small aircraft with a smaller number carried on maritime vessels.

Search and Rescue Sequence of Events

DIGITAL DATA RECORDER (DDR)
L-3 Communications

The DDR is a complete recording and data storage system that stores selected sensor data during each orbit for subsequent playback. The recorder is part of the Command and Data Handling subsystem of the spacecraft that downloads data to NOAA CDA stations. It replaces the digital tape recorders flown on previous POES satellites. The DDRs record and play back TIROS Information Processor (TIP), AMSU Information Processor (AIP), and Manipulated Information Rate Processor (MIRP) output data. The two memories within each DDR are independent but share a single interface to the spacecraft cross-strap unit (XSU), so they may be used simultaneously. Two DDRs are packaged within a common chassis called a Solid State Recorder (SSR) and share a single power supply. The spacecraft has five DDRs with DDR #5 configured as a double-capacity recorder.



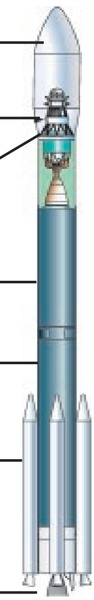
Solid State Recorder

The SSR packages use solid-state Dynamic Random Access Memory devices for storage. They provide a storage capacity of 2.4 Gbits (1.2 Gbits per DDR) and superior bit error rate performance with its custom Error Detection and Correction circuitry.

DELTA II LAUNCH VEHICLE

Boeing Space and Defense

The NOAA-N satellite will be launched from the Western Range (WR) at Vandenberg AFB, California, by a two-stage Delta II 7320-10 space launch vehicle (SLV). A Boeing Rocketdyne-built RS-27A main engine will power the first stage. Three thrust augmentation graphite epoxy motors (GEMs) built by Alliant Techsystems will provide added boost. The second stage will be powered by Aerojet's AJ10-118K liquid propellant engine. The Delta II second stage engine is restarted in flight and works in conjunction with the Redundant Inertial Flight Control Assembly (RIFCA). This key component, built by L3 Communications Space & Navigation, will provide guidance and control for the rocket. The satellite is enclosed in a 3-m (10-ft)-diameter composite fairing.



Delta II 7320-10 Space Launch Vehicle

The NOAA-N launch and orbit insertion sequence starts with a thrust buildup period following Stage 1 engine ignition. The three GEM motors are ignited approximately 0.2 second before liftoff when main engine thrust has reached the appropriate level. The SLV lifts off and after clearing the launch pad, rolls to its desired flight azimuth. It then begins to pitch over in the trajectory plane. At approximately 264 seconds after liftoff, main engine cutoff (MECO) occurs when the booster propellants are depleted. The control logic then provides a signal that ignites the Stage 2 engine and fires separation nuts to separate it from Stage 1. The payload fairing is jettisoned at approximately T+296 seconds. The second stage burns until the desired orbit is reached at approximately 676 seconds, when an inertial guidance system (IGS)-initiated Stage 2 shutdown is initiated (SECO-1). The launch vehicle performs a reorientation maneuver and coasts until the second stage is restarted at T+3561 seconds. Following a 13-second burn, the second

Delta II SLV Engine Data (Vacuum)

	Stage 1	Stage 2	GEM
No. of Engines	1	1	3
Thrust per engine (lb)	200,000	9800	112,200
Thrust per engine (N)	889,644	43,593	499,090.5
Thrust duration (sec)	264.2	398.4/13.3	64.0

stage is shut down (SECO-2) for the final time. The spacecraft then separates from Stage 2 at approximately T+3940 seconds once the required attitude and attitude rates have been achieved.

NOAA-N Major Launch Events	
Event	Nominal Time From Liftoff (seconds)
Liftoff	0.0
Mach 1	36.1
Max. Dynamic Pressure	54.0
Solid motor burnout (3)	60.0
Solid motor separation (3)	99.0
Main engine cutoff (MECO)	264.2
Stage 1/2 separation	272.2
Stage 2 ignition	277.7
Jettison 10-ft composite fairing	296.0
First Stage 2 cutoff (SECO 1)	676.0
Restart Stage 2	3561.0
SECO 2	3574.3
NOAA-N spacecraft separation	3940.0
Solar array deployment	4240.0
Solar array boom deployment	4340.0
Solar array cant	4580.0
SRA deployment	4750.0
UDA deployment	4830.0
VRA deployment	4880.0
VRA pin puller activation	5000.0
Sunshade deployment	5000.5
Transition mode	5040.0
Handover to orbit mode	5090.0

NOAA-N ORBIT

NOAA-N 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 98.73° (retrograde) to the Equator.

The total orbital period will be approximately 102.14 minutes. The sunlight period will average about 72 minutes, and the Earth shadow period will average about 30 minutes. Because the Earth rotates 25.59° during each NOAA-N orbit, the satellite observes a different portion of the Earth's surface during each orbit.

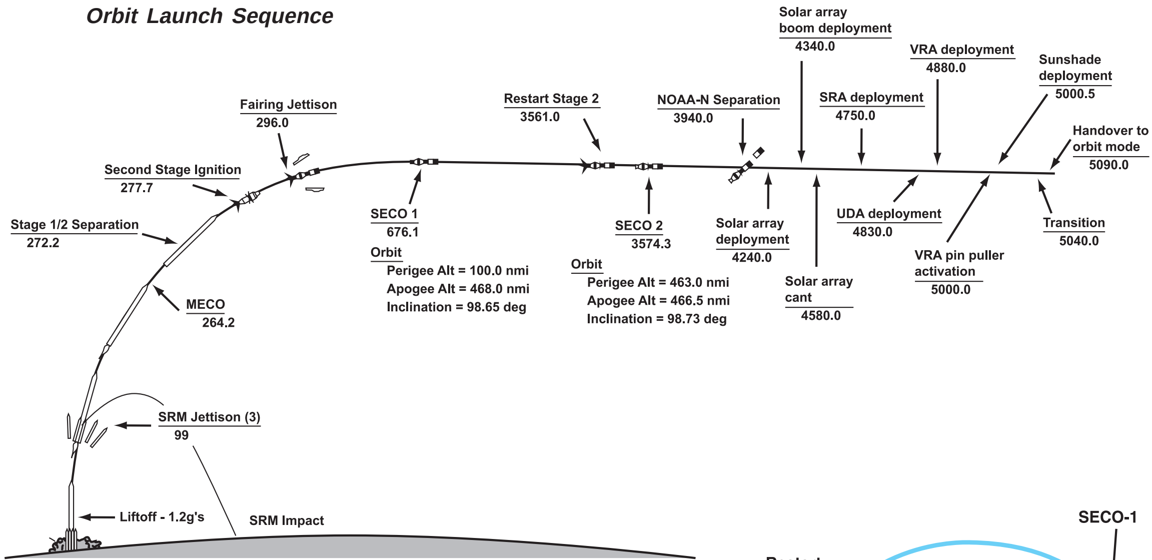
The nominal orbit is planned to be Sun-synchronous and precesses (rotates) eastward about the Earth's polar axis 0.986° per day (the same rate and direction as the Earth's average daily rotation about the Sun). The precession keeps the satellite in a constant position with reference to the Sun for consistent illumination throughout the year.

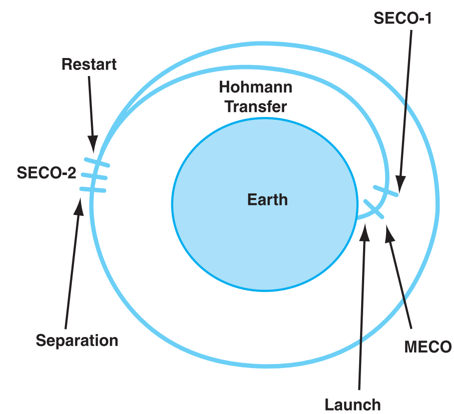
ORBITAL CHARACTERISTICS

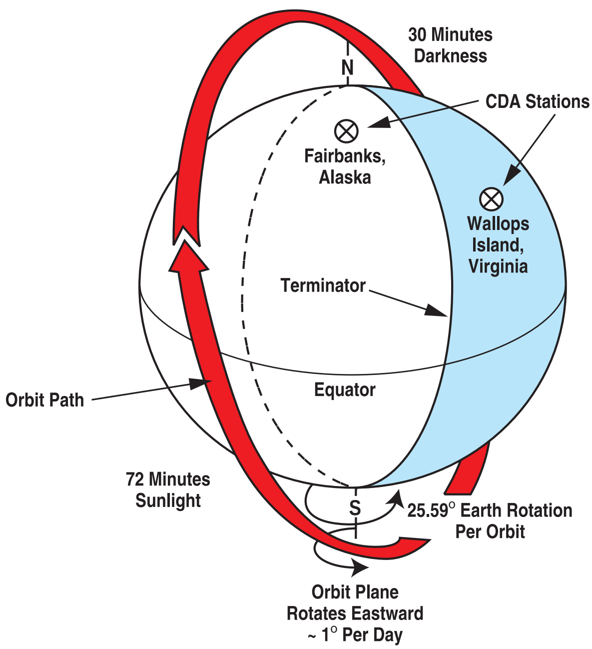
Apogee .... 870 km (470 nmi)
Perigee .... 870 km (470 nmi)
Minutes per orbit 102.14
Degrees inclination 98.730

NOAA-N will be launched at 10:22:01 GMT or 2:22:01 a.m. PST with a 10-minute window. The spacecraft will be launched so that it will cross the Equator at about 2 p.m. northbound and 2 a.m. southbound local solar time.

Orbit Launch Sequence

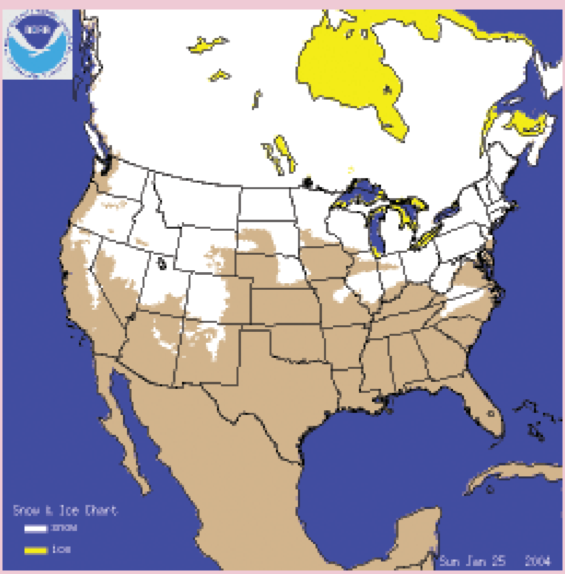




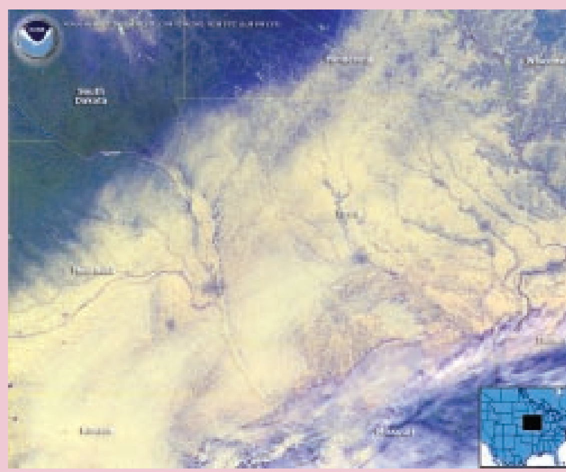


POLAR OPERATIONAL ENVIRONMENTAL SATELLITE PRODUCTS

The NOAA polar operational environmental satellites collect global data on cloud cover; surface conditions such as ice, snow, and vegetation; atmospheric temperatures; and moisture, aerosol, and ozone distributions; and collect and relay information from fixed and moving data platforms. The primary imaging system, the AVHRR/3, consists of visible, near-IR, and thermal IR channels. The primary sounding suite flying on NOAA-N is the HIRS/4, AMSU-A, and MHS, which measure atmospheric temperature and humidity. The SBUV-2 instrument is both an imager and a sounder. As an imager, it produces total column ozone maps. As a sounder, it obtains and measures ozone distribution in the atmosphere as a function of altitude. The SEM-2 contains two sets of instruments that monitor the energetic charged-particle environment near Earth. The TED in SEM-2 provides the data used to determine the level of auroral activity. The SEM-2 MEPED includes four solid-state detector telescopes that are designed to monitor the intensities of energetic particles in the Earth's radiation belts and during solar particle events. Examples of products derived from the processed data follow.

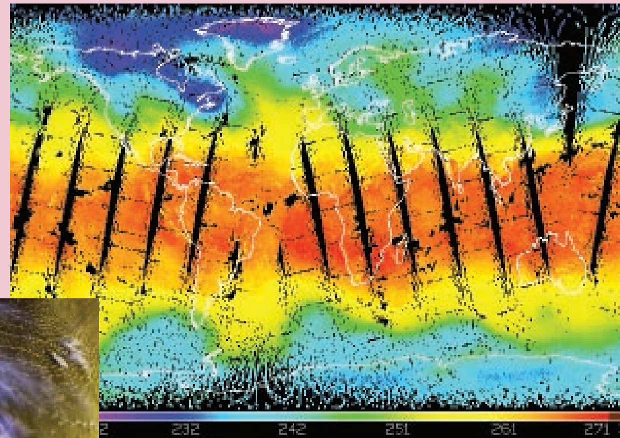


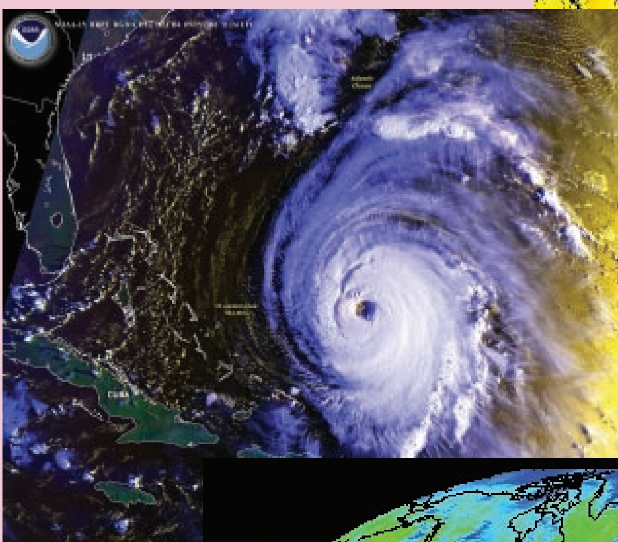
Multisensor snow and sea ice products are generated from the blending of data from the AVHRR and AMSUs in addition to data from other satellite systems. They are produced for the Northern Hemisphere, North America, Alaska, and Asia/ Europe. This image was produced for North America on January 25, 2004. Snow cover is shown in white, while sea ice is yellow.



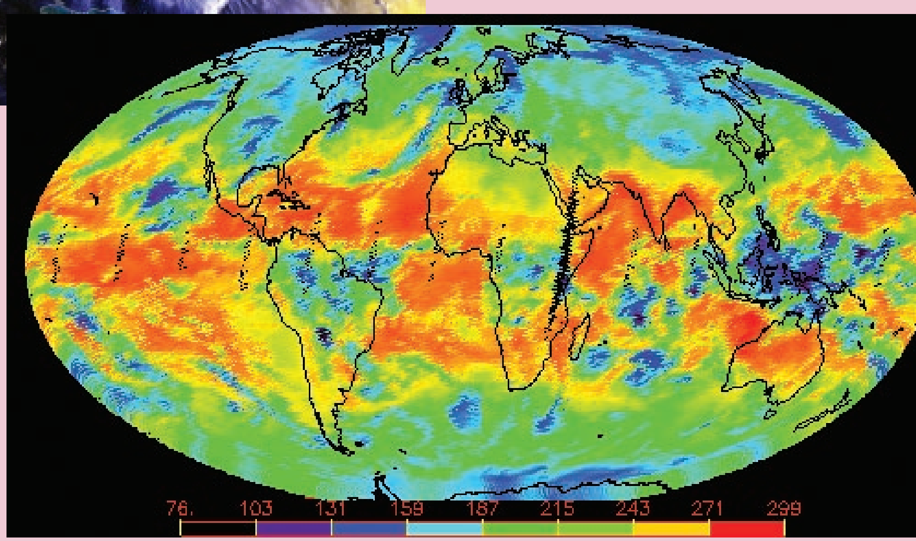
Snow cover (off white) is visible in this NOAA-16 image over parts of the Plains and Midwest states. It was generated from AVHRR HRPT 1.1-km (0.7-mi) data for February 6, 2002.

Global atmospheric temperature profiles are derived from the AMSU-A, HIRS, and AVHRR/3 instruments. This 500-millibar atmospheric temperature sounding was produced from NOAA-16 data on January 25, 2004.

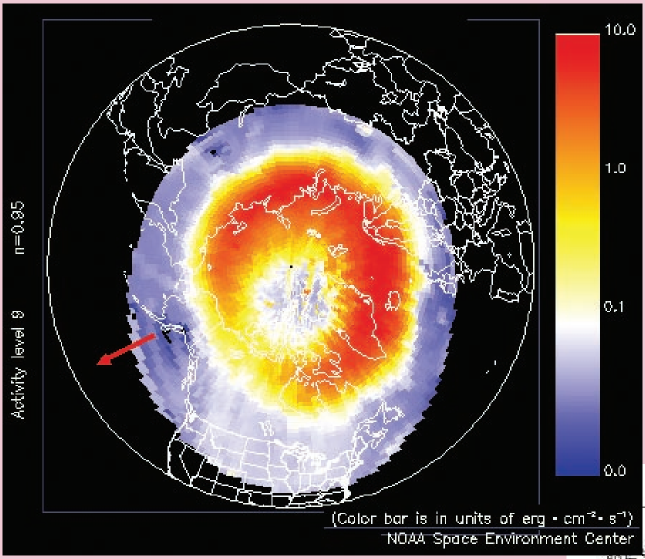




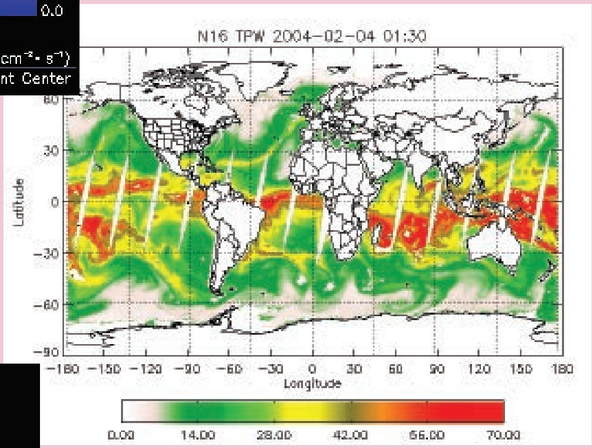
Hurricane Isabel was located over the Atlantic Ocean on September 15, 2003. Isabel was moving westward with maximum sustained winds estimated at 130 knots (241 km/hr or 150 mph) and gusts to 160 knots (296 km/hr or 184 mph). This image was derived from NOAA-17 AVHRR HRPT 1.1-km (0.7-mi) data.



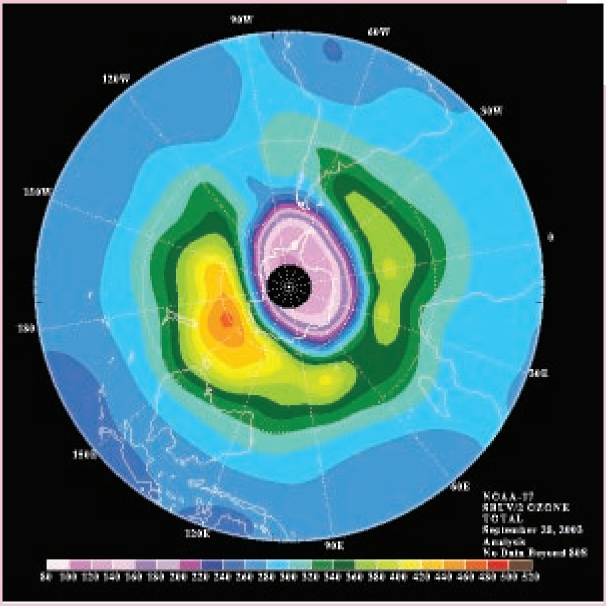
NESDIS Radiation Budget products include daily, monthly, seasonal, and annual mean global maps of outgoing longwave (IR) radiation and absorbed incoming shortwave (solar) radiation. This image, produced on February 4, 2004, shows the Outgoing Longwave Radiative (OLR) flux at the top of atmosphere, which was derived from NOAA-16 nighttime observations. The NESDIS AVHRR OLR product is used to monitor global climate change and derive the global precipitation index.



This image shows the extent and position of the auroral oval in the Northern Hemisphere extrapolated from measurements taken from a pass from the NOAA-17 satellite on January 26, 2004. The red arrow at the left of the image points toward the noon meridian. An estimate of the location, extent, and intensity of aurora is generated by NOAA's Space Environment Center on a global basis from the SEM-2 instrument.

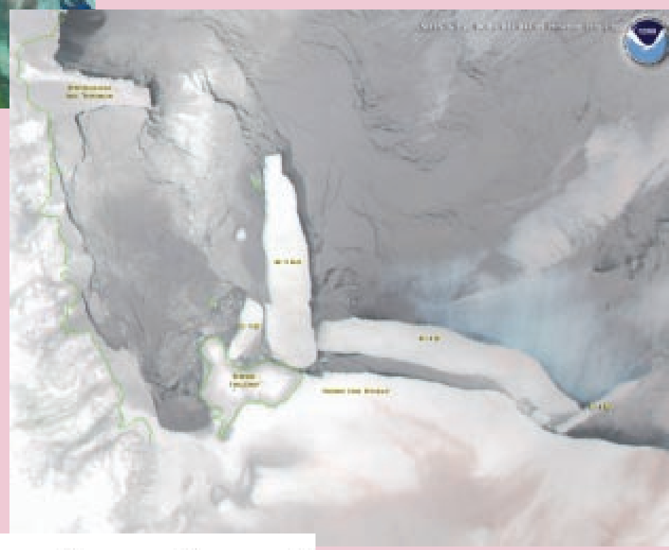


Total precipitable water shows the amount of water vapor in a column extending from the surface to the top of the atmosphere. This image, produced on February 4, 2004, shows the total precipitable water derived from NOAA-16 AMSU-A data.

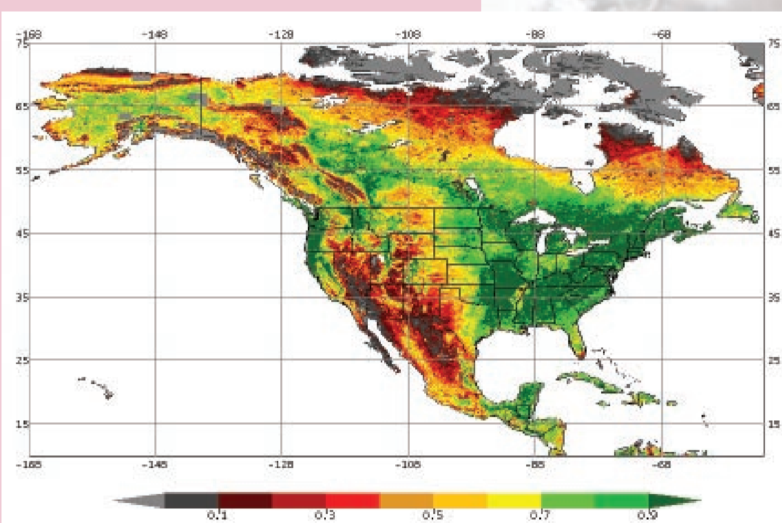


Long-term changes in stratospheric ozone levels and the extent of climate change are identified from satellite data. This image shows total ozone over the Southern Hemisphere on September 28, 2003, generated from NOAA-17 SBUV/2 data. Colors in the violet shades indicate lowered levels of stratospheric ozone.

These NOAA-16 image heat signatures (red), and smoke (light blue haze) are visible from wildfires in California from Simi Valley to San Diego. The image was generated from NOAA-16 AVHRR Local Area Coverage (LAC) 1.1-km (0.7-mi) data on October 27, 2003.



This image shows icebergs (named C-18 and C-19) calved from the Ross Ice Shelf in Antarctica on May 14, 2002. It was generated from NOAA-16 AVHRR 1.1-km (0.7-mi) LAC data.



This image of North America shows the fraction of the observed surface that was covered with active green vegetation during the week of June 16, 2003. It was derived from AVHRR data and is used in numerical weather forecast models.

SPACECRAFT DATA COMMUNICATIONS

The spacecraft transmits instrument data to the ground for three primary functions: CDA, Direct Broadcast, and Search and Rescue.

COMMAND AND DATA ACQUISITION STATION DOWNLINKS

CDA stations located at Fairbanks, Alaska, and Wallops Island, Virginia, receive stored GAC and LAC data from each spacecraft. The CDA stations can also receive real-time data when the satellites are within the direct readout footprint.

GAC data is recorded and contains satellite housekeeping information, AMSU data, and 4-km (2.5-mi)-resolution AVHRR imagery. GAC data contains more than

NOAA KLMNN' Spacecraft Communications Radio Frequency (RF) Links (frequencies are in MHz)

100 minutes (one full orbit) of imagery and is transmitted to a NOAA ground CDA station for relay to centralized viewers.

LAC data is recorded information that contains 1-km (0.6-mi) AVHRR imagery. LAC data is recorded for up to 10 minutes and transmitted to a NOAA ground CDA station for relay to centralized users.

High Resolution Picture Transmission (HRPT) is real-time transmission of instrument data and satellite housekeeping data. CDA stations intercept HRPT data primarily for satellite housekeeping data but also relay the higher resolution data to centralized users.

DIRECT BROADCAST DOWNLINKS

For more than 30 years, NOAA has freely and openly provided satellite data through direct broadcasting to users in the United States and in 100 other countries throughout the world. In the United States, any commercial firm receiving data through direct broadcasting (commonly called direct readout service) may provide tailored products to customers and/or viewers.

There are three types of direct broadcasting: (1) real-time HRPT, (2) real-time very high frequency (VHF) beacon transmissions, and (3) Automatic Picture Transmission (APT).

High Resolution Picture Transmission

HRPT provides worldwide direct readout of full-resolution spacecraft parameters and instrument data to ground stations within the footprint of the NOAA polar orbiters. HRPT service was originally designed to provide timely day and nighttime sea surface temperature and ice, snow, and cloud cover information to diverse users, but applications have expanded because of the proliferation of moderately priced equipment and software. HRPT transmissions contain data from all instruments aboard the NOAA polar satellites. The data stream includes information from the TIP, the AIP, and from the AVHRR/3, providing five of six channels at 1-km (0.6-mi) resolution. The TIP contains spacecraft attitude data, time codes, housekeeping, and low rate instrument science data from the HIRS/4, SEM-2, DCS/2, and the SBUV/2. The AMSU-A and MHS are also included in HRPT from the AIP.

To receive the data, users can purchase the necessary equipment (computer, software, and antenna) from commercial companies for unlimited access to HRPT signals. In 2004, there were 663 HRPT receivers worldwide registered with the World Meteorological Organization (WMO).

Very High Frequency (VHF) Beacon Transmission

VHF beacon transmission is available to users who do not intend to install the more complex equipment necessary to receive high data rate S-band service. The lower data rate from the TIP permits the user to install less complex, less costly equipment to receive the data (HIRS/4, SEM-2, DCS/2, and SBUV/2, but not AMSU).

Parallel outputs are provided for the real-time VHF beacon transmission. The instrument data is multiplexed with analog and digital housekeeping data. TIP output directly modulates the beacon transmission. The data is transmitted as an 8.32-kbps split phase signal over one of the beacon transmitters at 137.35 MHz or 137.77 MHz.

Automated Picture Transmission (APT) Data

APT data is smoothed 4-km (2.5-mi)-resolution IR and visible imagery derived from the AVHRR/3 instrument and transmitted within the footprint of the NOAA polar orbiters. Because APT data is captured on low-cost VHF ground stations, it is also very popular in schools. Users purchase the necessary equipment (computer, software, and antenna) from commercial companies for unlimited access to APT signals. In 2004, there were 4,945 APT receivers worldwide registered with the WMO.

The Satellite Operations Control Center (SOCC) can select by command any two of the active five AVHRR/3 channels provided to the MIRP, which are further processed as “Video A” and “Video B.” One APT line, consisting of one line of Video A and one line of Video B, is output every third AVHRR scan. Ancillary AVHRR data appears at one edge of each line and their 64-second repetition period defines the APT frame length. The resulting line rate is two per second. The data is transmitted continuously over a dedicated VHF link as an analog signal consisting of an amplitude-modulated 2400-Hz subcarrier frequency modulating the RF carrier at 137.1 MHz or 137.9125 MHz.

SEARCH AND RESCUE DOWNLINKS

For information about SAR, please refer to the previous section titled *Search and Rescue Instruments* that begins on page NOAA-N/12.

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

SATELLITE OPERATIONS CONTROL CENTER (SOCC)

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

CDA Stations—The primary CDA stations are located at Fairbanks, Alaska, and Wallops Island, Virginia. A remote limited-function CDA facility, built and maintained by the NOAA Fairbanks CDA station, is located at Point Barrow, Alaska, on the Arctic Circle. Because of its high latitude, Point Barrow provides monitoring and S-band command capability for the “blind orbits” not normally seen by the primary Wallops and Fairbanks CDA stations.

13-m Antenna at Fairbanks, Alaska

The CDA stations transmit commands to the satellites and acquire and record environmental and engineering data from the satellites for retransmission to the SOCC. All data and commands are transmitted between the SOCC and the CDA stations via commercial communications links.

Ground Communications—The ground communication links for satellite operations are provided by the Satellite Communications Network (SATCOM) and NASA Integrated Services Network (NISN). SATCOM provides all voice and data links between the SOCC and the CDA stations after launch. NISN provides launch-unique communication links for satellite launch; the National Environmental Satellite, Data, and Information Service (NESDIS) provides and operates SATCOM.

ENVIRONMENTAL SATELLITE PROCESSING CENTER (ESPC)

The NESDIS ESPC acquires the data from the CDA stations via the SOCC and is responsible for data processing and the generation of meteorological products on a timely basis to meet POES program requirements. NOAA provides all hardware and software for ESPC and will provide ephemeris data.

OTHER SUPPORT SYSTEMS

SEARCH AND RESCUE GROUND SYSTEM

The United States has recently completed installation of a new generation of LUTs. The U.S. LUTs are located at Gilmore Creek Command and Data Acquisition Station at Fairbanks, Alaska; Vandenberg AFB, California; the U.S. Coast Guard (USCG) Communications Station at Wahiawa, Hawaii; the USCG Communications Station at Miami, Florida; NOAA at Suitland, Maryland; and Anderson AFB, Guam.

The LUTs receive SAR data from the NOAA polar and geosynchronous satellites and also from other low-Earth-orbiting satellites, determine the location of any activated distress beacons, and forward the data to the U.S. Mission Control Center (USMCC) at Suitland, Maryland. The USMCC first validates the distress situation and then determines the proper RCC. It then forwards the distress location data to the RCC after removing redundant information. Additionally, a test ground station is maintained at NASA Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. This system is part of the worldwide Cospas-Sarsat Program that now consists of 35 countries: 26 of these provide MCCs and LUTs, and nine additional countries receive the data. All MCCs cooperate in sending data to provide rapid global delivery of distress locations received through the satellites.

GODDARD SPACE FLIGHT CENTER FACILITY SUPPORT

Support associated with NASA's Space, Ground, and Deep Space Networks (DSNs) is requested through the Detailed Mission Requirements documents, with other support as described in Memoranda of Understanding. NASA GSFC provides nominal prelaunch orbital and prediction information, special support for initial orbit estimation, and initial quality control checks of North American Aerospace Defense (NORAD) orbital data. All ground attitude determination is accomplished by the NOAA central data processing facility.

THE NORTH AMERICAN AEROSPACE DEFENSE COMMAND (NORAD)

NORAD has prime responsibility for orbit determination, including establishment of the initial orbit solution, and providing updated orbital parameters routinely throughout the life of the mission.

LAUNCH, EARLY ORBIT, AND CONTINGENCY DOWNLINK

A 2247.5-MHz S-band downlink is used during satellite ascent to recover TIP boost telemetry through WR tracking sites. From launch through spacecraft separation, WR stations, mobile telemetry, McMurdo NASA Antarctic Interactive Launch Support (NAILS), and Malindi in Kenya will provide spacecraft tracking and telemetry. Following spacecraft separation and through spacecraft transition and handover to orbit, the Air Force Satellite Control Network (AFSCN) Telemetry and Command Station (TCS) in Oakhanger, England; the DSN in Madrid, Spain; the AFSCN Thule Tracking Station in Thule, Greenland; and the NOAA Fairbanks CDA facility will provide spacecraft tracking and telemetry. The Tracking and Data Relay Satellite System (TDRSS) will provide best-effort tracking and telemetry support on a near-continuous basis from launch through spacecraft separation and handover and transition to orbit mode.

During on-orbit operations, orbit mode TIP will be available for early orbit and contingency support through the ground tracking network operated by the Jet Propulsion Lab (JPL) DSN, which provides contingency command uplink capability. The McMurdo Tracking Facility in Antarctica can also provide contingency on-orbit telemetry and command support. TDRSS will provide telemetry on a best-effort basis as requested by the Project.

Synopsis of Prior Spacecraft

TIROS-N was launched October 13, 1978, into a 470-nmi (870-km) afternoon orbit. It was the first satellite in the 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 N' spacecraft. The satellite was equipped with a four-channel AVHRR, HIRS, Microwave Sounding Unit (MSU), Stratospheric Sounding Unit (SSU), SEM, and DCS. TIROS-N was deactivated following an Inertial Measurement Unit (IMU) power supply failure on February 27, 1981.

NOAA-A (6) was launched June 27, 1979, into a 450-nmi (833-km) morning orbit. The satellite carried the four-channel AVHRR, HIRS/2, MSU, SSU, SEM, and DCS. The HIRS, a primary mission sensor, failed on September 19, 1983. The satellite greatly exceeded its two-year lifetime. It was totally deactivated on March 31, 1987, after nearly eight years of operational service.

NOAA-B was launched May 29, 1980. It failed to achieve a usable orbit because of a booster engine anomaly.

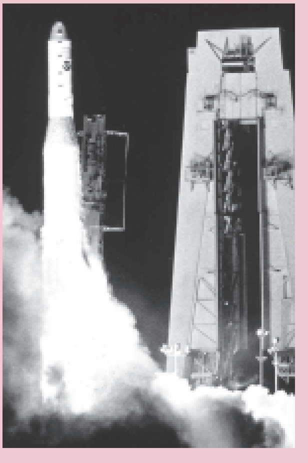
NOAA-C (7) was launched June 23, 1981, into a 470-nmi (870-km) afternoon orbit. It carried a five-channel AVHRR rather than the four-channel AVHRR that flew on earlier spacecraft. Other instruments were the HIRS/2, MSU, SSU, SEM, and DCS. The HIRS, a primary mission sensor, failed on February 7, 1985. The satellite was deactivated on June 7, 1986, following a failure in the power system.

NOAA-E (8) was launched March 28, 1983, into a 450-nmi (833-km) morning orbit. It was the first of the ATN satellites and included a stretched structure to provide growth capability. It also included the first search and rescue package. In addition, the spacecraft carried a four-channel AVHRR, HIRS/2, MSU, SSU, SEM, and DCS. The redundant crystal oscillator (RXO) failed after 14 months in orbit. The RXO recovered from its failure, finally locking up on the backup RXO in May 1985. The satellite was stabilized and declared operational by NOAA on July 1, 1985. The NOAA-8 spacecraft was finally lost on December 29, 1985, following a thermal runaway that destroyed a battery.

NOAA-F (9) was launched December 12, 1984, into a 470-nmi (870-km) afternoon orbit. This mission tested the Earth Radiation Budget Experiment (ERBE) and the SBUV radiometer as part of the expanded capabilities of the ATN satellites as well as carrying the instruments found on earlier ATN missions. The ERBE consisted of shortwave and longwave radiometers that were used to study the Earth's albedo in an attempt to recognize and interpret seasonal and annual climate variations. The SBUV measured the vertical structure of ozone in the atmosphere. The satellite also had real-time and global SAR instruments onboard. The MSU, a primary mission sensor, failed on May 7, 1987. The Digital Tape Recorder (DTR) 1A/1B failed two months after launch. The ERBE scanner stopped outputting science data in January 1987. Earlier in the mission, the AVHRR periodically exhibited anomalous behavior in its synchronization with the MIRP. The SBUV/2 and the SSU instruments aboard continued to operate satisfactorily. The MSU channels 2 and 3 failed, and the satellite's power system was degraded. In August 1995, a very high power overvoltage condition resulted in the failure of the MIRP, the AVHRR, the Battery #1 charge regulator, and the IMU temperature control amplifier. The MIRP failure also resulted in the loss of the global SAR data via the GAC data stream. The satellite's ability to collect, process, and distribute SBUV/2, SSU, and ERBE-nonscanner data was now limited to stored TIP data. The SARR transmitter failed on December 18, 1997. The satellite was deactivated on February 13, 1998.

NOAA-G (10) was launched September 17, 1986, into a 450-nmi (833-km) morning orbit. It carried the AVHRR, HIRS/2, MSU, SSU, SEM, DCS, the SARSAT system, and ERBE. The ERBE scanner exhibited a scan-sticking anomaly that was apparently generic to the instrument. The SARP 406-MHz receiver also failed. The SARP provided global SAR data before its failure. In December 1994, the AVHRR IR channels were damaged and remained severely degraded from a satellite tumble caused by an overflow of the satellite's ephemeris clock. NOAA-10 was placed in standby mode on September 17, 1991 (the date NOAA-12 became fully operational). In January 1997, the MSU scanner displayed anomalous readings. Telemetry indicated that the digital encoder had failed. The MSU scanner motor was commanded off in February 1997. A MIRP-related missing minor frame anomaly occurred in August 1998. The HRPT data was unusable because of an unstable MIRP and a faulty AVHRR. The satellite was deactivated on August 30, 2001.

NOAA-H (11) was launched September 24, 1988, into a 470-nmi (870-km) afternoon orbit. It carried a five-channel AVHRR, the HIRS/2, MSU, SSU, SBUV/2, SEM, DCS, and SARSAT system. The AVHRR failed on September 13, 1994. The spacecraft was modified for a 0° to 80° Sun angle and included fixed and deployable sunshades on the IMP. The increase of maximum Sun angle from 68° to 80° allowed an afternoon nodal crossing closer to noon to enhance data collection. Two gyros failed early in its life, and attitude control was 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 to provide attitude control, at expected reduced accuracy, should the X-gyro fail. The satellite was placed in standby mode in March 1995. It was reactivated to provide soundings after a NOAA-12 HIRS filter wheel anomaly in May 1997. The HIRS filter wheel on NOAA-11 stopped moving on April 13, 2000, and the instrument was subsequently turned off on April 26, 2000. It remained in standby operational mode, transmitting global and real-time SAR data directly to local users worldwide, until it was deactivated on June 16, 2004.



NOAA-11 was launched on September 24, 1988. It was deactivated in June 2004 after completing more than 81,000 orbits.

NOAA-D (12) was launched May 14, 1991, into a 450-nmi (833-km) morning orbit. It replaced NOAA-10 in orbit and carries the same instruments as the earlier spacecraft; however, it does not have a SAR package or SBUV/2 onboard. The Skew Gyro periodically exhibits a high drift rate, which is corrected with real-time operational command procedures. In May 1997, the HIRS filter wheel mechanism degraded to the point that soundings were unusable. The MSU scan motor failed on March 12, 2003. The remaining instruments and other subsystems continue to operate satisfactorily. NOAA-12 was placed in standby mode on December 14, 1998, when NOAA-15 became operational. It is currently the semi-operational backup morning satellite.

NOAA-I (13) was launched August 9, 1993, into a 470-nmi (870-km) afternoon orbit. On August 21, 1993, two weeks after launch, the spacecraft suffered a power system anomaly. All attempts to contact or command the spacecraft since the power failure have been unsuccessful.

NOAA-J (14) was launched December 30, 1994, into a 470-nmi (870-km) afternoon orbit. It carries a five-channel AVHRR, the SBUV/2, SSU, HIRS/2, MSU, SEM, SARSAT system, and DCS. In January 1995, it was determined that one of the four SEM telescopes had become inoperative, reducing data collection by 12 percent. In February 1995, the SARP and the SBUV/2 CCR failed, and DTR 4A/4B was deemed inoperable. In addition, the ESA exhibited high Quadrant 3 (Q3) data counts due to apparent contamination of the detector. In March 1995, the MSU scanner seized, and the instrument was powered off. After three weeks, the MSU was powered on and has been operating satisfactorily ever since. Flight software was modified in April 1995 to correct the high ESA Q3 counts and to turn off the MSU should the scanner seize up again. Between April 1995 and December 1996, the SBUV grating drive experienced significant degradation. The grating drive control was reprogrammed to compensate for these problems as well as for the CCR failure. All other instruments operate satisfactorily. In November 1995, the demodulator portion of the Command Receiver and Demodulator for On-board Processor #1 (OBP1) failed, resulting in the loss of the backup OBP. OBP1 was commanded off. Flight and ground software packages were modified to permit the use of, and commanding to, only OBP2. On October 18, 2001, the AVHRR scanner became unstable, rendering its imagery unusable. NOAA-16 replaced NOAA-14 as the operational afternoon satellite on March 19, 2001. On November 27, 2003, the SBUV grating motor failed and was powered off. Recovery operations were successful and the unit resumed operations on November 28, 2003. NOAA-14 is now a backup afternoon satellite.

NOAA-K (15) was launched May 13, 1998, into a 450-nmi (833-km) morning orbit. It replaced NOAA-12 on December 14, 1998, as the primary morning spacecraft. It is currently the morning backup satellite. NOAA-K was the first in the ATN series to support dedicated microwave instruments for the generation of temperature, moisture, surface, and hydrological products where visible and IR instruments have decreased capability. NOAA-K replaced the MSU of earlier spacecraft with the AMSU-A and AMSU-B instruments. It also carries a six-channel AVHRR/3, a HIRS/3 and SEM/2, a SARSAT system, and a DCS. The S-band transmitter (STX)-1, STX-2, and STX-3 high-gain antennas have shown degraded performance in orbit. Beginning September 28, 1999, the satellite was configured to transmit HRPT using the STX-2 omnidirectional antenna and transmit data playbacks using STX-4. The STX-1 and STX-3 downlinks are not used. Since launch, the AMSU-B instrument has had a bias in the science data that has been corrected by software processing on the ground. This bias is caused by interference from on-board L-band and S-band transmit systems. With the use of the omnidirectional antennas and only the STX-2 and STX-4 downlinks, the interference can be modeled to remove the bias to the science data. AMSU-B instruments on NOAA-16 and later spacecraft have been modified to correct this bias. Gyro 3 was turned off in June 2000, because of excessive drift in the gyro. The AVHRR scan motor is showing degraded performance that began on May 30, 2000, and AVHRR products are marginally usable. The AMSU-A1 Channels 14 and 11 have failed. Other AMSU-A1 channels are fine. The SARR 243-MHz receive system developed a thermal-related intermittent failure beginning on December 5, 2000. An antenna subsystem is the most likely cause. A HIRS filter motor anomaly, which first occurred in December 1999, recovered in January 2001. Surges with the filter motor occurred throughout 2002. The HIRS has had a problem with its filter motor current and temperature beginning on February 1, 2003, which negatively affected the radiometry.

NOAA-L (16) was launched on September 21, 2000, into a 470-nmi (870-km) afternoon orbit. It replaced NOAA-14 on March 19, 2001, as the primary afternoon spacecraft. It carries the same instruments as NOAA-15 with the addition of the SBUV/2. The APT VHF downlink showed a severely degraded performance starting on November 13, 2000. A hybrid failure in the VRA antenna subsystem was the most likely cause. The APT downlink was commanded off on February 26, 2001. A HIRS instrument cross-track pointing error has been observed since launch. The problem was traced to a procedural error during the instrument's scan mirror installation. Data processing procedures were developed to correct for instrument misalignment. The SARR 243-MHz receive system developed what is believed to be a thermally induced failure in the antenna (SRA). The STX-3 output power dropped to 1 watt on September 28, 2001. The link is still usable by the NOAA CDA station. On September 17, 2003, the AVHRR began to show evidence of scan motor degradation. The condition worsened in early 2004 and products are being intermittently affected. NOAA-16 is currently the designated operational afternoon satellite.

NOAA-M (17) was launched on June 24, 2002, into a 450-nmi (833 km) morning orbit. It replaced NOAA-15 on October 15, 2002, as the primary morning spacecraft and is currently the designated operational morning satellite. It carries the same instruments as NOAA-16. On April 28, 2003, the STX-3 output dropped to 2.48 W. Link margin is still sufficient for most users. On October 30, 2003, AMSU-A1 powered off because of a scan motor failure. All other instruments and subsystems continue in full operational mode. NOAA-17 is currently the designated operational morning satellite.

Appendix A

HIRS/4 Channel Characteristics

Channel Number	Channel Frequency (cm^{-1})	µm	Half Power Bandwidth (cm^{-1})	Anticipated Max. Scene Temperature (K)	Specified Sensitivity [1]	Design Goal
1	669	14.95	3	280	3.00	0.75
2	680	14.71	10	265	0.67	0.25
3	690	14.49	12	240	0.50	0.25
4	703	14.22	16	250	0.31	0.20
5	716	13.97	16	265	0.21	0.20
6	733	13.64	16	280	0.24	0.20
7	749	13.35	16	290	0.20	0.20
8	900	11.11	35	330	0.10	0.10
9	1,030	9.71	25	270	0.15	0.15
10	802	12.47	16	300	0.15	0.10
11	1,365	7.33	40	275	0.20	0.20
12	1,533	6.52	55	255	0.20	0.07
13	2,188	4.57	23	300	0.006	0.002
14	2,210	4.52	23	290	0.003	0.002
15	2,235	4.47	23	280	0.004	0.002
16	2,245	4.45	23	270	0.004	0.002
17	2,420	4.13	28	330	0.002	0.002
18	2,515	4.00	35	340	0.002	0.002
19	2,660	3.76	100	340	0.001	0.001
20	14,500	0.69	1,000	100% A	0.10% A	———

[1] NEΔN in mW/m^2-sr-cm^{-1}

AMSU-A Channel Characteristics

Ch. No.	Center Frequency	No. of Pass Bands	Bandwidth (MHz) (spec)	Center Frequency Stability (MHz)	Temperature Sensitivity (K) NEΔT* (spec)	Calibration Accuracy (K) (spec)	Angle θp
1	23,800 MHz	1	270	10	0.30	2.0	V
2	31,400 MHz	1	180	10	0.30	2.0	V
3	50,300 MHz	1	180	10	0.40	1.5	V
4	52,800 MHz	1	400	5	0.25	1.5	V
5	53,596 MHz ±115 MHz	2	170	5	0.25	1.5	H
6	54,400 MHz	1	400	5	0.25	1.5	H
7	54,940 MHz	1	400	5	0.25	1.5	V
8	55,500 MHz	1	330	10	0.25	1.5	H
9	57,290.344 MHz = f_{LO}	1	330	0.5	0.25	1.5	H
10	f_{LO}±217 MHz	2	78	0.5	0.40	1.5	H
11	f_{LO}±322.2 ±48 MHz	4	36	1.2	0.40	1.5	H
12	f_{LO}±322.2 ±22 MHz	4	16	1.2	0.60	1.5	H
13	f_{LO}±322.2 ±10 MHz	4	8	0.5	0.80	1.5	H
14	f_{LO}±322.2 ±4.5 MHz	4	3	0.5	1.20	1.5	H
15	89.0 GHz	1	<6,000	50	0.50	2.0	V

* NEΔT—Noise Equivalent Temperature Difference

AVHRR/3 Channel Characteristics

Channel Number	(50% Points) Max Spectral Band Micrometers	Signal-to-Noise-Ratio	Res. SSP km	Albedo Range %	Counts Range
1	0.58 - 0.68	9:1 @ 0.5% Albedo	1.09	0 - 25 26 - 100	0 - 500 501 - 1000
2	0.725 - 1.00	9:1 @ 0.5% Albedo	1.09	0 - 25 26 - 100	0 - 500 501 - 1000
3A	1.58 - 1.64	20:1 @ 0.5% Albedo	1.09	0 - 12.5 12.6 - 100	0 - 500 501 - 1000
		NEΔT		Max Scene Temp K	
3B	3.55 - 3.93	0.12 @ 300K Scene	1.09	335	
4	10.30 - 11.30	0.12 @ 300K Scene	1.09	335	
5	11.50 - 12.50	0.12 @ 300K Scene	1.09	335	

SBUV Discrete Ozone Position

Channel Number	Wavelength (nm)	Description
0	252.00	Discrete Pos. 0
1	273.61	Discrete Pos. 1
2	283.1	Discrete Pos. 2
3	287.7	Discrete Pos. 3
4	292.29	Discrete Pos. 4
5	297.59	Discrete Pos. 5
6	301.97	Discrete Pos. 6
7	305.87	Discrete Pos. 7
8	312.57	Discrete Pos. 8
9	317.56	Discrete Pos. 9
10	331.26	Discrete Pos. 10
11	339.89	Discrete Pos. 11

MHS Channel Characteristics

Channel Number	Center Frequency (GHz)	RF Bandwidth (MHz)	Temperature Sensitivity NEΔT (K)		Polarization
			Spec	Goal	
H1	89.0	2x1100	1.0	0.6	V
H2	157.0	2x1100	1.0	0.6	V
H3	183.311 ± 1.0	2x500	1.0	0.6	H
H4	183.311 ± 3.0	2x1000	1.0	0.6	H
H5	190.311	2x1000	1.0	0.6	V

Appendix B

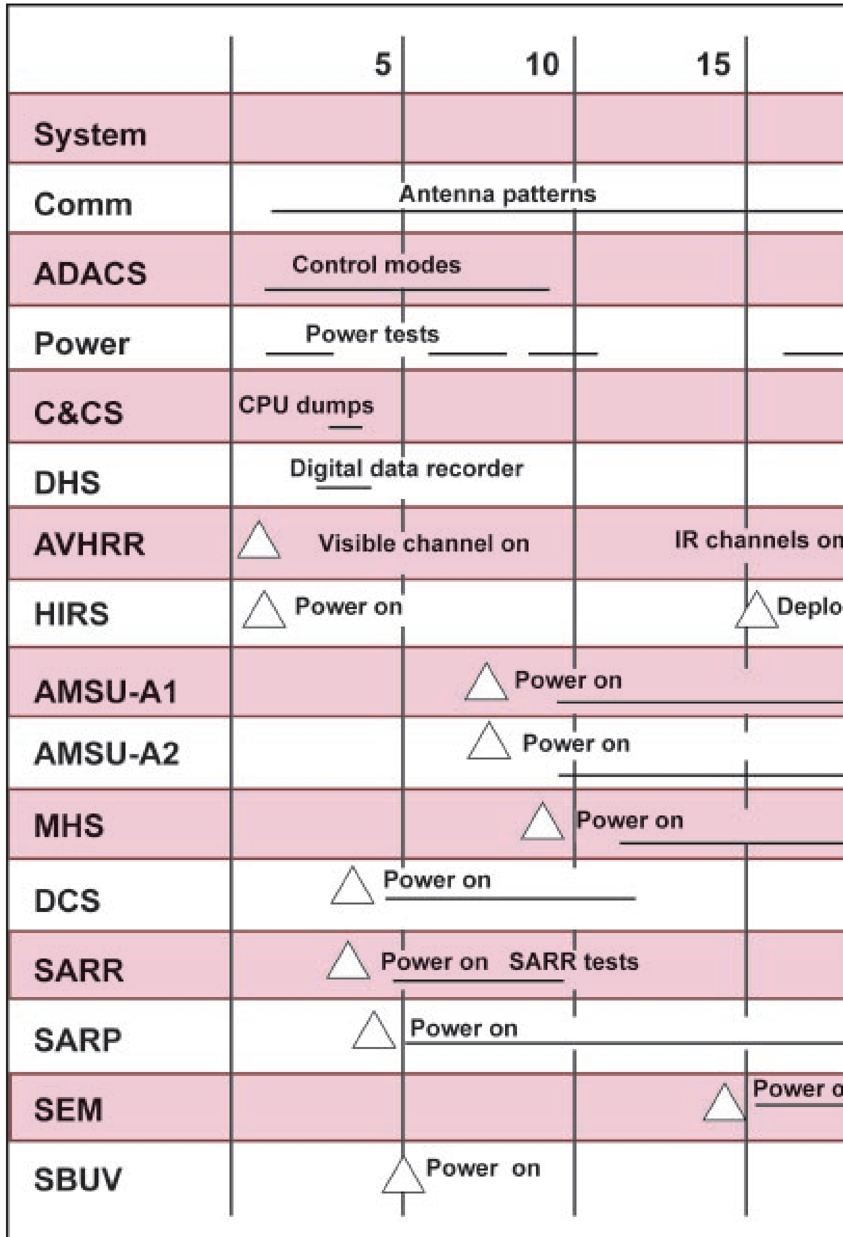
Communications and Data Handling

Link	Carrier Frequency	Information Signal	Data Rate and Baseband Modulation	RF Modulation	Subcarrier Frequency
Command	2026 MHz	Digital commands Clear or encrypted	2 kbps/NRZ-M	PM-carrier BPSK-subcarrier	16 kHz
Beacon	137.77 and 137.35 MHz	TIP data	8.320 kbps split phase	PM ±67 deg.	
VHF real time (APT)	137.1 and 137.9125 MHz	Medium-resolution video data from AVHRR	Analog	FM-carrier AM-subcarrier	2.4 kHz
S-band real time	1698 or 1707 MHz	HRPT	665.4 kbps split phase	PM ±67 deg.	
S-band playback	1698, 1702.5, or 1707 MHz	High-resolution AVHRR data from MIRP; medium-resolution AVHRR data from MIRP; TIP and AIP outputs	2.66 Mbps NRZ-L or 322 kbps split phase (AIP)	PM ±67 deg.	
Data collection (uplink)	401.65 MHz	Earth-based platforms and balloons	400 bps split phase	PM ±63 deg.	
S-band playback to European ground station	1698, 1702.5, or 1707 MHz	TIP or AIP data recovered from tape recorders as scheduled	332 kbps split phase	PM ±67 deg.	
S-band contingency and launch	2247.5 MHz	Boost during ascent and real-time TIP in orbit	Boost 16.64 kbps; in orbit 8.32 kbps split phase (TIP) or 16.64 kbps (AIP)	PM ±67 deg.	
SAR L-band downlink	1544.5 MHz	Data transmission from SARR and SARP to ground LUTs	Less than or equal to 800 Hz	PM	
SAR uplinks	SARR 121.5/243/406 MHz SARP 406 MHz	From ground ELT/EPIRBs/PLBs to spacecraft	25 kHz bandwidth (BW) for 121.5 MHz; 45 kHz BW for 243 MHz; 400 bps for 406.05 MHz	AM for 121.5/243 MHz; PM for 406 MHz	

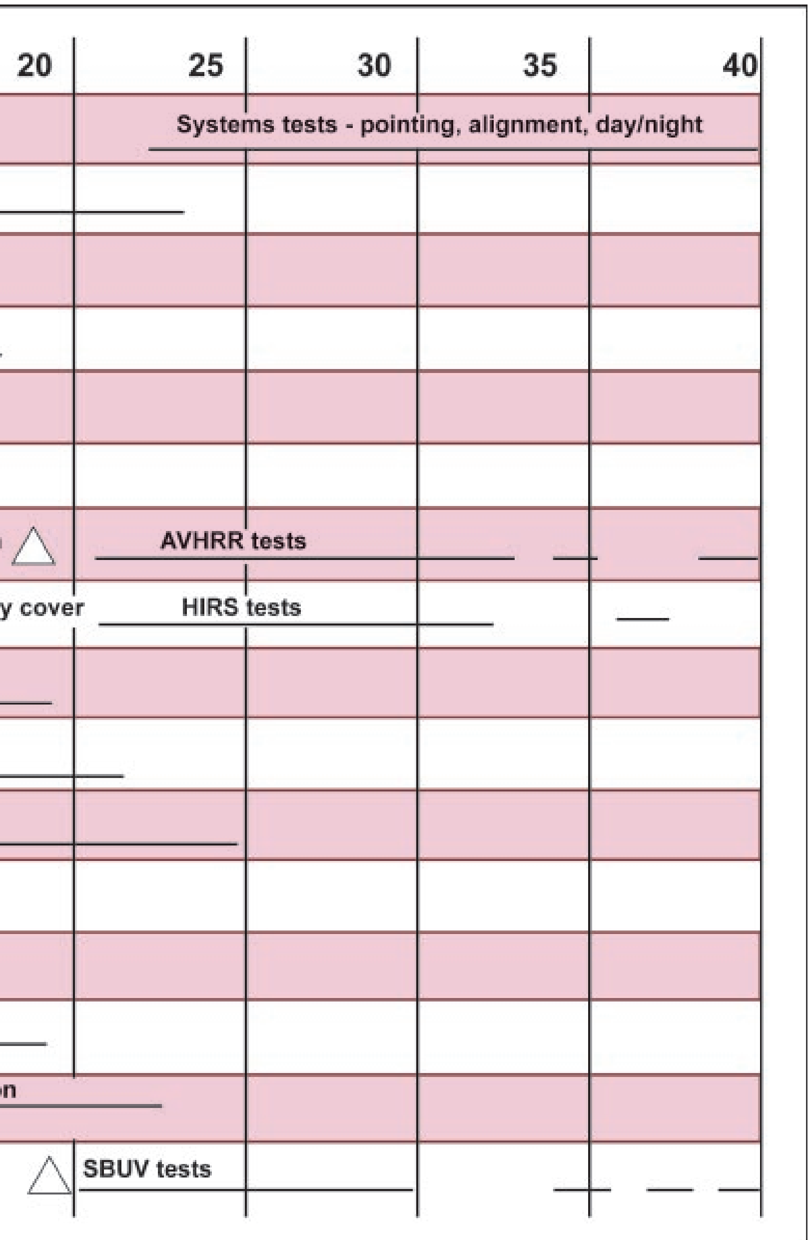
Appendix C

NOAA-N Activation and Evaluation Timeline

Orbit



Days


20
25
30
35
40
Systems tests - pointing, alignment, day/night
AVHRR tests
y cover
HIRS tests
n
SBUV tests

GLOSSARY

ADACS	Attitude Determination and Control System
AFB	Air Force Base
AFSCN	Air Force Satellite Control Network
AIP	AMSU Information Processor
Alt	Altitude
AM	Amplitude Modulation
AMSU	Advanced Microwave Sounding Unit
APT	Automatic Picture Transmission
ATN	Advanced TIROS-N
AVHRR	Advanced Very High Resolution Radiometer
BDA	Beacon Dipole Antenna
bps	Bits Per Second
BW	Bandwidth
C&CS	Command and Control Subsystem
CCR	Cloud Cover Radiometer
CDA	Command and Data Acquisition
cm	Centimeter
CNES	Centre National d'Etudes Spatiales
COSPAS	Russian Space Systems for the Search of Vessels in Distress
DCS	Data Collection System
DDR	Digital Data Recorder
DPU	Data Processing Unit
DSN	Deep Space Network
DTR	Digital Tape Recorder
ELT	Emergency Locator Transmitter
EPIRB	Emergency Position-Indicating Radio Beacon
ERBE	Earth Radiation Budget Experiment
ESA	Earth Sensor Assembly
ESPC	Environmental Satellite Processing Center
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FM	Frequency Modulation
ft	Feet
GAC	Global Area Coverage
Gbit	Gigabit
GEM	Graphite Epoxy Motor
GHz	Gigahertz
GMT	Greenwich Mean Time
GSFC	Goddard Space Flight Center
HIRS	High Resolution Infrared Radiation Sounder
HRPT	High Resolution Picture Transmission
Hz	Hertz
IFOV	Instantaneous Field of View
IGS	Inertial Guidance System
IJPS	Initial Joint Polar-Orbiting Operational Satellite System
IMP	Instrument Mounting Platform
IMS	Inertial Measurement System
IMU	Inertial Measurement Unit
in	Inch
IR	Infrared
ITT	ITT Aerospace/Communications Division
JPL	Jet Propulsion Lab
K	Kelvin temperature
kbps	Kilo bits per second
keV	Kiloelectron volts
kg	Kilogram
kHz	Kilohertz
km	Kilometer
LAC	Local Area Coverage
lb	Pound
LMSSC	Lockheed Martin Space Systems Company
LUT	Local User Terminal
Mbps	Mega bits per second
MCC	Mission Control Center
MECO	Main Engine Cutoff
MEPED	Medium Energy Proton/Electron Detector
MeV	Million electron volt(s)
MHS	Microwave Humidity Sounder
MHz	Megahertz
mi	Mile
MIRP	Manipulated Information Rate Processor

mph	miles per hour
mps	meters per second
ms	Millisecond
MSU	Microwave Sounding Unit
N	Newton
NAILS	NASA Antarctic Interactive Launch Support
NASA	National Aeronautics and Space Administration
NEA	Nitrogen Engine Assembly
NEΔN	Noise Equivalent Radiance
NEΔT	Noise Equivalent Temperature Difference
NESDIS	National Environmental Satellite, Data, and Information Service
NISN	NASA Integrated Services Network
nm	Nanometer(s)
nmi	Nautical mile
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NRZ	Non-Return to Zero
OBP1	On-Board Processor #1
OLR	Outgoing Longwave Radiation
PLB	Personal Locator Beacon
PM	Phase Modulated
POES	Polar Operational Environmental Satellites
PSK	Phase Shift Keyed
PST	Pacific Standard Time
Q3	Quadrant 3
RCC	Rescue Coordination Center
RF	Radio Frequency
RIFCA	Redundant Inertial Flight Control Assembly
RXO	Redundant Crystal Oscillator
SAD	Solar Array Drive
SAR	Search and Rescue
SARP	Search and Rescue Processor
SARR	Search and Rescue Repeater
SARSAT	Search and Rescue Satellite Aided Tracking
SATCOM	Satellite Communications Network
SBA	S-Band Antenna
SBUV	Solar Backscatter Ultraviolet Radiometer
sec	Second
SECO	Second Stage Engine Cutoff
SEM	Space Environment Monitor
SLA	Search and Rescue Transmitting Antenna (L-Band)
SLV	Space Launch Vehicle
SOA	S-Band Omni Antenna
SOCC	Satellite Operations Control Center
SRA	Search and Rescue Receiver/Real-Time Antenna
SSP	Sub-Satellite Point
SSR	Solid State Recorder
SSU	Stratospheric Sounding Unit
STX	S-Band Transmitter
TCS	Telemetry and Command Station
TDRSS	Tracking and Data Relay Satellite System
TED	Total Energy Detector
TEMP	Temperature
TIP	TIROS Information Processor
TIROS	Television Infrared Observation Satellite
UDA	Ultra High Frequency Data Collection System Antenna
USCG	U.S. Coast Guard
USMCC	U.S. Mission Control Center
VHF	Very High Frequency
VRA	Very High Frequency Real-time Antenna
W	Watt
WMO	World Meteorological Organization
WR	Western Range
XSU	Cross-Strap Unit
µm	Micrometer

NASA POES Project: *http://goespoes.gsfc.nasa.gov*

In-orbit Products and Services: *http://www.oso.noaa.gov/poesstatus*
NOAA Products and Services: *http://www.osd.noaa.gov*
NOAA Satellite Product Information Tool: *http://satprod.osd.noaa.gov/satprod/controlcenter.cfm*
POES Users Guide: *http://www2.ncdc.noaa.gov/docs/klm*

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