(NASA-News-Release-78-136) NASA TO LAUNCH FIRST GLOBAL ATMOSPHERE POLLUTION MONITOR (National Aeronautics and Space Administration) 37 p

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Press Kit

Project Nimbus-G

RELEASE NO: 78-136

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RELEASE NO: 78-136

NASA TO LAUNCH FIRST GLOBAL ATMOSPHERE POLLUTION MONITOR

Nimbus-G, the first satellite designed to monitor the Earth's atmosphere for manmade and natural pollutants will be launched by NASA no earlier than Sept. 18, 1978, from the Western Test Range (WTR) at Vandenberg Air Force Base, Calif. It is the last in a series of seven Nimbus environmental research spacecraft launched since August 1964.

Liftoff of the two-stage Delta launch vehicle is planned for 4:14 a.m. EDT, the opening of a 20-minute launch window. The 907-kilogram (2,000-pound) observatory will be lofted into a 955-kilometer (593-mile) high near-polar orbit and will circle the Earth every 104 minutes, or almost 14 times a day.

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Nimbus-G will provide for the first time continuous environmental data to help scientists throughout the world determine the physical characterization of the global atmosphere, the oceans, the dynamic atmosphere-ocean interface and the Earth's heat balance -- information vital to man's understanding of climate, oceanography, atmospheric pollution and regional and global weather patterns.

Working with NASA scientists on the Nimbus-G Project are scientists from the U.S. National Oceanic and Atmospheric Administration (NOAA) and a number of American universities.

International participants include scientists from the United Kingdom, Denmark, Switzerland, Canada, South Africa, West Germany, France and Belgium.

For the first time, the European Space Agency (ESA) will be bringing on line a direct Nimbus-G reception and data processing capability at Lannion, France, where it will eventually receive, process and distribute Nimbus-G data to approved European investigators on a regular basis.

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Nimbus-G's eight, highly complex sensors -- seven from the U.S. and one from Great Britain -- are improved versions of one or more instruments flown on six previous Nimbus flights and hold promise of providing scientists with insight into the answers to three questions of importance to mankind: is the ozone in the Earth's upper atmosphere changing? is the Earth warming up or cooling down? and what is the extent of pollution in the world's oceans?

Among the sensors carried aboard Nimbus-G are four instruments designed to measure various atmospheric gases and pollutants and their interrelationships in the Earth's stratosphere and mesosphere -- the part of the upper atmosphere from 10 to 90 km (6.2 to 56 mi.) in altitude. They are:

- <u>The Limb Infrared Monitoring of the Stratosphere (LIMS)</u> -- an improved version of the Limb Radiance Imversion Radiometer (LRIR) that flew on Nimbus-6. By focusing on sunrise or sunset at the Earth's limb -- or edge -- the LIMS's six channels should measure on a global scale the limb radiances of the narrow infrared spectral bands associated with specific gases in the upper atmosphere that are suspected of influencing changes in the Earth's environment, i.e., nitrogen chemistry and its effect on the ozone layer.

- The Stratospheric and Mesospheric Sounder (SAMS) -- a British-designed and built scanning spectral radiometer which will measure concentrations of water vapor, nitric oxide, methane, carbon monoxide and nitrogen oxides in the upper atmosphere, the temperature of the stratosphere and mesosphere at 90 km (56 mi.) altitude, the velocity of gases under study, and hence, the wind direction of the air masses carrying the gases.

- The Stratospheric Aerosol Measurement-II (SAM-II) -- the data from which will be used to determine the reason for and characteristics of a dust, or aerosol layer at about 20 km (13 mi.) altitude and its effect on climate.

- The Solar Backscatter Ultraviolet and Total Ozone Mapping Spectrometer (SBUV/TOMS) -- designed to continue and improve the mapping and measuring of ozone in the atmosphere started by Nimbus-5. The SBUV module should provide measurements of incident solar ultraviolet radiation and ultraviolet radiation backscattered from the Earth while the TOMS module will map the total ozone. The combined SBUV/TOMS will be the only instrument measuring the total ozone distribution on a global basis and how it varies by season and region.

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Other Nimbus-G instruments designed to provide data vital to scientists studying regional and global climate are:

- The Earth Radiation Budget (ERB)-- a continuation of an experiment carried on Nimbus-6. ERB is designed to measure the Earth's incoming and outgoing (both reflected and emitted) solar radiation and thus determine regional and global heat balance. Knowing the global heat balance will assist scientists to better understand and possibly predict climate change.

- The Scanning Multichannel Microwave Radiometer (SMMR) -- an instrument to sense the microwave thermal emissions from the Earth's surface and atmosphere. This all-weather data will be used to extract sea surface winds and temperatures -- information vital to further our understanding of weather patterns and ocean circulation.

- The Temperature-Humidity Infrared Radiometer (THIR) -- also a continuation of a Nimbus-6 experiment. THIR is designed to measure in two spectral bands the day and night infrared radiation from the Earth, thus providing three dimensional pictures of clouds; cloud, sea and land temperatures; and cirrus cloud content, contamination and relative humidity. Such information is vital to meteorologists in the prediction of storm systems.

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An eighth instrument, the Coastal Zone Color Scanner (CZCS), by sensing colors of the oceans will permit oceanographers to map chlorophyll concentrations, sediment distribution and salinity over large areas of coastal or ocean water.

The instrument will be used to determine how water pollution -- such as oil spills, sewage and industrial waste dumpings and river sediment -- can be detected and tracked.

Data from either the CZCS or SMMR should help determine the feasibility of applying remotely sensed oceanographic data to applications such as:

- Detection of upper level ocean pollutants;
- Determination of the nature of water-suspended materials;
- Mapping of: sediments, biologically productive areas, interactions between coastal effluents and open ocean waters;
- Sea surface temperature mapping; and
- Sea ice characteristics and location.

The Nimbus Program is directed by NASA's Office of Space and Terrestrial Applications, Washington, D.C.

NASA's Goddard Space Flight Center, Greenbelt, Md., is responsible for management of the spacecraft, the Delta launch vehicle and the global network for tracking and two-way communications with the spacecraft.

Launching the Delta is supervised by NASA's Kennedy Space Center, Fla., unmanned launch operations team.

General Electric Co., Space Division, Valley Forge, Pa., is the Nimbus prime contractor. McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is prime contractor for the Delta launch vehicle.

More than 50 major subsystem contractors are responsible for the sensors and various components in the spacecraft, launch vehicle and ground receiving equipment. In addition, there are more than 1,000 subcontractors and vendors working on the program.

The Nimbus-G spacecraft and instruments cost $79 million, $2.6 million less than was budgeted. The Delta launch vehicle cost about $4.6 million.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

THE NIMBUS-G SPACECRAFT

Nimbus-G is similar to the previous six spacecraft in this series. In its orbit configuration, it is a butterfly-shaped satellite measuring about 3 meters (10 feet) tall by about 2 m (5 ft.) wide.

Experiments and major service subsystems are housed in a circular structure on the bottom of the spacecraft. One of these is a three-axis attitude control subsystem which keeps the sensors pointed toward Earth with an accuracy of better than 1 degree about all axes.

Two solar paddles automatically unfold after the spacecraft is separated from the launch vehicle. These track the Sun during daylight operation and convert its energy into spacecraft power. About 550 watts of peak power are required to operate the Nimbus-G.

Spacecraft and experiment data are handled by a versatile information processor and either transmitted to Earth immediately or stored on a high-speed tape recorder for subsequent playback when the spacecraft is in full view of a data acquisition station.

SPACECRAFT DESCRIPTION

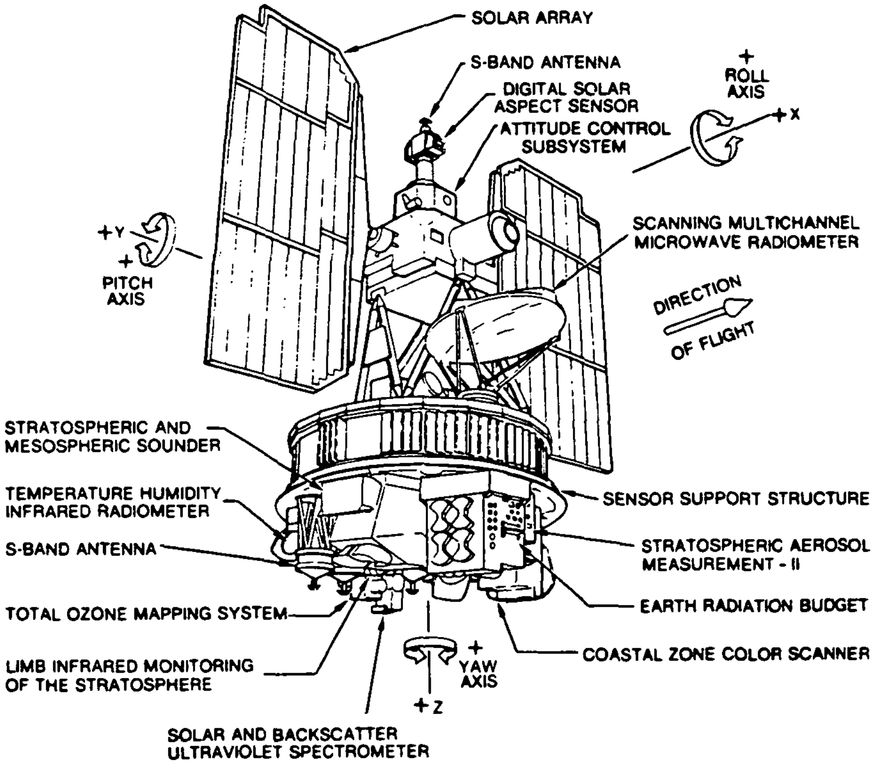
The basic Nimbus-G spacecraft structure, thermal control, power, clock, command and attitude control systems are similar to the Nimbus-5 and 6 design; the data processing and transmission systems and the payload sensors are significantly different and were supplied as government furnished equipment.

The principal spacecraft parameters are as follows:

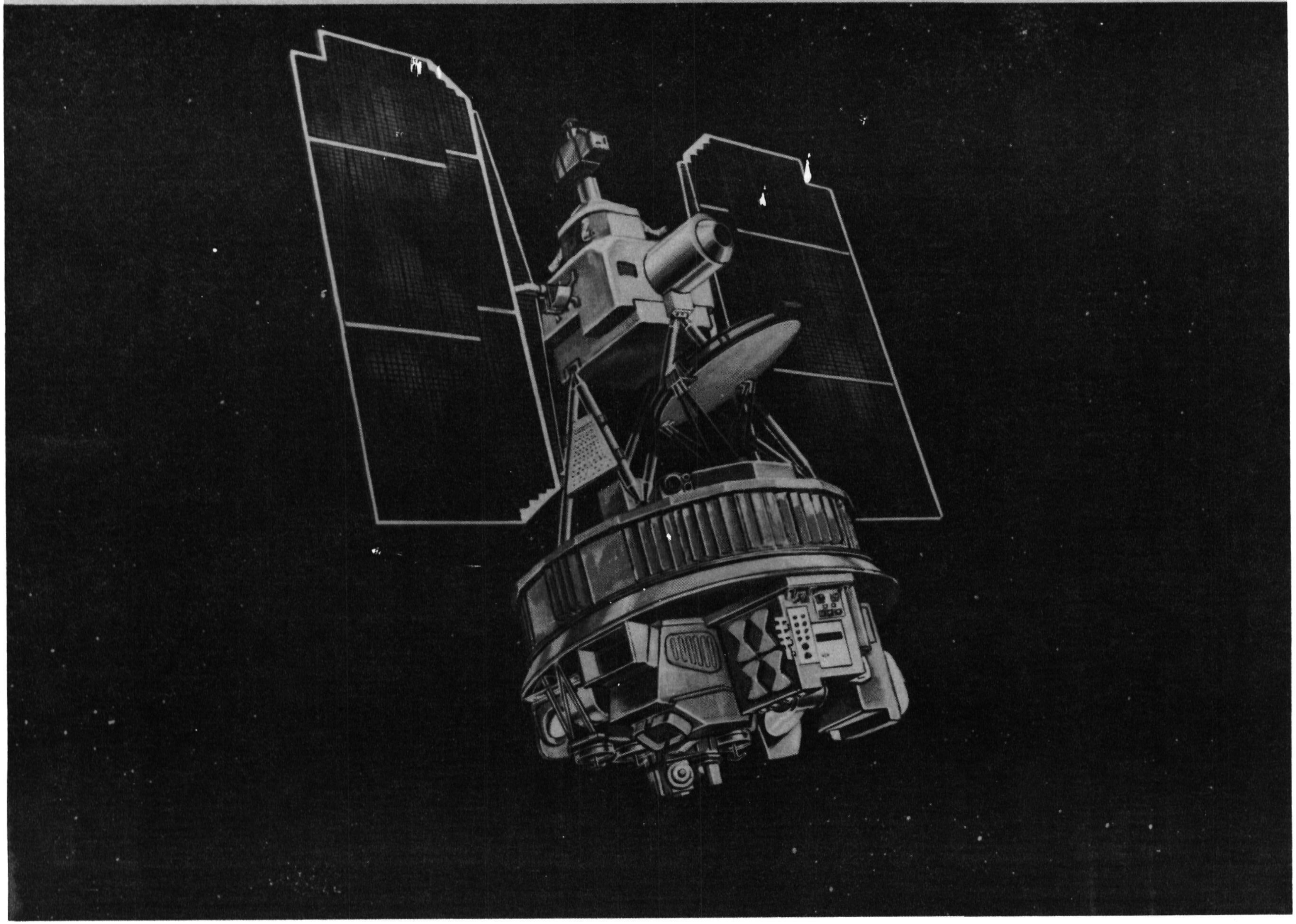
Spacecraft Weight: 987 kilograms (2,176 pounds)
Stabilization Type: Three-axis, Earth-oriented
Stabilization Accuracy: 0.7 degree pointing error
0.01 degree/sec rate
Power Available for Experiments: 140 watts
Thermal Control Range: 10 to 30 degrees Celsius
(50 to 86 degrees Fahrenheit)
Data Storage: Three 10^8 standard tape recorders

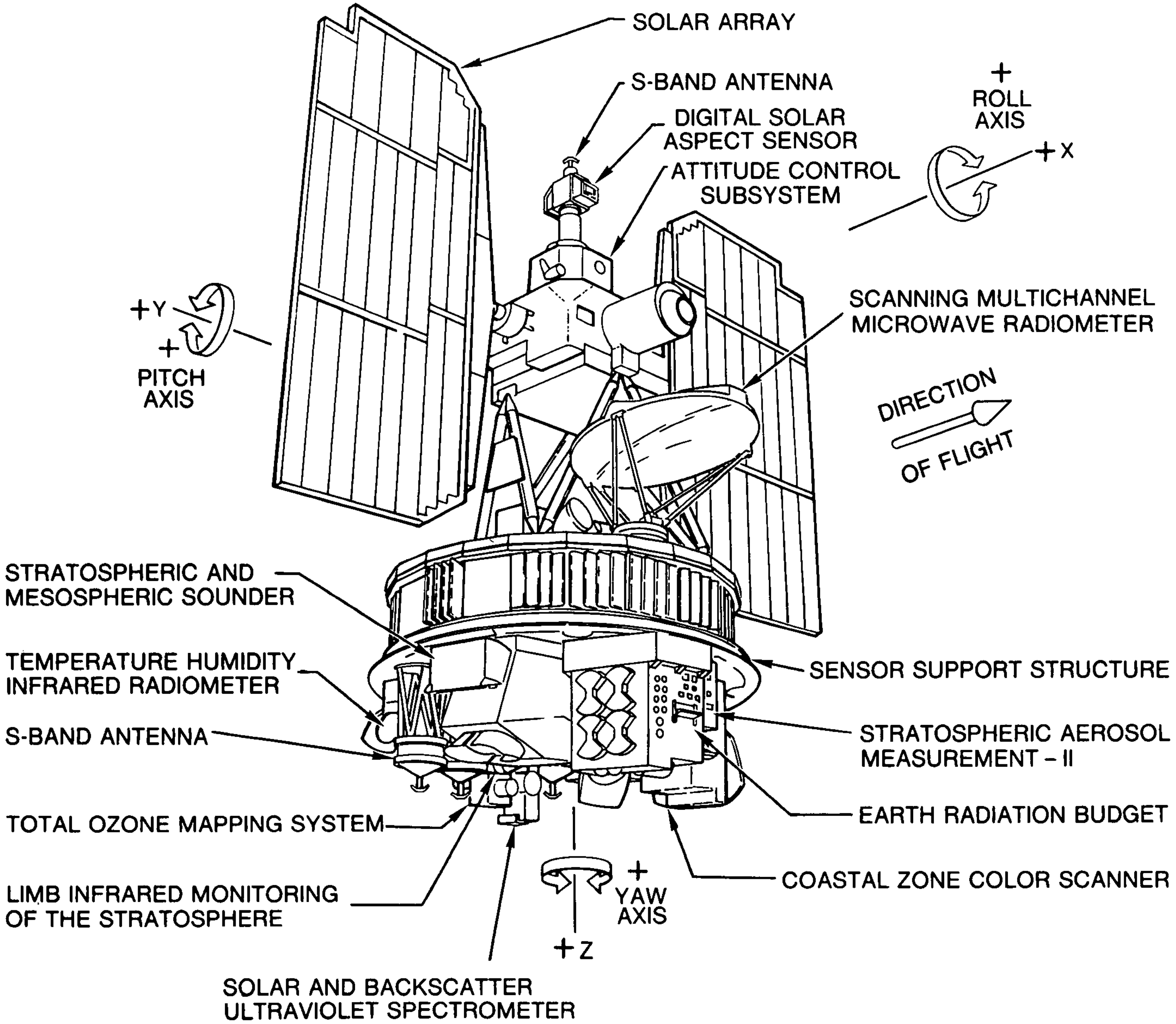
The illustration below shows the Nimbus-G configuration with the Earth-viewing sensors mounted below the torus structure, and the attitude control system and solar array supported above the torus by a truss. A photograph of the spacecraft-mounted sensors appears on page 10.

NIMBUS-G SPACECRAFT

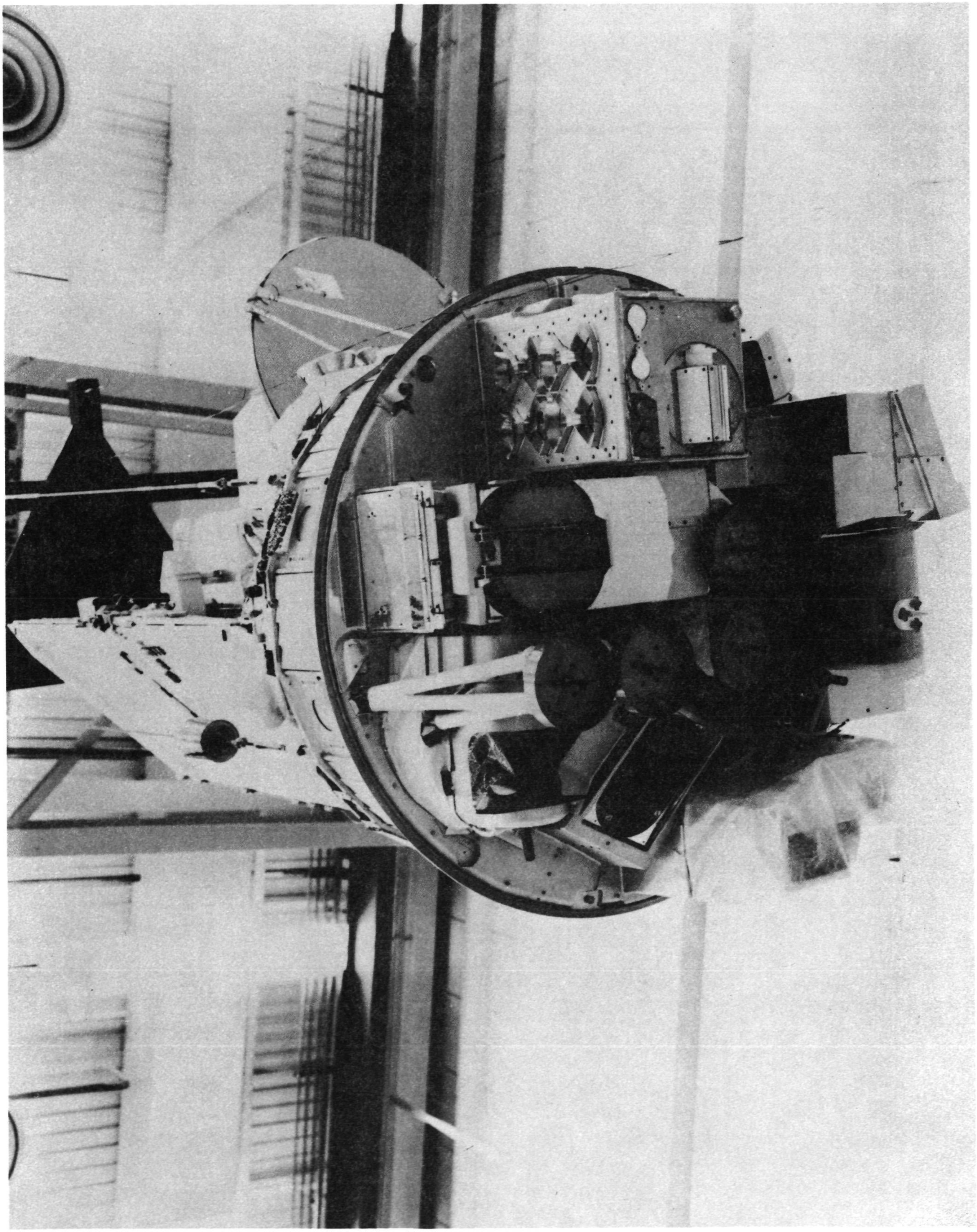


NIMBUS-G





NIMBUS - G OBSERVATORY



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INSTRUMENT SUMMARY

Instrument	Type of Device	Parameter Determinations	Discipline
LIMS - Limb Infrared Monitor of the Stratosphere	Limb Scanning Infrared Radiometer	H_2O, HNO_3, NO_2, O_3, Temperature - Vertical Profiles	Pollution, Meteorology
SAMS - Stratospheric and Mesospheric Sounder	Limb Scanning Pressure Modulated Infrared Radiometer	CH_4, CO, H_2O, NO, N_2O, Temperature - Vertical Profiles	Pollution, Meteorology
SAM II - Stratospheric Aerosol Measurement	Solar Extinction Photometer, Limb Viewing	Aerosols - Vertical Profiles	Pollution, Meteorology
SBUV/TOMS - Solar and Back-scattered Ultraviolet/Total Ozone Mapping System	Sun and Earth Viewing Monochromators, Nadir Viewing and Nadir Scanning	Solar UV Irradiance, Ozone Profiles, Global Maps of Total Ozone	Pollution, Meteorology
ERB - Earth Radiation Budget	Sun and Earth Viewing Spectroradiometer, Nadir Viewing and Nadir Scanning	Solar Irradiance, Flux and Radiance of Earth Reflected Short-wave and Emitted Long-wave Radiation	Meteorology
SMMR - Scanning Multichannel Microwave Radiometer	Earth Viewing Microwave Radiometer, Nadir Scanning	Sea Ice, Sea Surface Temperatures and Winds, Cloud Liquid Water Content, Precipitation, Water Vapor, Soil Moisture, Snow Cover	Oceanography, Meteorology
CZCS - Coastal Zone Color Scanner	Earth Viewing Radiometer Nadir Scanning	Chlorophyll, Sediment Distribution, Gelbstoffe Concentration (Salinity), Coastal Water Temperature, Currents	Oceanography, Meteorology
THIR - Temperature Humidity Infrared Radiometer	Earth Viewing Infrared Radiometer, Nadir Scanning	Correlative Imagery for Other Experiments, Sea Surface Temperature Patterns	Supports All Discipline Investigations

THE NIMBUS-G SENSORS

Seven of the eight remote sensors carried aboard the Nimbus-G are provided and funded by NASA. The remaining one is supplied by the United Kingdom.

Employing advanced technology, these remote sensors are designed to produce basic, correlated data on atmospheric constituents and parameters, the color of the oceans and their surface parameters and the dynamic interface between the atmosphere and the ocean. Other data measured includes both incoming solar radiation and energy reflected or emitted by the Earth.

Measurements of the atmospheric constituents are made primarily by scanning the atmosphere beneath the Nimbus-G and towards the horizon. By measuring sunlight as scattered, or absorbed and re-radiated by the upper atmosphere constituents, it is possible to identify those constituents and to determine their concentrations, distribution and temperature.

Measuring techniques being evaluated with Nimbus-G include: pressure modulated gas cell infrared radiometry; grating spectrometry; filter spectrometry; and multifrequency, dual polarization microwave radiometry.

Specific details of sensor characteristics and operation, along with the senior scientists who head up the Nimbus-G Experiment Teams (NETs) for each of the sensors are listed below.

Stratospheric and Mesospheric Sounder (SAMS)

Prof. J.T. Houghton, Oxford University, Oxford, England.

Scientific Objective -- The objective of the United Kingdom-supplied SAMS is to measure vertical concentrations of H_2O, N_2O, CH_4, CO and NO; observe resonant scattering of solar radiation in spectral bands H_2O, CO_2, CO and NO; measure the temperature of the stratosphere and the mesosphere to 90 km (56 mi.) altitude; investigate source function and departure from thermodynamic equilibrium between 80 and 130 km (50 to 80 mi.) associated with CO_2 emission bands; and measure the zonal wind velocity component along the line of sight.

Sensor Description -- The SAMS has a pressure broadening spectral radiometer with seven pressure-modulated cells and six detectors: four TGS, one PbS and one InSb; it scans approximately ±0.087 rad(±5 degrees) above the Earth's horizon at various altitudes. Doppler azimuth scan for wind velocity by horizontal scan is approximately ±0.26 rad (±15 degrees) to measure Doppler shift in emission spectrum. Doppler scan rate compensates for spacecraft motion during the 240-second scan period. A dichroic beam splitter separates spectral regions, and optics are coated to select spectral bands. Five-second pointing accuracy is self-contained. A radiation cooler door is opened by command for cooler outgassing and contamination control. Radiation from the limb of the atmosphere is incident on the scan mirror, 202 by 185 millimeters (8 by 7.4 inches) in size. The scan mirror can scan over the limb, view space for calibration and view at a slant angle into the atmosphere for vertical-type sounding.

There are three adjacent FOVs, each 28 by 2.8 mrad (corresponding to 100 by 10 km (62 to 6 mi.) at the limb). They are focused by means of a telescope onto a field-splitting mirror which directs radiation to six detectors. The remaining division into channels is accomplished through a dichroic beam splitter. There are seven pressure modulator cells (PMC) containing CO_2 (two cells), N_2O, NO, CH_4, CO and H_2O. The pressure in the cells may be varied on command by changing the temperature of a small container that holds molecular sieve material attached to each of the PMCs. Within the telescope, a chopper operating at 240 Hz is included so that, from all the detectors, two separate signals can be measured, one at the 240-Hz frequency and one at the PMC frequency. Comparison of these signals enables emission from interfering gases within a particular spectral interval to be eliminated. In front of the chopper, a small black body at known temperature can be introduced from time to time for calibration. Accurate measurement of the atmospheric pressure at the level being viewed is obtained from the two signals from the CO_2 channel.

Scanning Multichannel Microwave Radiometer (SMMR)

Dr. Per Gloersen, NASA Goddard Space Flight Center, Greenbelt, Md.

Scientific Objective -- The primary purpose of the SMMR is to obtain and use ocean momentum and energy transfer parameters on a nearly all-weather operational basis. One parameter, the speed of the ocean surface wind, is not now available from remote sensors. Because microwave signatures of the ocean surface depend upon the state of the surface, from which sea surface winds can be inferred, and as most clouds are not completely opaque to microwaves, microwave radiometry provides an opportunity for realizing these objectives.

Sensor Description -- The SMMR is an outgrowth of the Electrically Scanning Microwave Radiometers (ESMR), the Nimbus-E Microwave Spectrometer (NEMS) and the Scanning Microwave Spectrometer (SCAMS) on the Nimbus-5 and Nimbus-6 satellites. The instrument simultaneously measures microwave thermal emission from Earth's atmosphere and surface in five channels of different center frequency and wavelength. Each channel measures radiation in two orthogonal linear polarizations. The microwave thermal emission from the Earth and its atmosphere is collected by an offset parabolic reflector antenna which focuses this radiation into a multifrequency feed system. The feed system is connected to the five radiometer inputs either through an orthomode transducer or directly for separating the polarizations and then through polarization, calibration and Dicke switches. The radiometers detect, amplify and convert the signals to digital data which are multiplexed with instrument engineering and calibration data and fed into the satellite data system for transmission to the ground. The radiometric data outputs are sampled at integration times varying from 30 milliseconds to 126 milliseconds. The instrument uses a parabolic section antenna, 80 centimeters (32 in.) in diameter, with a five-frequency dual-polarization feed system.

To obtain the ocean parameters of interest from microwave brightness temperatures of the ocean surface, it is necessary to correct for interfering surface effects as well as atmospheric absorption and emission. The five-wavelength, dual-polarized (that is, 10-channel) scanning radiometer, operating at the wavelengths of 0.8, 1.4, 1.7, 2.8 and 4.0 cm, separates the parameters of interest. The spectral and polarization signatures of the various effects will be used for sorting out these parameters. The wind speed information will be contained primarily in the horizontal channels of all wavelengths.

Atmospheric water vapor information will be obtained from the 1.4-cm channels. Four channels, at wavelengths of 0.8, 1.7, 2.8 and 4.0 cm are used for sorting the nonlinear dependence of the liquid water droplet microwave signature on wavelength from competing surface effects.

Remote sensing in the polar regions will be enhanced beyond the single wavelength measurements of the microwave radiometers on Nimbus-5 and Nimbus-6 with this complement of radiometers. Although the spatial resolution will not be improved, the capability of distinguishing between open water and multiyear ice in partial beam-filling situations will be enhanced because of the different spectral signatures of these two targets.

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Locating the position and extent of open areas in the polar ice canopies is very important for obtaining the heat balance in the polar regions. The motion of multiyear ice within the canopy can be used to study the dynamics of the ice canopy motion in the Arctic region.

SMMR PERFORMANCE CHARACTERISTICS

Parameter	Channels				
Frequency (GHZ)	6.63	10.69	18.00	21.00	37.00
R-F Bandwidth (MHz)	250	250	250	250	250
Integration Time (ms) (approximate)	126	62	62	62	30
I-F Frequency Range (MHz)	10-110	10-110	10-110	10-110	10-110
Dynamic Range (°K)	10-330	10-330	10-330	10-330	10-330
Absolute Accuracy (°K rms)	<2.0	<2.0	<2.0	<2.0	<2.0
Temperature Resolution, ΔTrms (°K) (per cell)	0.9	0.9	1.2	1.5	1.5
Antenna Beam Width (±0.2°) (θa)	4.2	2.6	1.6	1.4	0.8
Antenna Beam Efficiency (percent)	87.0	87.0	87.0	87.0	87.0
Wavelength (cm)	4.54	2.8	1.66	1.36	0.81
Scan Cycle ±0.4 rad (±25°) (s)	4.096	4.096	4.096	4.096	4.096
Double Sideband Noise (dB) (maximum)	5.0	5.0	5.0	5.0	5.0

Coastal Zone Color Scanner (CZCS)

Dr. Warren A. Hovis, Jr., National Environmental Satellite Service, NOAA, Rockville, Md.

Scientific Objective -- The objective of the CZCS is to map chlorophyll concentration, sediment distribution, gelbstoffe (yellow substance) concentration as a salinity indicator, and temperature of coastal waters and the open ocean.

Sensor Description -- The received energy from the sea will be measured in six channels. Five of the channels will sense the solar energy and, therefore, water color, as affected by absorption and scattering due to chlorophyll, sediment and gelbstoffe.

Spectral bands at 443 and 670 nanometers are centered on the most intense absorption bands of chlorophyll, while the band at 550 nm is centered on the hinge point, the wavelength of minimum absorption. Ratios of measured energies in these channels have been shown to closely parallel surface chlorophyll concentrations. The data from the scanning radiometer will be processed to produce maps of the above measured materials. The temperature of coastal waters and the open ocean will be measured in a spectral band centered at 11.5 μm (channel 6). To avoid Sun glint, the scanner mirror can be tilted about the observatory pitch axis on command, such that the line of sight of the sensor is moved $\pm$0.350 rad in steps of 0.035 rad with respect to nadir.

Solar Backscatter Ultraviolet and Total Ozone Mapping Spectrometer (SBUV/TOMS)

Dr. Donald F. Heath, NASA Goddard Space Flight Center, Greenbelt, Md.

Scientific Objectives -- The SBUV/TOMS will provide measurements of incident solar UV radiation and UV radiation backscattered from the Earth. Eight of the shortest SBUV wavelengths are centered at levels ranging from 255 to 300 nm and are used to sound vertical ozone distribution. The four longest SBUV wavelengths (300 to 340 nm) have contributing functions in the troposphere, which are used to compute the total ozone amount. The continuous spectral scan from 160 to 400 nm (1600 to 4000A) permits a detailed examination of the extraterrestrial solar spectrum, the Earth radiance spectrum and the temporal variations. The TOMS uses six wavelengths to map the total ozone.

Sensor Description -- The SBUV/TOMS sensor contains the SBUV module, the TOMS module and the electronics module. The SBUV will measure the backscattered solar UV that is backscattered by the Earth's atmosphere at 12 discrete wavelengths and a continuous scan of the wavelengths ranging between 160 and 400 nm (1600 and 4000A). The 1-nm (10A) spectral bands are centered on the wavelengths listed in the table on page 20. They are the same as those flown on the Nimbus-4 backscatter ultraviolet spectrometer (BUV). The Sun can be viewed through a common diffuser plate. The SBUV consists of a tandem double Ebert-Fastie monochrometer for stray light rejection. The detector is a photo multiplier. A parallel photometer channel using a vacuum photodiode with a 3-nm (30A) spectral band pass centered at 343 nm (3430A) measures the UV reflectivity of a lower boundary of the atmosphere.

Both the SBUV and the photometer channel have a nadir viewing a 0.20 rad (11.3 degree) square IFOV.

SBUV/TOMS DISCRETE WAVELENGTH COVERAGE

SBUV		TOMS	
Step No.	**Wavelength Center Å**	**Step No.**	**Wavelength Center Å**
0	3398	1	3125
1	3312	2	3312
2	3175	3	3175
3	3125	4	3398
4	3058	5	3600
5	3019	6	3800
6	2975		
7	2922		
8	2876		
9	2830		
10	2735		
11	2555		

The TOMS module maps the total ozone with a 0.052 rad (3 degree) square IFOV step scan across a 1.8 rad (105 degree FOV. The 1-nm (10A) wide spectral bands are centered at the wavelengths given in the table above. The TOMS consists of a single Ebert-Fastie monochrometer and a photomultiplier detector.

Earth Radiation Budget (ERB)

Dr. Herbert Jacobowitz, NOAA, Rockville, Md.

Scientific Objective -- The objective of the ERB experiment, a continuation of the Nimbus-6 ERB, is to determine, over a period of a year, the Earth radiation budget on both synoptic and planetary scales by simultaneous measurements of:

- Incoming solar radiation
- Outgoing Earth-reflected (shortwave) and emitted (longwave) radiation by:
  - Fixed wide-angle sampling of these terrestrial fluxes at the satellite altitude
  - Scanned narrow-angle sampling of the angular radiance components

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Sensor Description -- The ERB subsystem is a 22-channel radiometer containing separate subassemblies to perform the required solar, Earth flux (wide angle) and scanned Earth radiance (narrow angle) measurements.

Optical filters are used for the required spectral discriminations. Uncooled thermal detectors are employed: thermopile detectors in the solar and fixed-Earth-flux channels and pyroelectric detectors in the scanning channels. Independent amplifier, demodulator and integrator circuitry are provided for each channel. The channel signals will be integrated during various time intervals and then sampled and digitized while the integrators are reset in preparation for integration of the next data samples. Data are sampled and transmitted through the spacecraft's VIP and DIP subsystems.

Temperature-Humidity Infrared Radiometer (THIR)

Lewis J. Allison, NASA Goddard Space Flight Center, Greenbelt, Md.

Scientific Objectives -- The objectives for the THIR sensor are to measure the infrared radiation from the Earth in two spectral bands during both day and night portions of the orbit to provide pictures of the cloud cover, three-dimensional mappings of the cloud cover and temperature mappings of the clouds, land and ocean surfaces, cirrus cloud content, contamination and relative humidity.

Sensor Description -- The THIR is a two-channel scanning radiometer. It contains a 6.5 to 7.0 um (water vapor) channel that has a 21-mrad FOV and a 10.5 to 12.5 um (window) channel that has a 7.0-mrad FOV. The subsystem uses the concept of dc restoration of the ac-coupled radiometric signals once each scan period when the radiometer views space, so that absolute radiometric data are obtained and the need for a radiation chopper is eliminated.

The THIR consists of an optical scanner and an electronics module. The optical scanner provides the necessary scan motion to produce cross-course scanning of the radiometer's instantaneous FOVs. It contains the radiometer optics, detectors, preamplifiers, detector bias supply, scan drive and scan synchronization pip amplifiers. The electronics module provides the necessary amplification and data processing of the detected radiometer signals and provides it as an input to the data processing system.

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The scanner design uses an elliptically shaped, plane scan mirror and primary optics that are common to both channels. The scan mirror is set at an angle of 0.78 rad to the scan axis rotating at 48 rpm. The scanner opening permits an unobstructed scan angle of 1.31 rad. The two channels are separated by means of a dichroic beam splitter, after which the radiation in each channel is imaged in a plane coincident with a trimmer field stop and then relayed onto the channel detector.

Limb Infrared Monitoring of the Stratosphere (LIMS)

Dr. James M. Russell, III, NASA Langley Research Center, Hampton, Va.

Scientific Objectives -- Changes in concentration of certain trace gases in the upper atmosphere are suspected of influencing changes in the Earth's environment. The objective of the LIMS program is a global survey of selected gases to establish a data base on gas concentrations and temperature profiles for the region of the stratosphere bounded by the upper troposphere and the lower mesosphere. Remote detection of Earth limb radiances is employed for narrow spectral bands associated with specific gas emission spectra. The radiance data are processed on the ground by inversion techniques to derive gas concentrations and temperature profiles.

Sensor Description -- The LIMS radiometer is a modified version of the Limb Radiance Inversion Radiometer (LRIR) Nimbus-6 instrument design. Primary modifications include increasing the data channels from four to 6; slowing the scan rate from 17.45 mrad/s (1 degree/s) to 4.36 mrad/s (0.25 degree/s); readjusting channel IFOVs to accommodate six detectors in the detector capsule assembly (DCA); improving the design of the in-flight calibrator (IFC); and improving radiometric accuracy consistent with these changes.

The instrument (an infrared radiometer) has a servo-driven mirror which scans from horizon to space 0.21 rad (12 degrees). The adaptive scanning mode of 0.052 rad (3 degrees) is automatically referenced to the peak CO_2 layer about the Earth. This is considered sufficiently consistent to use as an attitude reference. The Hg Cd Te detectors are cooled to 65 k by means of a two-stage solid cryogen (methane/ammonia) cooler. Characteristic radiances are monitored for the following gases: nitrogen dioxide (NO_2), water vapor (H_2O), ozone (O_3), nitric acid (HNO_3) and carbon dioxide (CO_2). Radiance from both wide and narrow band CO_2 channels are monitored to derive temperature profiles in the stratosphere.

Stratospheric Aerosol Measurement II (SAM II)

Dr. M. Patrick McCormick, NASA Langley Research Center, Hampton, Va.

Scientific Objective -- The objective of the SAM II is to map the concentration and optical properties of stratospheric aerosols as a function of altitude, latitude and longitude. When no clouds are present in the IFOV, tropospheric aerosols can also be mapped.

Sensor Description -- During spacecraft sunrise and sunset events, the instrument tracks the center of the Sun in the azimuth direction as it simultaneously scans back and forth vertically (elevation) across the refracted solar image. Using the Sun as a constant radiant source, the instrument measures the solar radiation reaching the spacecraft after penetrating the Earth's atmosphere. A given sunrise or sunset event is monitored for a fixed time span to ensure Earth limb altitude coverage from 10 km (6 mi.) to clear space (above the atmosphere). A single narrow band channel is monitored at a spectral frequency of 1 μm. The pass band relates to the absorption frequency of aerosol particles of a specific size that are suspended in the atmosphere. Hence, attenuation of refracted solar radiation beyond that due to a clear atmosphere can be related to aerosol concentrations.

The instrument package consists of optical and electronic subassemblies mounted side by side. The optical subassembly consists of gimbals, a flat entrance window, Cassegrain optics, a flat scanning mirror, Sun acquisition sensors and a detector package. The entire optical subassembly is gimballed in azimuth. The azimuth servo employs Sun sensors driven to null on the center of the Sun to a tolerance of ± 0.58 mrad (2 arc min). At the beginning of a sunrise or sunset event, the instrument slews in azimuth to a position to acquire the Sun (approximately π rad (180 degrees) from the last event or as determined by commands).

Upon acquisition in azimuth, the mirror servo scans in elevation until the Sun is acquired. The scan range is then reduced to scanning back and forth across the solar image only. The flat entrance window filters out the UV component of the spectrum. The detector package at the focal plane consists of an interference-type band pass filter, a science data detector and two edge detectors to monitor solar limb crossings. Time is recorded for each detected limb crossing, both going on and going off the Sun. Also, each time a limb is crossed going off the Sun, a servo timer is triggered to reverse scan mirror direction in a fixed time increment. The scan sequence is also reinitiated again.

Scientific data are read at a constant 50 samples per second, synchronized with the data system versatile information processor main frame pulse. Data points can be correlated with position on the solar image by extrapolating edge crossing time, linear scan rates and spacecraft ephemeris data in coordination with a model of solar refraction by the Earth's atmosphere.

NIMBUS-G EXPERIMENT TEAMS

The Nimbus-G Experiment Teams (NETs) were established by NASA to allow world scientists to participate in pre-launch planning for the Nimbus-G mission as well as evaluate post launch sensor performance and conduct initial analysis.

As representatives of the user community, the NETs defined the output products which would be most useful. They participated in the development of the algorithms required to extract the geophysical parameters from the sensor observations. They further developed plans for validation of the data products by comparison with measurements obtained by aircraft, balloons, sounding rockets and surface stations.

Four scientists will conduct initial post-launch investigations designed to demonstrate the practical usefulness of the Nimbus-G observations. They are:

- Climate - Dr. Albert Arking, NASA Goddard Space Flight Center, Greenbelt, Md.
- Environmental Quality - Dr. J. D. Lawrence, NASA Langley Research Center, Hampton, Va.
- Oceanography - Dr. James L. Mueller, Goddard Space Flight Center
- Meteorology - John Theon, Goddard Space Flight Center

NETs have been established for each of six NASA-provided sensors. A seventh NASA sensor supports all of the other sensors and requires no NET. It is the Temperature-Humidity Infrared Radiometer (THIR).

The United Kingdom selected members for the U.K.-provided sensor -- the Stratospheric and Mesospheric Sounder (SAMS).

The following is a list of the NETs by sensor. Sensor scientists are indicated by the asterisk:

Limb Infrared Monitor of the Stratosphere (LIMS)

*Dr. James M. Russell, III, NASA Langley Research Center,
Hampton, Va.

*Dr. John Gille, National Center for Atmospheric Research,
Boulder, Colo.

Dr. S. Roland Drayson, University of Michigan, Ann Arbor.

Dr. Herbert Fischer, University of Munchen, West Germany.

Dr. Andre Girard, ONERA, Chapillon, France.

Dr. John Harries, National Physical Laboratories,
Teddington, Middlesex, United Kingdom.

Dr. Frederick House, Drexel University, Philadelphia, Pa.

Dr. Conway Leovy, University of Washington, Seattle.

Walter G. Planet, NOAA/NESS, Suitland, Md.

Dr. Ellis Remsberg, Langley Research Center.

Stratospheric Aerosol Measurement II (SAM II)

*Dr. M. P. McCormick, NASA Langley Research Center, Hampton,Va.

Dr. Gerald W. Grams, National Center for Atmospheric Research,
Boulder, Colo.

Dr. Benjamin W. Herman, University of Arizona, Tucson.

Dr. Theodore J. Pepin, University of Wyoming, Laramie.

Dr. Phillip B. Russell, Stanford Research Institute,
Menlo Park, Calif.

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Stratospheric and Mesospheric Sounder (SAMS)

*Dr. John Houghton, Clarendon Laboratory, University of Oxford, United Kingdom.

Dr. M. Ackerman, Institute d'Aeronomie Spatiale de Belgique, Bruxelles, Belgium.

Dr. C. B. Farmer, NASA Jet Propulsion Laboratory, Pasadena, Calif.

Dr. John Harries, National Physical Laboratory, Teddington, Middlesex, United Kingdom.

Dr. K. H. Stewart, Meteorological Office, Bracknell Berks, United Kingdom.

Harold Yates, NOAA/NESS, Suitland, Md.

Coastal Zone Color Scanner (CZCS)

*Dr. Warren Hovis, National Oceanic and Atmospheric Administration, National Environmental Satellite Service, Suitland, Md.

Dr. John Apel, Pacific Marine Environmental Laboratory, Seattle, Wash.

Roswell W. Austin, Scripps Institution of Oceanography, La Jolla, Calif.

Dr. Frank Anderson, National Research Institution of Oceanology, South Africa.

Dennis Clark, NOAA/NESS, Suitland, Md.

Dr. Sayed Z. El-Sayed, Texas A&M University, College Station.

Dr. Howard R. Gordon, University of Miami, Fla.

Dr. B. Sturm, JRC, ISPRA, EURASAP-Commission of the European Communities

Robert Wrigley, NASA Ames Research Center, Mountain View, Calif.

Dr. Charles Yentsch, Bigelow Laboratory for Ocean Sciences, West Booth Bay Harbor, Maine.

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Earth Radiation Budget (ERB)

*Dr. Herbert Jacobowitz, NOAA, National Meteorological Center,
Washington, D.C.

Dr. K. L. Coulson, University of California, Davis.

John Hickey, The Eppley Lab, Inc., Newport, R.I.

Dr. Frederick House, Drexel University, Philadelphia, Pa.

Dr. Andrew Ingersoll, California Institute of Technology,
Pasadena.

G. L. Smith, NASA Langley Research Center, Hampton, Va.

Dr. Larry Stowe, NOAA/NESS, Suitland, Md.

Dr. Thomas Vonder Haar, Colorado State University, Ft. Collins.

Solar and Backscattered Ultraviolet - Total Ozone Mapping System (SBUV/TOMS)

*Dr. Donald Heath, NASA Goddard Space Flight Center,
Greenbelt, Md.

Dr. Arthur Belmont, Control Data Corp., Minneapolis, Minn.

Dr. Derek Cunnold, Massachusetts Institute of Technology,
Cambridge.

Dr. Alex Green, University of Florida, Gainesville.

Dr. William Imhof, Lockheed Space Sciences Lab, Palo Alto, Calif.

Arlin J. Krueger, Goddard Space Flight Center.

Dr. Carlton Mateer, Atmosphere Environmental Service,
Downsview, Ontario, Canada

Alvin J. Miller, NOAA National Meteorological Center,
Washington, D.C.

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Scanning Multichannel Microwave Radiometer (SMMR)

*Dr. Per Gloersen, NASA Goddard Space Flight Center, Greenbelt, Md.

*Frank Barath, NASA Jet Propulsion Laboratory, Pasadena, Calif.

Dr. William Campbell, U.S. Geological Survey, Tacoma, Wash.

Dr. Preben Gudmandsen, Technical Institute of Denmark, Lyngby.

Dr. Klaus Kunzi, University of Berne, Switzerland.

Dr. Rene Ramseier, Department of Environment, Ottawa, Canada.

Duncan Ross, NOAA, Atlantic Oceanography and Meteorology Laboratories, Miami, Fla.

Dr. David Staelin, Massachusetts Institute of Technology, Cambridge.

Dr. Thomas Wilheit, Goddard Space Flight Center

Dr. E.P.L. Windsor, British Aircraft Corp., Bristol, United Kingdom

GLOBAL ATMOSPHERIC RESEARCH PROGRAM

The Global Atmospheric Research Program (GARP) is an international effort to enhance the understanding of and ability to predict weather. It is jointly directed by the World Meteorological Organization and the International Council of Scientific Unions.

This well organized cooperative program has as its main thesis the concept that satellite and surface observations can be used in the development of mathematical models of the atmosphere to achieve a major improvement in the quality and duration of weather forecasts. The First GARP Global Experiment (FGGE), a major international experiment to test this thesis, is planned for 1978 and 1979.

FGGE will be the largest and most complex international cooperative space effort yet undertaken. It will involve five geosynchronous satellites launched by the United States, the European Space Agency and Japan. More than 20 countries have volunteered supplementary facilities for use in the FGGE.

Both theoretical studies and numerical experimentation have demonstrated a critical need for direct wind measurements with high accuracy at various altitudes in the equatorial zone. The World Weather Watch surface-based network provides only about 20 per cent of the necessary coverage. For the remaining areas, a combination of ships and carrier balloon systems, capable of deploying windfinding sondes, is planned for the FGGE.

A prototype system has been developed to obtain meteorological wind data from balloons on command.

In preparing for FGGE, NASA and other government agencies and universities undertook a large scale test of the major elements involved in 1974-76. Called the Data Systems Test (DST), it involved supplementing conventional weather data and operational satellite observing systems with research and development systems as they became available. It included processing data in numerical forecast models for feedback to improve the observational and data management systems.

LAUNCH OPERATIONS

NASA launch operations from its West Coast facility are conducted by the Kennedy Space Center's Expendable Vehicles Directorate. This facility is located at the Western Test Range, Vandenberg Air Force Base, near Lompoc, Calif., approximately 201 km (125 mi.) northwest of Los Angeles and 451 km (280 mi.) south of San Francisco. Launch facilities are located on a promontory which juts into the Pacific Ocean near Point Arguello, making it possible to launch to the south to place payloads into polar orbit without overflying populated areas.

Nimbus-G will be launched aboard Delta 145 from Space Launch Complex 2 West, which has been extensively updated over the years to accept the various Delta configurations, including the powerful new version now in use.

Some Kennedy Space Center personnel are on permanent assignment as members of the Delta Western Operations Branch and Western Operations Support Office. These personnel are augmented by a management and technical group from the Kennedy Space Center in Florida during final preparations and the launch countdown.

Preparations for the launch of Nimbus-G began July 6 with the erection of the Delta first stage on the launch pad. The nine solid strap-on rocket motors were mounted around the base of the first stage July 11-14 and the second stage was erected July 20.

The Nimbus-G spacecraft was received Aug. 15 and underwent checkout in the Spacecraft and Telemetry Building at the KSC facility on South Vandenberg. The spacecraft was taken to the pad and mated with the second stage Sept. 7. The payload fairing which will protect it during its flight through the atmosphere is to be placed atop the stack Sept. 10. The canisters for the CAMEO piggyback experiment were mounted around the second stage mini-skirt Sept. 5.

DELTA LAUNCH VEHICLE

Nimbus-G will be launched by a two-stage Delta 2910 launch vehicle, managed for NASA's Office of Space Transportation Systems by the Goddard Space Flight Center. The launch vehicle is Delta 145.

To date, the Delta has launched 144 payloads and has a success record of more than 90 per cent.

The 35.3-m (116-ft.) tall Delta vehicle consists of a liquid-fuel McDonnell Douglas Astronautics Co. extended long-tank Thor booster, nine Thiokol strap-on Castor II solid-fuel rocket motors and a TRW Corp. liquid-fuel second stage engine. The diameter of the 132,180-kg (290,796-lb.) Delta vehicle is 2.44 m (8 ft.) not including the strap-on motors.

An all-inertial guidance system, consisting of an inertial sensor package and digital guidance computer, controls the vehicle and sequence of operations from liftoff to spacecraft separation. A sensor package provides vehicle attitude and acceleration information to the guidance computer, which generates vehicle steering commands to each stage. The system thus corrects trajectory deviations by comparing computed position and velocity against prestored values.

In addition the guidance computer performs the functions of timing and staging as well as issuing pre-programmed attitude rates during the coast phases.

ORBIT EVENTS

About 75 minutes after the Nimbus-G reaches orbital altitude still attached to the Delta second stage, the two vehicles will be separated.

Once free of the Delta second stage, the Nimbus-G spacecraft will unfold its large solar arrays and automatically become stabilized and oriented. In this configuration, the solar arrays will view the Sun for maximum power generation and the sensors will view the Earth.

During the initial orbits, the spacecraft subsystems and sensors will be turned on and checked out upon command from the Nimbus Operations Control Center at Goddard. Simultaneously, the Nimbus-G's precise orbit will be determined with information obtained from the Space Tracking and Data Network (STDN), also centered at and managed by Goddard.

Due to power limitations in the Nimbus-G, its sensors will be energized for regular use in a planned sequence to satisfy the global and time requirements for best application of the collected data. This sequence will be changed daily and repeated every 18 days.

Four tracking stations around the globe will be used to communicate with and collect data from the Nimbus-G. They are located at Goddard Center; Fairbanks, Alaska; Madrid, Spain; and Orroral, Australia.

LAUNCH SEQUENCE FOR DELTA 2910/NIMBUS-G

	Time			Altitude		Velocity	
Event	Hr	Min	Sec	Miles	Kilometers	Mph	Km/Hr
Liftoff	0	0	0	0	0	0	0
Six Solid Motor Burnout	0	0	38	4	6	1,137	1,830
Three Solid Motor Ignition	0	0	39	4	6	1,134	1,826
Three Solid Motor Burnout	0	1	17	14	22	1,837	2,958
Nine Solid Motor Jettison	0	1	27	16	26	1,979	3,185
Main Engine Cutoff (MECO)	0	3	47	59	96	11,249	18,104
First/Second Stage Separation	0	3	54	64	102	11,231	18,075
Second Stage Ignition	0	4	01	64	104	11,242	18,093
Fairing Jettison	0	4	37	78	126	11,660	18,764
First Cutoff Stage II(SECO I)	0	8	57	103	166	17,953	28,893
Restart Stage II	0	56	38	594	957	16,016	25,776
Second Cutoff Stage II(SECO II)	0	56	50	594	957	16,491	26,540
Achieve Spacecraft Separation Attitude	1	14	50	598	963	16,491	26,540
Nimbus-G/Stage II Separation	1	15	40	599	964	16,491	26,540
Tumble Second Stage	1	29	10	602	968	16,489	26,537

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Trajectory

The launch vehicle is programmed to inject the satellite into a nearly circular Sun-synchronous orbit. The nearly polar orbit will provide latitudinal coverage and the rotation of the Earth will provide longitudinal coverage over successive orbits. The launch will occur about 4 a.m. EDT in order to achieve the desired "high noon" characteristics. The spacecraft will view the Earth at near local noon on the sunlit side and near midnight on the dark side. Its orbital plane will precess at a rate equal to the Earth's rotation around the Sun and will always include the Earth-Sun line. The use of this orbit will make solar paddle rotation about one axis possible. The launch sequence is shown on page 32. The orbital period of 104.2 minutes will yield between 13 and 14 orbits per day with 25 degree spacing between orbits at the equator.

MISSION SUPPORT

Launch Vehicle Support

The U.S. Air Force Space and Missile Test Command at Vandenberg Air Force Base will provide telemetry, tracking and command support until loss of radio contact with the launch vehicle. Madrid (MAD) and Alaska (ULA) STDN stations will receive, record and transmit real time launch vehicle second-stage telemetry data to Goddard Space Flight Center. MAD will display selected telemetry parameters and voice-report in real time the occurrence of designated mark events. One ARIA aircraft will be located in the Indian Ocean to receive, record and transmit second-stage telemetry data to Goddard. The USAF Seychelles Indian Ocean station will receive and record launch vehicle telemetry and will voice-report in real time the occurrence of designated mark events. The STDN stations will not, however, be able to view the launch vehicle until just prior to spacecraft separation. ULA and MAD will provide S-band tracking of the launch vehicle after spacecraft separation and Hawaii (HAW) C-band tracking.

Spacecraft Support

Primary tracking, command and global data acquisition support is provided by the MAD, Orroral (ORR), Goddard (ETC) and ULA STDN stations. HAW and Goldstone (GDA) are backup support stations for ULA.

At launch, ULA, ORR, MAD and ETC will be equipped with mission-unique global data system demultiplexers (D/Gs), used to demultiplex the received spacecraft 800 kilobit/second data for reformatting and transmission to Goddard Center via 1.5 megabit/second wideband lines. Following launch, two additional D/Gs will be available for STDN use. Tentative plans call for installing these D/Gs at HAW and GDS.

Coastal Zone Color Scanner (CZCS) data will normally be recorded on analog magnetic tapes which will be shipped to Goddard Center. For special interest coverage requirements, such as oil spills which would necessitate providing quick turn around imagery, CZCS operation will be scheduled as needed and STDN-received data may be transmitted postpass to Goddard over existing data transmission links.

ESA is configuring the Lannion, France, station to receive and process Nimbus-G sensor data. The ESA will support European investigators with data, as appropriate, at some later mutually-agreed date.

The Nimbus Operations Control Center, located at Goddard Center, will be the central location for control of the Nimbus-G mission, and will be under the management of the Nimbus Mission Operations Manager.

NIMBUS-G MISSION TEAM

NASA Headquarters

Dr. Anthony J. Calio	Associate Administrator for Space and Terrestrial Applications
Samuel W. Keller	Deputy Associate Administrator for Space and Terrestrial Applications
Dr. Lawrence R. Greenwood	Director, Environmental Observations Division
Douglas R. Broome, Jr.	Nimbus Program Manager
John F. Yardley	Associate Administrator for Space Transportation Systems
Joseph B. Mahon	Director, Expendable Launch Vehicles Program
Peter T. Eaton	Delta Program Manager

Goddard Space Flight Center

Dr. Robert S. Cooper	Director
Robert E. Smylie	Deputy Director
Robert N. Lindley	Director of Project Management
Ronald K. Browning	Project Manager - Nimbus
Richard A. Devlin	Deputy Project Manager, Technical
J. Edward Baden	Deputy Project Manager, Resources
William R. Bandeen	Project Scientist
William I. Gould, Jr.	Spacecraft Manager
Ralph B. Shapiro	Mission Operations Manager
William F. Mack	Mission Support Manager
Jerre B. Hartman	Networks Support Manager
Robert C. Baumann	Associate Director for Space Transportation Systems
David W. Grimes	Delta Launch Vehicle Project Manager
Don V. Fordyce	Associate Director of Project Management for Projects
William A. Russell	Deputy Delta Project Manager, Technical
Earl Reese	Deputy Delta Project Manager, Resources
Robert J. Goss	Mission Analysis and Integration Manager, Delta Project Office

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Kennedy Space Center

Lee R. Scherer	Director
Gerald D. Griffin	Deputy Director
Dr. Walter J. Kapryan	Director of Space Vehicles Operations
George F. Page	Director, Expendable Vehicles
W. C. Thacker	Chief, Delta Operations Division
P. J. Kimlincer	Chief, Delta Western Operations Branch
H. P. Van Goey	Chief, Western Operations Support Office
Gene Schlimmer	Spacecraft Coordinator

CONTRACTORS

Spacecraft

General Electric Co. Space Division Valley Forge, Pa.	Prime contractor; Nimbus-G Integration and Test Stabilization and Control Subsystem Integration; Spacecraft Structures and Antennas

Nimbus-G Sensors

Ball Brothers Corp. Boulder, Colo.	Coastal Zone Color Scanner
Gulton Industries, Inc. Albuquerque, N.M.	Earth Radiation Budget
Honeywell Radiation Center Lexington, Mass.	Limb Infrared Monitor of the Stratosphere
University of Oxford Oxford, England	Stratospheric and Mesospheric Sounder

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Nimbus-G Sensors (cont'd.)

University of Wyoming Laramie, Wyo.	Stratospheric Aerosol Measurement
Beckman Instruments, Inc. Anaheim, Calif.	Solar Backscattered Ultraviolet Total Ozone Mapping System
NASA Jet Propulsion Laboratory Pasadena, Calif.	Scanning Multichannel Microwave Radiometer
General Electric Co. Valley Forge, Pa.	Temperature/Humidity Infrared Radiometer

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