NEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

TELS. WO 2-4155
WO 3-6925

FOR RELEASE: WEDNESDAY A.M.
April 2, 1969

RELEASE NO: 69-50

PRESS KIT

PROJECT: NIMBUS-B2

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3/27/69

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NIMBUS-B2 SCHEDULED FOR LAUNCH

Another advanced Nimbus research and development weather observatory, carrying experiments that scientists hope will ultimately lead to reliable long-range weather forecasting, is scheduled to be launched April 11.

The butterfly-shaped "weather-eye," weighing a record for meteorological satellites, 1,269 pounds, will be launched by the National Aeronautics and Space Administration from the Western Test Range, Lompoc, Calif., with a Thorad Agena-D rocket combination.

In addition to its primary role of meteorology, the 10-foot-tall observatory will obtain oceanographic data.

From orbit, it will communicate with sensors carried aboard platforms such as floating buoys, balloons and aircraft.

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Nimbus-B2 (Nimbus III in orbit) will be placed into a circular, nearly polar orbit 690 statute miles high. It will orbit the Earth every 107 minutes and view the entire planet twice daily.

Nimbus-B2 is a replacement spacecraft for Nimbus B which was destroyed in flight in May 1968 by the Western Test Range Safety Officer after telemetry and tracking data indicated abnormal vehicle behavior--increasing oscillations in yaw as well as deviation from the expected trajectory.

Cause of the failure was attributed to installation of the yaw-rate gyro 90 degrees from the design position. Since the failure, test procedures have been revised to preclude the possibility of an undetected misoriented rate-gyro.

Since the Nimbus B launch, seven successful missions involving the Thorad Agena as well as eight Thor Deltas have been flown.

Nimbus B nuclear power generators were recovered intact, Oct. 9, 1968, four miles north of San Miguel Island, Calif., in the Santa Barbara channel.

Without the Nimbus-B2 mission, there would have been a critical gap of two years in achieving the basic objectives of the United States' meteorological satellite program.

The experiments on Nimbus-B2 are identical to those which were on the Nimbus B observatory.

Launch window for the mission will be between 2:53 a.m. EST and 3:57 a.m., EST. A launch at this time permits Automatic Picture Transmission (APT) ground stations around the world to receive daytime television cloud-cover pictures at approximately noon and night (infrared) pictures at midnight.

A two-unit, nuclear isotopic system for generating electrical power, the Systems for Nuclear Auxiliary Power (SNAP-19) will also be aboard Nimbus-B2. It was developed by the Atomic Energy Commission. Prolonged successful operation of the nuclear power system could give Nimbus-B2 a longer and more useful operational lifetime than possible with solar cell power systems.

Nimbus-B2 will carry seven meteorological experiments which is a record for U.S. weather satellites.

The versatile observatory will be the first weather satellite to measure committed infrared energy that permits the inferring of the atmosphere's vertical temperature, water vapor, and ozone distributions on a global basis. These deductions are some of the key ingredients needed for numerical, or computerized, weather prediction.

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One of the key experiments for numerical forecasting, which is being tested for the first time on Nimbus-B2, is the Infrared Interferometer Spectrometer (IRIS). NASA scientists at Goddard Space Flight Center, Greenbelt, Md., believe that IRIS is a major step toward accurate, long range weather prediction.

Currently, quantitative three-dimensional weather data are obtained over less than 20 per cent of the Earth. The other 80 per cent, mostly over the oceans, remains relatively inaccessible except for an inadequate number of scattered observation stations.

Precise temperature readings at various layers in the atmosphere will also provide vital aeronautical information to the designers of supersonic commercial aircraft.

A secondary IRIS objective is to estimate the gases present in the atmosphere such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4).

Another vertical temperature experiment on Nimbus B is the Satellite Infrared Spectrometer (SIRS), provided by the Dept. of Commerce Environmental Science Services Administration. It will provide atmospheric temperature soundings like IRIS but using a different instrumental approach.

One of the new meteorological experiments for Nimbus-B2 is called Interrogation Recording and Location System. IRLS will demonstrate how a satellite can pinpoint the position of special platforms. Data are collected from these platforms, stored in the satellite, and then replayed to a central point for dissemination.

The IRLS system can be applied to meteorology, oceanography, geology (measuring strains in the Earth's crust), hydrology and ecology.

This first IRLS experiment will be limited to about 16 platforms. They will be placed on moored and floating buoys, balloons, an ice island, fixed land sites, hurricane hunter aircraft, air sea rescue aircraft and on an elk in Yellowstone National Park, Wyoming.

Ultimately a capability is envisioned for interrogating a large number of separate units deployed at random, accurately fixing their positions and recording data from them twice each day.

The IRLS package planned for the elk will weigh about seven pounds. It is an advanced system, developed for the Nimbus D mission in 1970. The remaining IRLS packages weigh about 26 pounds.

Several biological organizations have shown an interest in the IRLS experiment, for possible application to future Nimbus spacecraft. These groups (from the Smithsonian Institution, Office of Naval Research, University of Maryland and Johns Hopkins University), hope to learn more about the migratory habits of large animals on land and sea.

Before IRLS packages can be attached to most animals, additional miniaturization and technological improvements in electronics and antennas will be necessary.

The other Nimbus-B2 experiments include a television camera, Image Dissector Camera (IDC), High Resolution Infrared Radiometer (HRIR), Medium Resolution Infrared Radiometer (MRIR), and an experiment to Monitor Ultraviolet Solar Energy (MUSE).

In addition to the Nimbus-B2 experiments, the Agena-D upper-stage vehicle will carry a Department of Defense "piggy-back" payload into its own separate circular orbit, 690 statute miles above the Earth. The satellite will be separated from the Agena at a sufficient time interval after Nimbus-B2 so as not to interfere with the primary mission.

The "hitchhiker" package is the U.S. Army's Sequential Collation Of Range (SECOR) satellite, the 13th in this series of geodetic satellites.

SECOR will be carried by NASA for DOD as part of an interagency program to use available booster power for maximum space-research cost effectiveness.

The basic objective of a research and development spacecraft like Nimbus-B2 is to explore and understand the nature and behavior of the atmosphere, and to reduce the economic impact of adverse weather on the daily activities of nations.

Because of advances in space observations from meteorological satellites, high-speed computers and models of large-scale atmospheric motion it is expected that the next decade will see operationally useful forecasts of large-scale weather patterns of up to a week or more in advance.

The scientific and meteorological communities of the United States and many other countries are formulating and coordinating research directed toward placing long-range forecasting of global weather on a sound scientific basis. This international endeavor is called the Global Atmospheric Research Program (GARP).

Nimbus-B2 will provide data in the first experiment in the United States portion of GARP. This is the Barbados Oceanographic and Meteorological Experiment (BOMEX) which will be conducted in May, June and July by seven government agencies, including NASA, and other U.S. organizations in cooperation with the Government of Barbados. BOMEX is a national scientific study of the joint behavior and interactions of the atmosphere-ocean system in subtropical and tropical waters.

Nimbus-B2 is the fourth in a series of seven spacecraft. Both Nimbus I and II, launched Aug. 28, 1964, and May 15, 1966, respectively, met or exceeded their objectives.

Nimbus I worked for about one month before it stopped operating because of the failure of the solar array drive system. Nimbus II, designed for a six-month lifetime, operated far beyond this minimum goal before it became silent Jan. 18, 1969. The spacecraft's horizon scanner, which keeps the spacecraft oriented, stopped working and the spacecraft began to tumble. The satellite's beacon has been shut off.

The 32-month lifetime of Nimbus II is considered one of the notable accomplishments in spacecraft longevity.

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Nimbus D, scheduled for flight in 1970, will carry nine experiments that are being developed to expand the capability of quantitative (three dimensional) measurements of the atmosphere that will be initiated with Nimbus-B2.

Nimbus E and F are scheduled for launching in 1972 and 1973, respectively. Their purpose will be to develop an applications observatory that will test advanced technology and experiments for meteorology and other applications disciplines.

The Nimbus project is managed by NASA's Office of Space Science and Applications. NASA's Goddard Space Flight Center, is responsible for project management and its Lewis Research Center, Cleveland, has project management for the Thorad/Agena D. Launch operations will be conducted by the U.S. Air Force 6595th Aerospace Test Wing under the technical supervision of NASA's Unmanned Launch Operations, Kennedy Space Center, Fla.

The General Electric Co., Valley Forge, Pa., is the Nimbus-B2 integration and test contractor, and built the three-axis stabilization system. McDonnell-Douglas built the Thorad booster and Lockheed Missile and Space Co., built the Agena.

Nimbus is a combined government/industry effort. More than 30 major subsystem contractors are responsible for various components in the spacecraft, launch vehicle, or ground receiving equipment. In addition, there are more than 1,000 subcontractors and vendors working on the program.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

NIMBUS B2 FACT SHEET

Spacecraft	Butterfly shaped, 10-feet-tall 11 feet wide, with a five-foot diameter sensory ring for housing experiments and electronics weighing 1,268 pounds (Nimbus II weighed 912 pounds).
Stabilization	Earth oriented and three axes stabilized to within one degree.
Mission Objectives:	
Technology	To demonstrate a full spacecraft observatory for handling multiple experiments;
	To demonstrate radioisotope power (SNAP-19) for space use;
	To demonstrate data collection and ranging system;
	To demonstrate air-bearing gyro; and
	To demonstrate solid-state S-Band transmitter.
Meteorological	To study spatial and temporal distribution of atmospheric structure, particularly temperature; and
	To determine temporal variations in the solar radiation in the near ultraviolet.
Launch Information:	
Launch Vehicle	Thorad (long tank Thor)/Agena D.
Launch Pad	Western Test Range, Calif., SLC-2 East.
Launch Azimuth	189 degrees true.

Launch Information (Cont'd.):

Date	No earlier than April 11, 1969.
Launch Window	2:53 p.m. EST - 3:57 p.m. EST.

Orbital Elements:

Orbit	Circular, 690 statute miles high.
Period	107 minutes.
Inclination	Nearly polar and Sun-synchronous, 80 degrees retrograde to the Equator.

Meteorological Experiments:

Infrared Interferometer Spectrometer (IRIS)	Globally measure infrared energy and infer the atmosphere's vertical temperature, water vapor and ozone distribution;
Satellite Infrared Spectrometer (SIRS)	Measure, on a global basis, infrared energy and infer the atmosphere's vertical temperature;
Interrogation Recording and Location System (IRLS)	Demonstrate the feasibility of using a satellite to locate and determine the position of sensors (balloons, buoys, aircraft fixed platforms, and possibly an elk), for relay to a central ground station;
High Resolution Infrared Radiometer (HRIR)	Take infrared photos of the Earth in darkness with a resolution of about five miles at picture center. Stored pictures from a full orbit will be read out at Goddard, and "live" pictures will be read out at Automatic Picture Transmission (APT) ground stations;
Medium Resolution Infrared Radiometer (MRIR)	Measure the Earth's radiation balance which could affect weather storm development and dissipation.

Meteorological Experiments (Cont'd.):

Monitor of Ultraviolet Solar Energy (MUSE)	Measure the ultraviolet radiation flux from the Sun in five relatively broad bands. Flux variations could affect weather in the upper atmosphere.
Image Dissector Camera (IDC)	Take daytime pictures, with a resolution of one mile at picture center, of the entire Earth. Live pictures will be relayed to some 300 APT stations and a full orbit of pictures will be stored for read-out at Goddard. Previous weather satellites required two cameras to do the job of one IDCS.
Power Supply	10,500 negative on positive solar cells mounted on two, eight-by-three-feet rotating solar paddles produce an average of 211 watts. The two SNAP-19 nuclear powered generators produce 50 watts continuous. Spacecraft requires an average of 156 watts and the experiments require an average of 75 watts.

Tracking:

Orbit	Sixteen stations of the world-wide Space Tracking and Data Acquisition Network (STADAN).
Data Acquisition Facilities	Fairbanks, Alaska, and Rosman, N. C.
Automatic Picture Transmission ground stations	More than 400 APT stations, including 78 stations in 43 foreign countries.
Spacecraft Lifetime	Six months.
Space Management	Office of Space Science and Applications, NASA Headquarters, and the Goddard Space Flight Center, Greenbelt, Md.

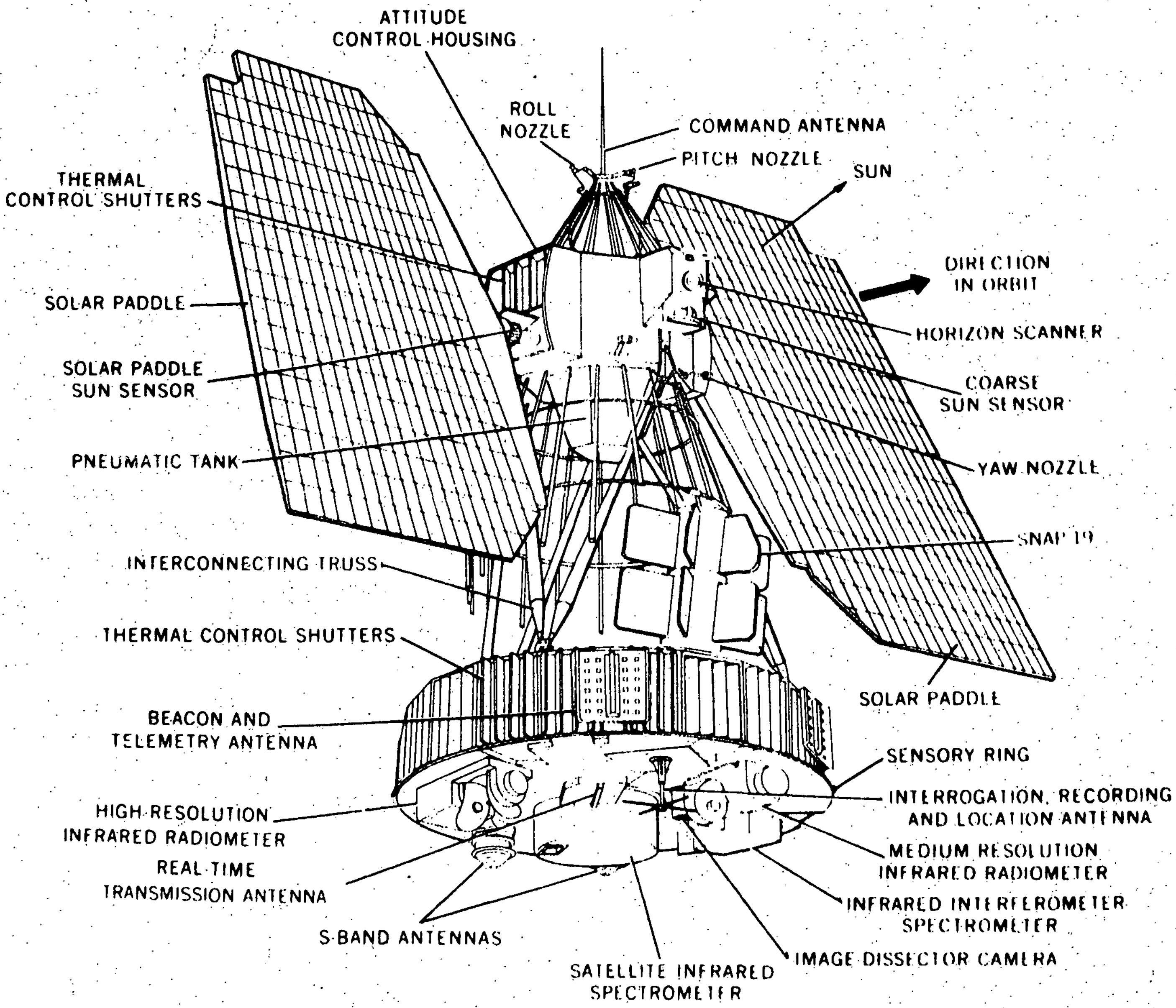
Launch Vehicle:

Management	NASA/Lewis Research Center, Cleveland, Ohio.
Launch Operations	U.S. Air Force 6595th Aerospace Test Wing, Vandenberg AFB, under the technical supervision of the NASA/Kennedy Space Center Unmanned Launch Operations.
Integration & Test Contractor	General Electric Co., Missile & Space Division, Valley Forge, Pa.

Launch Vehicle:

THORAD	McDonnell Douglas, Santa Monica, Calif.
Agena D	Lockheed Missile & Space Co., Sunnyvale, Calif.

NIMBUS B-2


ATTITUDE
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SOLAR PADDLE
SUN SENSOR
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PNEUMATIC TANK
YAW NOZZLE
SNAP 19
INTERCONNECTING TRUSS
THERMAL CONTROL SHUTTERS
SOLAR PADDLE
BEACON AND
TELEMETRY ANTENNA
SENSORY RING
INTERROGATION, RECORDING
AND LOCATION ANTENNA
HIGH RESOLUTION
INFRARED RADIOMETER
MEDIUM RESOLUTION
INFRARED RADIOMETER
REAL TIME
TRANSMISSION ANTENNA
INFRARED INTERFEROMETER
SPECTROMETER
S-BAND ANTENNAS
IMAGE DISSECTOR CAMERA
SATELLITE INFRARED
SPECTROMETER

NIMBUS AND SPACE APPLICATIONS

The Nimbus spacecraft is considered an ideal platform for conducting meteorological research and for studying other Earth applications because of its size, power, and attitude control system which keeps the satellite pointed precisely at Earth.

Data from Nimbus B2 and future Nimbus spacecraft are expected to enhance research in numerical forecasting, oceanography, air pollution, ice pack reconnaissance, geology, forestry and agriculture and hydrology.

Numerical Forecasting

To understand and predict the behavior of the atmosphere beyond a day or two, it is necessary to know the present conditions of the atmosphere, the structure and motion field throughout the world.

Polar orbiting satellites at altitudes of about 700 miles, such a Nimbus B2, are the only apparent means for obtaining every day on a global basis, the atmospheric measurements at various altitudes.

In order to make long-range weather predictions, meteorologists must have an adequate model of the atmosphere, sufficiently large computers, and quantitative measurements of the total atmospheric structure. The needed measurements are pressure, atmospheric temperatures, moisture content and wind velocity at various altitudes on regular, periodic schedules over the entire Earth.

At present, mathematical models that simulate the structure and circulation of the atmosphere are under development.

Scientists already have numerical methods for long-term integration of the governing thermo-hydrodynamical equations, electronic computers for carrying out the calculations, and some understanding of the physics of the heating processes which produce the large-scale motions.

Nimbus B will be the first U.S. weather satellite to make global observations of temperature over extended periods which will provide improved meteorological information for experimental weather predictions with new mathematical models.

A National Academy of Sciences study has indicated that meteorologists may be able to make reliable weather predictions for major frontal systems as much as two weeks in advance by using global information gathered from satellite and conventional meteorological observing systems.

Oceanography

The oceans affect weather, transportation and the world's supply of food. Nearly all the moisture in rain clouds originates in the sea. More than 95 per cent of the cargo transported overseas goes by ship. The transfer of heat, mositure and momentum at the air-water interface is of fundamental importance to meteorologists. The ocean is a significant source of food protein, not only directly for man but for the land animals ultimately consumed by man.

The Nimbus B2 IRLS experiment is one method of communication between the satellite in space and buoys in the oceans.

Moored and floating buoys (about four initially) will be in the Atlantic and Pacific Oceans. Participants in the buoy experiment are the Naval Oceanographic Office, the Bureau of Commercial Fisheries and Woods Hole Oceanographic Institution.

While research ships will still be needed, sensors and data collection equipment aboard the Nimbus satellite can cover all the oceans with great speed and economy.

Satellites will be able to sample only the top few hundred feet, or about one per cent of the ocean's depth, but this portion is most important to the fishing and shipping industries, and coastal activities.

Ice Pack Reconnaissance

The Arctic Ocean and surrounding seas, as well as the area bounding the Antarctic continent, are seasonally or perennially covered with sea ice, but weather scientists do not know enough about the properties, distribution, variability and behavior of the sea ice in these areas.

Ice and icebergs in remote areas could be covered by a spacecraft to furnish information for meteorological services, ice patrols and the shipping industries.

NIMBUS B2 METEOROLOGICAL EXPERIMENTS

The Nimbus B2 will carry seven weather-measuring instruments, including Infrared Interferometer Spectrometer (IRIS), Satellite Infrared Spectrometer (SIRS), Interrogation Recording and Locations System (IRLS), High Resolution Infrared Radiometer (HRIR), Medium Resolution Infrared Radiometer (MRIR), Monitor of Ultraviolet Solar Energy (MUSE) and a daytime camera, Image Disector Camera (IDC).

The daytime camera and infrared radiometers are line scan systems. Each will generate one complete global picture daily.

The other four instruments are being satellite-tested for the first time.

Infrared Interferometer Spectrometer
Experimenter: Dr. Rudolph H. Hanel, Goddard

This experiment will measure globally, the temperature from top to bottom in the atmosphere, together with water vapor content and ozone distribution. The 35-pound sensor will also provide data on gases in the atmosphere such as carbon dioxide, Nitrous oxide (N_2O), and methane (CH_4).

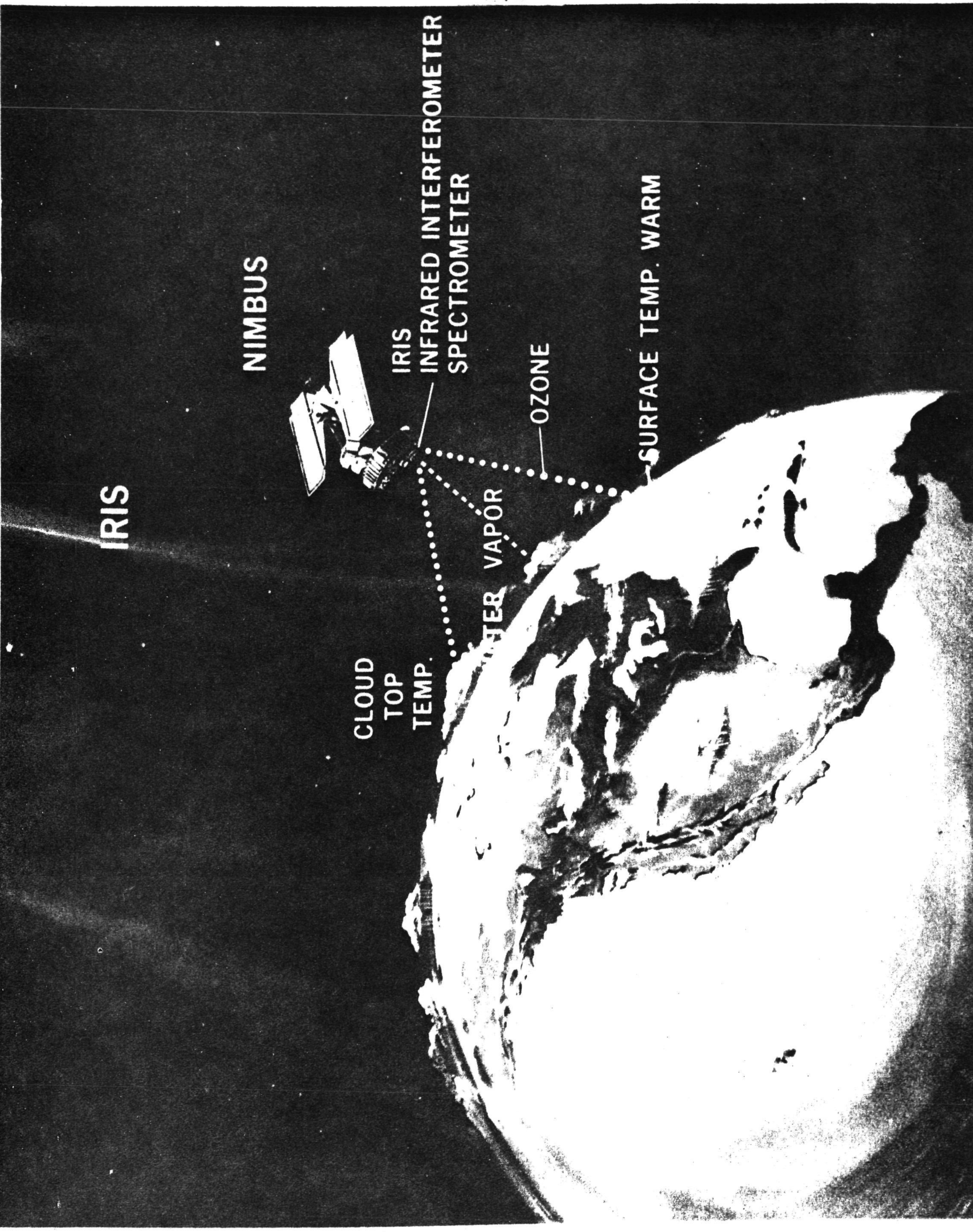
Operating in the infrared spectral region, from 6 to 20 microns (thousandths of a meter), IRIS will measure emitted radiation for determining temperature and ozone up to 15-mile altitudes, and water vapor up to 6 miles.

An important IRIS measurement will be the ozone distribution because ozone, normally found in the upper part of the Earth's atmosphere coverings absorbs incoming solar and outgoing infrared radiation. It thus has an effect on the Earth's heat balance and on meteorological phenomena.

This instrument, with a 100-mile-diameter field of view, is a Michelson interferometer. IRIS analyzes the infrared spectrum radiated from the Earth's surface, or cloud tops, along the orbital path. During each 11-second viewing interval, image motion compensation corrects for spacecraft travel.

A computer compares the computed spectra with ideal black body curves conforming to Planck's radiation formula. Thus, the basic source temperature and the local departures at various wave lengths are established. Thereby, the atmospheric composition, cloud height and other parameters may be determined.

The IRIS was built for NASA by Texas Instruments, Inc., Dallas.


IRIS
NIMBUS
IRIS
INFRARED INTERFEROMETER
SPECTROMETER
OZONE
SURFACE TEMP. WARM
VAPOR
CLOUD
TOP
TEMP.

Satellite Infrared Spectrometer
Experimenter: Dr. D. Wark, ESSA

SIRS will measure infrared energy and infer the temperature from the Earth's surface, or cloud tops, up to an altitude of about 15 miles. The instrument is a Fastee-Ebert grating spectrometer that measures atmospheric energy in the 15 micron carbon dioxide absorption band.

The 91-pound weather sensor will measure the temperature profile of the atmosphere over an area of 120 miles square directly beneath Nimbus B2.

From the energies measured in seven wave lengths in the band, the temperature distribution of the atmosphere can be computed.

An eighth measurement in the 11-micron window yields the Earth surface temperature within a few degrees in the absence of clouds or the cloud top temperature.

SIRS was developed by ESSA.

Interrogation Recording and Locations System
Experimenter: Charles E. Cote, Goddard

This experiment, designed to link the oceans with space for oceanographic research, is a 26-pound data collection device which is commanded and programmed to identify, locate, interrogate and store data from remote platforms (weather stations, buoys or balloons).

The frequent, periodic collection of scientific data relating to the Earth's surface and its atmosphere is essential to meteorology, oceanography, geophysics and other scientific disciplines.

Existing data collection systems are limited to regional coverage, at the best, and cannot be expanded to provide global observations.

This system permits accurate platform location (to about one mile), by triangulation techniques after two successive interrogations.

The experiment will be limited initially to about 12 platforms. Future IRLS will be capable of interrogating large numbers of surface or airborne units deployed anywhere in the world.

The system was built by Radiation, Inc., of Melbourne, Fla.

NIMBUS B2 EXPERIMENT

Experimenter and Experiment Location	Purpose
NASA -- two fixed platforms at Goddard Space Flight Center	Determine the accuracy of the position determining techniques.
NASA -- mobile van	Tracking experiment to determine if the van's position can be determined as it returns to the East Coast of the U.S. from the Western Test Range in California.
USAF Air Weather Service -- weather reconnaissance aircraft	Demonstrate the capability linking AWS aircraft with weather and communications satellites for future routine collection and rapid dissemination of operational weather data to appropriate world weather centers.
National Center for Atmospheric Research (NCAR) -- two balloons	Balloons will be released in Sioux Falls, S.D., to demonstrate and evaluate the IRLS positioning capability and also the capability of relaying meteorological data from a balloon to the ground via satellite.
Office of Naval Research -- Floating ice island (T_3)	Evaluate IRLS positioning accuracy of a moving ice island, and demonstrate the capability of IRLS to transmit seismometer data from the platform location in the Arctic to the U.S. in 2-3 hours instead of the usual weeks or months.

Experimenter and Experiment Location	Purpose
Naval Oceanographic Office -- moored buoy off Puerto Rico coast	Determine wave height, surface current speed and sub-surface buoy depth.
Naval Oceanographic Office -- fixed platform on a Texas-type tower on Argus Island near Bermuda	Determine wave height, surface temperature, water velocity and sub-surface temperature.
Woods Hole Oceanographic Institution -- one or two floating buoys in the Gulf Stream off Cape Hatteras, and possibly one floating buoy on Georges Bank (off Cape Cod)	Measure water surface temperature, water temperature at a depth of 985 feet and 490 feet, and the air temperatures above the surface.
Bureau of Commercial Fisheries -- drifting buoy in the North Pacific Ocean south of Alaska	Measure water surface temperature, water temperature and pressure at a depth of 165 feet, and salinity of sea water at a depth of 3 feet.
Naval Air Systems Command -- two platforms in conjunction with air-sea rescue beacons	Demonstrate the use of a satellite/IRLS system in the Air-Sea Rescue Program.
National Science Foundation/Environmental Science Services Administration -- USNS Eltanin (ship) operating in waters near Antarctic Continent	Study weather/sea conditions in the Antarctica area.

High Resolution Infrared Radiometer
Experimenter: Thomas Cherrix, Goddard

The 18-pound experiment, a scanning radiometer, will take pictures of clouds and the Earth in total darkness.

All surfaces on Earth (even ice) emit infrared radiation according to their temperature; hot surfaces radiate more intensely than cold.

Nimbus B2's HRIR senses radiation with a lead selenide photo-electric cell which operates at minus 135 degrees F.

A strip about 1,500 miles wide, extending halfway around the globe (12,500 miles) on the night side of each orbit is scanned by a continuously rotating mirror which focuses the radiation on the photo cell.

The mirror sweeps across this strip some 75 times every 100 seconds, thus covering the entire length of the strip with about 2,300 continuous scans.

Nimbus' photo-electric cell converts the radiation stimulus into electrical signals stored on magnetic tape aboard the spacecraft.

Pictures taken on the dark side of the Earth will be read out at Goddard while "live" pictures will be displayed on equipment at Automatic Picture Transmission stations anywhere in the world as Nimbus B2 passes overhead.

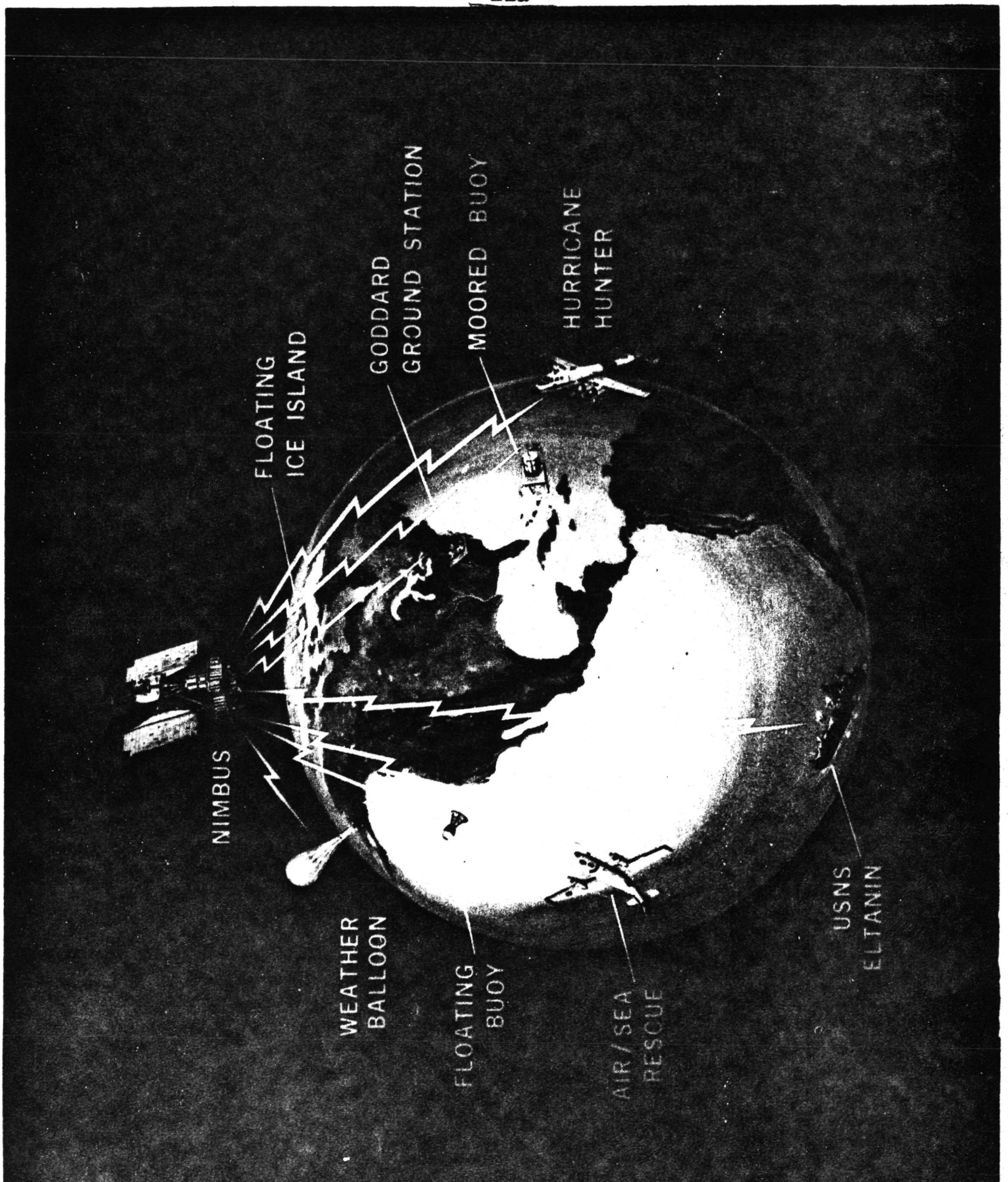
A modification has been made to the HRIR so the sensor can also provide useful daytime pictures.

On each infrared picture, warm bodies of water such as the world's seas and oceans appear very dark; land which is cooler at night than the oceans, appears somewhat lighter; and clouds which are generally much colder than water or land surfaces vary from light grey to brilliant white.

Since colder temperatures are usually found at higher altitudes, clouds appear whiter with increasing altitude.

By studying infrared pictures, meteorologists can estimate cloud height altitudes with an accuracy of 1,000 feet. Land and water surface temperatures can be determined with an accuracy of about two degrees F.

HRIR has a resolution of five miles at picture center. It operates at wavelengths of 3.4 to 4.2 microns in the infrared spectrum for night coverage and the visible region for daytime coverage.


NIMBUS
FLOATING ICE ISLAND
GODDARD GROUND STATION
MOORED BUOY
HURRICANE HUNTER
WEATHER BALLOON
FLOATING BUOY
AIR/SEA RESCUE
USNS ELTANIN

The system was built by ITT Industrial Labs, Ft. Wayne, Ind.

Medium Resolution Infrared Radiometer
Experimenter: Andrew W. McCulloch, Goddard

One of the main purposes of this experiment is to measure the Earth's radiation balance, the difference between incoming and outgoing radiation, to determine its long term effect on weather.

Another important meteorological objective is to map atmospheric motion and jet streams. This can be accomplished by comparing the radiation pictures obtained in the atmospheric window channel and the two water vapor channels.

The patterns of water vapor distribution and of cirrus clouds resulting from such a comparison are closely related to the dynamics of the atmosphere.

The 21-pound MRIR, a five channel radiometer, is designed to measure:

* Water vapor absorption -- this band, at 6.5 to 7.0 microns, provides information on water vapor distribution. The energy observed in this channel is connected with the relative humidity of the upper atmosphere.

* Atmospheric window -- measures the temperature of the Earth in the 10-11 micron band where the atmosphere is transparent. These measurements provide information on the Earth's surface temperature in the absence of clouds or cloud top temperatures. In addition, maps showing equal lines or radiant emittance can be interpreted as cloud cover maps offering a backup to daytime and infrared pictures.

* Stratospheric temperatures -- this band, at 14-16 microns, provides a measurement of the temperatures in the lower stratosphere by measuring the emission from the carbon dioxide absorption band.

* Water vapor absorption -- this 20-23 micron band provides information on atmospheric structure and water vapor distribution. The energy observed in this channel provides information on the relative humidity of the lower and middle sections of the atmosphere.

* Albedo radiation -- provides measurements of solar energy levels in the visible and near infrared bands at 0.2 to 4.0 microns.

The MRIR was built by the Santa Barbara Research Center, Santa Barbara, Calif., a subsidiary of Hughes Aircraft Co.

Monitor of Ultraviolet Solar Energy (MUSE)
Experimenter: Dr. Donald F. Heath, Goddard

Weighing nine pounds, this experiment will measure solar flux in five relatively broad spectral bands to detect variation of relative intensity with time.

The ultraviolet energy input and its variation with time at different wave lengths into the terrestrial atmosphere can be related to the formation of the ionosphere, the establishment of photo-chemical equilibrium or ozone layer, and the heating of the upper regions of the stratosphere. This experiment will have the Sun in its field of view during most of the daytime portion of the orbit.

The experiment was built by the Adcole Corp., Waltham, Mass.

Image Dissector Camera (IDC)

Experimenter: Gil Branchflower, Goddard

This experiment is a line scan television system, with a resolution of about two miles at picture center. It will provide a complete picture of the entire Earth daily.

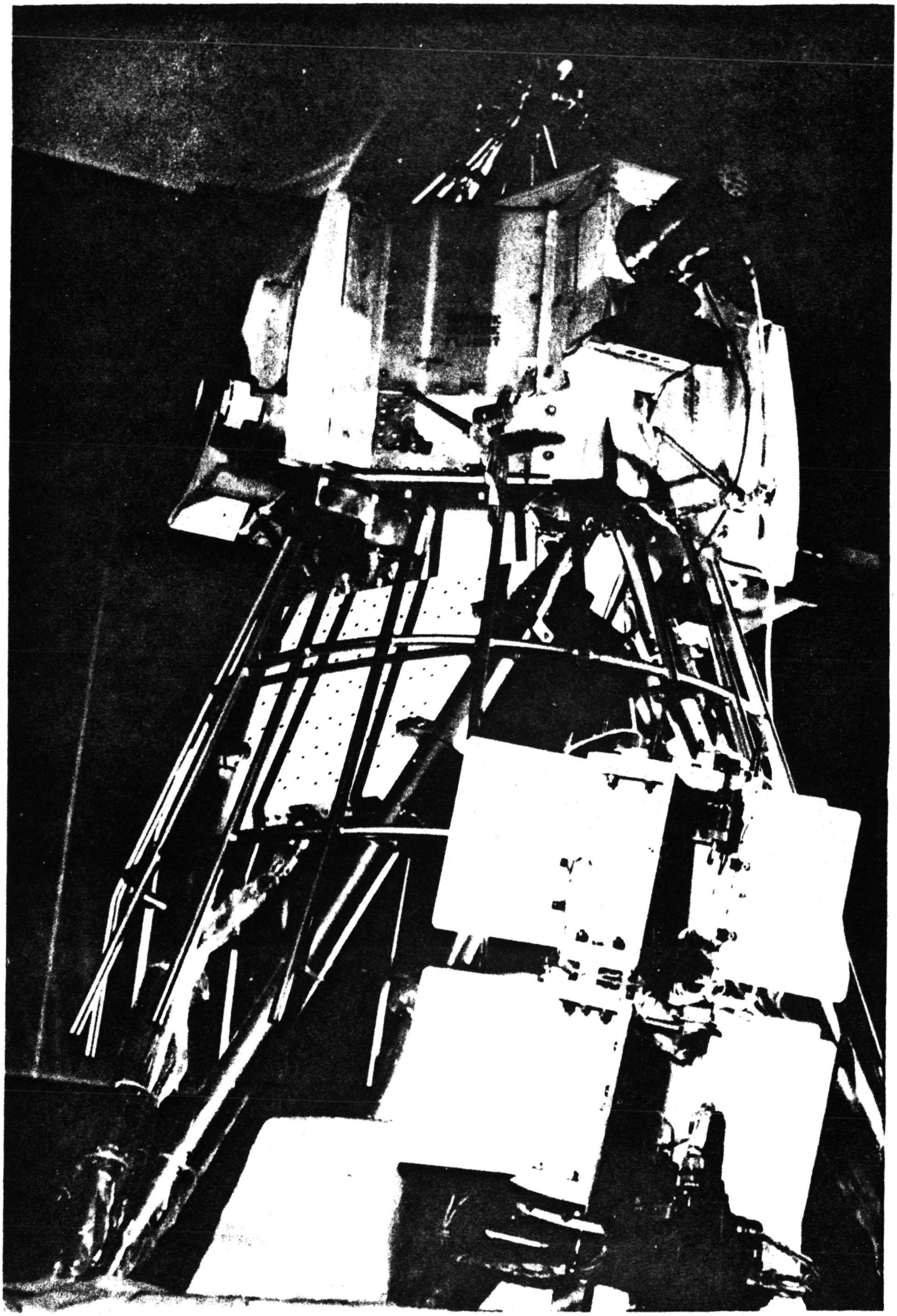
This camera, weighing 14 pounds, will relay "live" pictures to small Automatic Picture Transmission stations and will record pictures of the entire world for playback to Goddard.

Previous Nimbus and ESSA weather satellites required two cameras to do the job of one IDC.

More than 400 APT stations will receive daytime photographs about three times daily. Approximately 80 stations will be operated in 43 nations or territories.

The IDC is completely electronic except for a protective lens shutter which closes over the face of the sensor when the camera is not operating.

The experiment was built by ITT Industrial Laboratories, Ft. Wayne, Ind.



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SNAP-19 Radioisotope Thermonuclear Generator
Experiment provided by Division of Space Nuclear Systems, Atomic Energy Commission

SNAP-19 is one of a series of radioisotope thermoelectric generators (RTG), or atomic batteries, developed by the Atomic Energy Commission under its SNAP (Systems for Nuclear Auxiliary Power) program. The SNAP program is directed at development of generators and reactors for use in space, on land and in the sea. Nimbus B2 will mark the first use of a nuclear power system on a NASA spacecraft, although systems of this type have been used on Navy navigational satellites. (The SNAP-19 system is the same one installed on the Nimbus B satellite.)

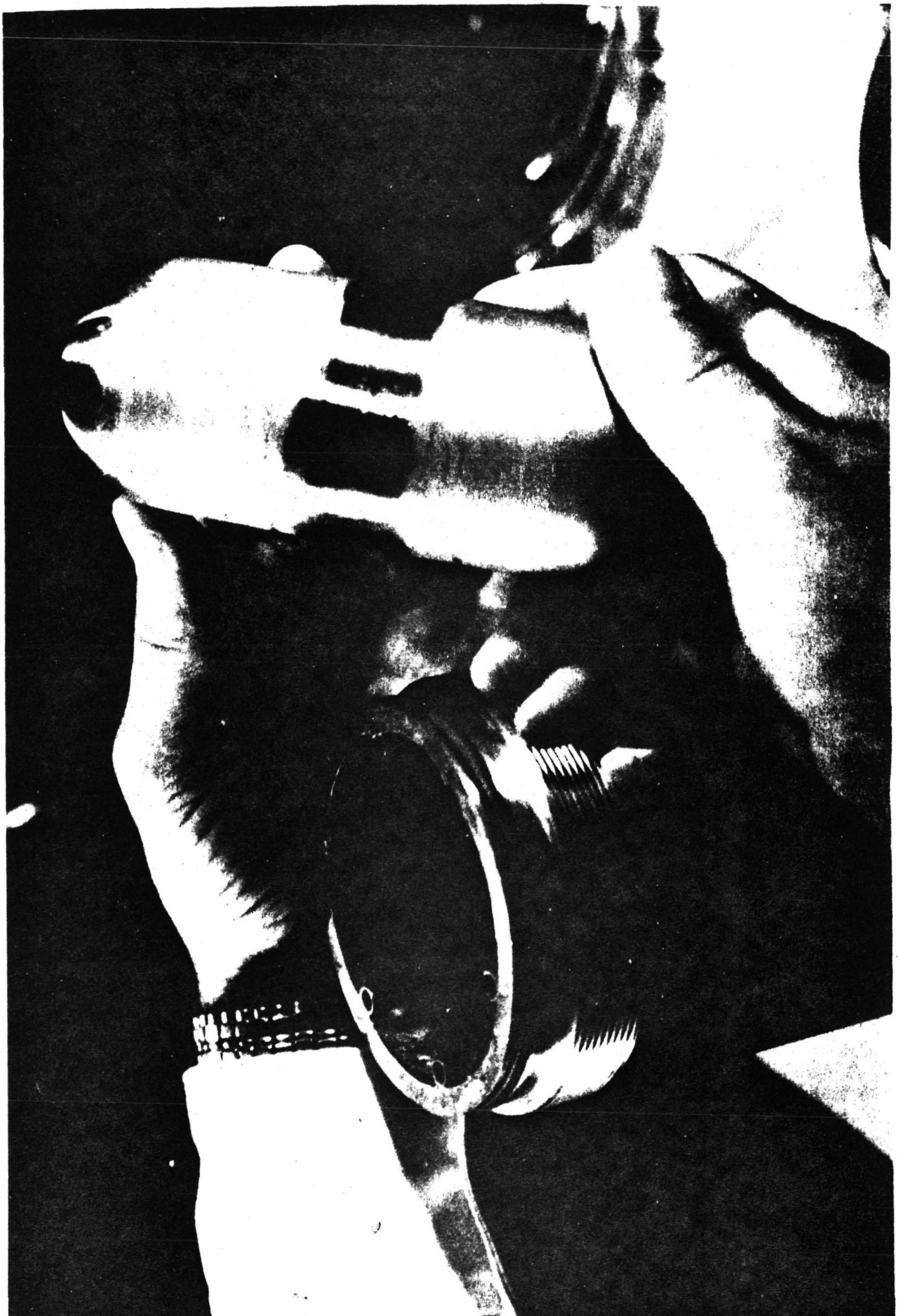
While the SNAP-19 is not the primary power system for Nimbus B2, this test flight is considered a logical and necessary step and a major milestone in the development and acceptance of long-lived, highly reliable isotope power systems for space use by NASA.

The characteristics of nuclear subsystems for a future operational satellite will be assessed and up to 50 watts of additional power will be available to supplement Nimbus B2's solar cell power system. It is expected that the output of the solar power system will be decreased by space radiation and other factors in three months to a level below that required for spacecraft housekeeping and simultaneous operation of all on-board meteorological experiments. The additional power provided by the SNAP-19 will permit full spacecraft operation for more than a year. In addition, the SNAP-19 power may be of special importance by providing power continuously in the event of a malfunction of the solar power system.

Description

The basic SNAP-19 unit is a 25-watt generator fueled with the radio-isotope plutonium-238. The chemically inert fuel is contained in a rugged 6-X 3-inch cylindrical capsule in the center of the generator. Each fueled generator weighs about 28 pounds, is 11 inches high and 22 inches in diameter including heat-radiating fins.

Two SNAP-19 generators will be mounted in tandem on the Nimbus B2 satellite. They will provide about 50 net watts of electrical power. This power is in addition to the approximate 211 watts to be provided by the satellite's large solar cell paddles.



Operation

In the generator, the spontaneous radioactive decay of the plutonium-238 generates heat. Thermoelectric elements convert this heat directly into electrical energy. There are no moving parts.

Advantages and Applications

Nuclear power is considered essential to the development of a long-lived, highly reliable, rugged, relatively small and lightweight electrical system for a variety of space applications including Earth orbital satellites, lunar missions and probes to distant planets. Present long-life spacecraft power systems depend on the use of solar cells for generating power for direct use and for recharging chemical batteries. Ever-increasing power requirements, however, are creating difficult problems in the design of increasingly larger solar cell panels and associated battery storage systems. Additionally, nuclear power sources would be required for any exploratory missions travelling great distances outward from the Sun. The size of solar cells required for such missions would be too large to be practical.

A SNAP generator has the potential of supplying many watts of electricity for several years. Since the operation of a SNAP generator does not depend on exposure to the Sun, only a minimal storage battery system is needed for spacecraft operation. The isotope power source is a rugged device in comparison to solar cells and is significantly less susceptible to radiation and heat damage.

Heat Source and Safety Considerations

The unique properties of plutonium-238 make it an excellent isotope for use in space nuclear generators. At the end of almost 90 years plutonium-238 is still supplying half of its original heat. Since, in the decay process, plutonium-238 emits mainly the nuclei of helium, a very mild type of radiation, the generator which houses the fuel requires no shielding and thus avoids a weight penalty for radiation protection of the spacecraft hardware.

The Nimbus B2 satellite will be placed in a 600-mile-high polar orbit and will remain in orbit for about 1,600 years, by which time essentially all of the plutonium-238 will have been consumed through the radioactive decay process.

The fuel form in the SNAP system is biologically inert and represents no health hazard to people or marine life, and in most abort cases it will be contained within its capsules.

Before the use of the SNAP-19 system was authorized, a thorough review was conducted to assure that no undue health hazards existed to anyone involved in the launch or to the general public.

For this review, extensive tests were conducted which demonstrated that the fuel would be safely contained under all accident conditions.

In the abort of the Nimbus B last May, the fuel capsules remained in sea water at a depth of 300 feet for about five months and, as expected, there was no release of fuel or degradation of the capsules.

Development of SNAP Radioisotope Program

The first significant step in the SNAP isotopic power program was SNAP-3. This proof-of-principle device was introduced to the world by President Eisenhower in 1959.

The first isotopic space generator was put into service on June 29, 1961. The grapefruit-sized, five-pound, 2.7 watt generator, designated SNAP-3A*, was launched on a Navy navigational satellite to supplement the satellite's solar power. The SNAP-3A generator marked its sixth anniversary last June. At that time it had operated one year beyond its five-year design life. The satellite is still signaling intermittently to tracking stations around the world.

The AEC subsequently developed an advanced type of radioisotope thermoelectric generator -- designated SNAP-9A -- which weighs about 25 pounds and generates 20 watts of power. SNAP-9A generators provided all of the power for two Navy navigational satellites launched in 1963.

The SNAP radioisotope program has brought forth new technology which has resulted in the use of radioisotopes as sources of compact, reliable, long-lived power on land, on sea and in space. SNAP generators have operated, are now operating, or will operate in offshore oil platforms, weather stations, acoustic beacons, lighthouses, navigational and weather satellites, lunar experiments, deep sea and ocean bottom projects and other potential manned and unmanned space projects.

* SNAP radioisotopic devices are designated by odd numbers, reactors by even.

Contractors for SNAP-19

Isotopes Inc., Nuclear Systems Division, Baltimore, designed, developed and fabricated the SNAP-19 generators for the Nimbus B2.

Mound Laboratory, Miamisburg, Ohio, operated by Monsanto Research Corp., for the AEC, fabricated the raw fuel into the final fuel form and encapsulated the fuel.

Sandia Corp., a subsidiary of Western Electric, operator of AEC's Sandia Laboratory, Albuquerque, New Mexico, provided technical direction for the SNAP-19 program.

Savannah River Laboratory, Aiken, S.C., operated by the Du Pont Co., for the AEC, prepared the raw plutonium fuel.

Nimbus B Technological Experiment
Experimenter: R. Shelley, Goddard

Rate Measuring Package (RMP), is an alternate source of rate information for the reaction wheel and gas jet torquing devices in the attitude and control system. It is a technological experiment of one single-degree-of-freedom, rate-integrating gas-bearing gyro operating in a rate mode. The input axis of the gyro is oriented in the roll-yaw plane, 45 degrees from the negative roll and the positive yaw axes.

Its primary function is to provide data on the characteristics of gas-bearing gyros in the space environment..

The RMP was built for NASA by Sperry Gyroscope Co., Great Neck, N.Y.

NIMBUS RESULTS

Both Nimbus I and II, launched in 1964 and 1966, respectively, met or exceeded their objectives. Nimbus B, launched in May of 1968, never achieved orbit because the rocket veered off course and had to be destroyed by the Range Safety Officer.

Two Nimbus experimental satellites took about 1-million cloud-cover pictures of the Earth. The day and night (infrared) pictures produced from these two observatories have given meteorologists a look at the Earth's cloud cover never before possible.

Meteorology

Meteorologists single out the APT camera (which provides instant weather pictures to small ground stations anywhere) as the "single most significant contribution to meteorology in the past twenty years."

More than 400 APT stations are now scattered around the world. In many parts of the world APT pictures are the major, and in some cases the only weather information source.

A number of private users in the United States and numerous foreign countries have built their own receivers and facsimile machines at costs ranging from several hundred to several thousand dollars.

Many of the world's large airports have APT pictures for commercial pilots to study before a flight. Pilots can see what the weather is currently like, during the day or at night, from New York to London, or San Francisco to Tokyo before taking off.

Nimbus II demonstrated, for the first time, that infrared pictures could be read out "live" on simple APT ground equipment.

Probably the most significant results from Nimbus satellites have been their ability to identify and track known meteorological phenomena such as hurricanes and typhoons, extra-tropical cyclones and frontal systems on a daily global basis, particularly during night time (infrared).

Storm system photographs have stimulated new studies and new approaches to determining the morphology and life history of storms.

The radiation measurements obtained with Nimbus II's Medium Resolution Infrared Radiometer (MRIR) experiment render the best satellite observations yet of the vertical structure of the lower atmosphere.

Radiation measurements in the water vapor channel (6.4 - 6.9 microns) permit inferences of the total water vapor content in the upper atmosphere and atmospheric dynamics.

These moisture patterns provide the best means yet to map, from a satellite, large scale stratospheric circulation and the course of jet streams.

From HRIR and MRIR data, meteorologists have been able to observe the course and intensity of the Intertropical Convergence Zone (ITCZ) as manifested by cloud formations girdling the globe near the Equator.

A typical set of infrared pictures was taken June 5, 1966, between 30 degrees North latitude and 30 degrees South latitude. Although activity was relatively weak on this day, the course of the ITCZ was followed around the entire globe.

Pictures showed that the ITCZ generally follows the 10 degree North latitude parallel except over the Indian Ocean and Africa, where it dips down to the Equator. It is most intense over India and Indonesia and all but disappears over portions of the Pacific. Some lesser intensifications occur over Africa and South America. Over the Central Pacific, an interesting splitting into two narrow bands occurs.

<u>Oceanography</u>

It has been possible at night under certain cloud-free conditions to detect areas of sharp temperature contrast, such as currents and upwelling, from Nimbus HRIR photographs.

A study on large scale fluctuations of the Gulf Stream was based on Nimbus infrared pictures. Under cloudless skies the northern boundary of the Gulf Stream between Cape Hatteras and 60 degrees West was identified by the contrasting gray tones on pictures over several months.

Nimbus infrared data were compared with information collected by a ship. Although a degree of uncertainty in boundary location arises from distortion in the satellite photos, comparisons suggest that continuity can be established.

The Gulf Stream boundary was seen on Nimbus photos in about 50 cases. Other ocean current boundaries and pronounced sea-surface temperature patterns, such as the Falkland and Brazil Current discontinuity, the Agulhas Current and the Kurohsio Current could be seen from Nimbus infrared photographs.

In one single infrared photo, oceanographers were able to trace the meandering path of the Gulf Stream for 1,000 miles.

Ice Pack Reconnaissance

High resolution television cameras and infrared radiometers on Nimbus were able to "photograph" an iceberg in the Weddell Sea. This is the first known case in which an iceberg has been' photographed from a satellite over the Arctic or Antarctic.

The iceberg was an estimated 71 miles long and 20 miles wide.

Another series of Nimbus II pictures showed a southward drift of an individual iceberg along the Greenland coast over a six-week period. Progress was observed regularly as it followed the major East Greenland Current.

By such satellite photography, circulation and sea ice drift measurements are possible, adding new knowledge in the study of the central Arctic environment.

Nimbus II, regularly covering the Antarctic areas, presented possibilities for mapping extremely remote areas where conventional techniques are at best difficult and expensive.

Nimbus pictures of the Weddell Sea regions depict a semi-permanent coastline that is generally marked as a fixed feature on charts of the Antarctic Ocean. Portions of this coast have not been mapped for more than 20 years.

Numerous fractures in the pack ice appear in all photographs of this area, revealing enormous stresses and strains in the ice.

Cartography and Geology

Information obtained by Nimbus weather satellites has also provided useful data for geographers and geologists

The U.S. Geological Survey, after studying more than 300 Nimbus I pictures over the Antarctic, found that relief maps of the Antarctic were in slight error.

As a result, Mount Siple, a 10,000-foot high Antarctic mountain was repositioned 45 miles to the West. Nimbus I pictures of the Kohler Range area at the Antarctic showed one group of mountains, not two as depicted on earlier maps.

Geologists have used Nimbus photos to increase their knowledge of past geologic formations in certain areas of the world such as a river basin in Oregon, Paris Basin in Central France and the Appalachian Mountains of Pennsylvania.

Snow Cover and Hydrology

Snow depth of one inch or more can be detected by Nimbus satellites as a continuous snow cover. Snow depths of less than one inch have usually been detected, but often did not appear as continuous cover.

Areas with snow cover greater than about three inches in nearly all cases had reflectivities significantly higher than areas with lesser snow depths.

Nimbus II APT pictures of the East Coast of the United States showed a very bright Delaware-Maryland-Virginia peninsula blanketed the day before by an eight-inch snowfall. The rest of Maryland and Virginia had received only a trace to 4 inches of snowfall and thus showed lesser reflectivities.

Although present satellite photography cannot provide the quantitative (three dimensional) measurements of snow depth provided by a network of surface stations, it can provide the limits of snow cover and detailed qualitative estimates of snow depth in the areas between reporting stations.

This information is of much importance to hydrologists in making ground water run-off estimates and flood control forecasts.

LAUNCH VEHICLE

The launch vehicle used for the Nimbus B-2 satellite is a Thorad-Agena-D rocket. The Thorad, or long tank Thor, is an uprated version of the Thrust Augmented Thor (TAT) used in combination with an Agena second stage to launch the first two Nimbus weather satellites.

The Thorad booster has a 50 per cent greater tank volume than previous Thors which increases engine burn time. Previous Thors carried 33,000 lbs. of RJ-1 fuel and 67,000 lbs. of liquid oxygen. Thorad carried 45,000 lbs. of fuel and 100,000 lbs. of oxidizer. Although no increase in thrust is realized, the main engine burn time is increased from approximately 146 seconds to about 218 seconds.

The three strap-on solid rocket motors used on the Thorad are also uprated from the ones used on the TAT's. The Thorad strap-ons provide 52,130 lbs. of thrust for 37 seconds. This compares with 54,300 lbs. for 27 seconds for the old motors.

The greater propellant capacity of the Thorad coupled with the new strap-on solid motors make it possible to boost about 50 per cent more payload into Earth orbit than the original TAT.

The Agena-D second stage is the same configuration used in the past. Its 16,000-pound-thrust engine burns UDMH (Unsymetrical dimethylhydrazine) and IRFNA (Inhibited red fuming nitric acid). For the Nimbus mission 3,824 lbs. of UDMH fuel is carried and 9,703 lbs. of IRFNA oxidizer.

The launch vehicle including the 18.7 foot Nimbus shroud stands 109.5 feet high. Because the spacecraft is designed to take cloud cover pictures near local noon during its south to north pass over the Earth, the possible launch time from complex 2 of the Western Test Range is restricted. The launch window for April 11 is 2:53 p.m. to 3:57 p.m. EST.

Sun-Synchronous Orbit

A high noon orbit is ideal for weather satellites because it provides maximum illumination for photographic purposes, and pictures of the Earth will always be taken at the same local Sun Times every day. Night photos will be taken about midnight local time.

In a Sun-synchronous orbit, the preceission (eastward drift) of Nimbus will be about one degree daily, at the same rate and direction as the Earth moves around the Sun. The Sun will always be behind Nimbus during daylight orbit, which results in ideal lighting conditions for cloud cover photography.

Countdown Milestones for Thorad-Agena-D Nimbus- Launch

Event	Minutes
Countdown initiation	T-750
Thorad preparation	T-750
WECO and Thorad telemetry checks	T-730
Destruct checks	T-680
Solid motor arming	T-620
Gantry removal	T-500
Agena tanking	T-190
Agena pressurization	T-95
Countdown evaluation and start terminal count	T-60

Typical Sequence Of Flight Events

Event	Seconds
Liftoff	0
Start roll program	2
Stop roll program - start pitch program	16
Solid motor burnout	39
Eject solid motors	102
WECO steering commands commence	125
Thorad Main Engine Cutoff	222
Thorad Vernier Engine Cutoff	231
Thorad-Agena separation	237
Agena first ignition	256
Agena first burn cutoff	487
Agena second burn ignition	3261
Agena second burn cutoff	3267
Nimbus separation	3517
Begin Agena yaw and roll maneuver	3519
Fire first Agena retro	3710
Fire second Agena retro	6217
SECOR separation	6385

Thorad-Agena Flight Sequence

Event	Nominal Time (sec.)	Altitude Statute Miles	Surface Range from Pad Statute Miles	Inertial Vel/MPH
Solid Motor Burnout	39	3.11	.683	1068
Solid Motor Ejection	102	16.1	10.1	1520
MECO	222	59.8	141	8840
Thorad-Agena Separation	237	68.1	178	8760
Agena first ignition	256	77.3	225	8700
First Burn Cutoff	487	97.5	995	18,100
Second Burn Ignition	3261	686	12,904	15,790
Second Burn Cutoff	3267	686	12,926	16,300
Nimbus Separation	3517	684.5	------	16,320
SECOR Separation	6385	682	------	16,320

Flight Sequence

Thorad Phase

After liftoff, the Thorad-Agena vehicle rises vertically for about 16 seconds before beginning its pitch program. Starting at approximately two seconds after liftoff and continuing until 16 seconds, the vehicle rolls to the desired flight azimuth of 193.77 degrees. Roll and pitchover are controlled by the Thorad autopilot programmer. The three solid rocket motors provide thrust for approximately 39 seconds and are ejected at about 102 after liftoff. Beginning at approximately 125 seconds, the WECO ground guidance system corrects the launch vehicle trajectory by comparing the vehicle trajectory with a predetermined trajectory and then making small pitch and yaw steering corrections.

Main engine cutoff of the Thorad is commanded by the WECO guidance system along with the start of the Agena start sequence. A Thorad fuel depletion switch can also command main engine cutoff.

Agena Phase

Separation of the Agena stage is initiated by command from the WECO ground station. Small retrorockets are ignited to retard the flight of the Thorad first stage. Approximately 12 seconds after separation the Agena and its spacecraft execute a pitch maneuver followed by Agena engine start. Initial steering corrections are provided by the WECO ground station which stops transmitting commands approximately 139 seconds after engine start. First burn cutoff is determined by velocity of the Agena stage and is initiated by the Agena velocity meter.

The nose fairing which protects the Nimbus spacecraft during flight through the atmosphere is jettisoned approximately 10 seconds after first burn ignition of the Agena main engine.

When velocity of the Agena reaches approximately 26,500 feet-per-second, the Agena main engine shuts down and the vehicle begins a coast period.

During the 46-minute coast period the Agena vehicle and Nimbus spacecraft continue on a trajectory which takes it almost 12,000 miles measured along the earth surface and from an altitude of 97 miles to an altitude of 686 miles. At that point the Agena main engine is fired for about 6 seconds to circularize the orbit.

Nimbus Separation

During the approximately 250 seconds between Agena engine cutoff and spacecraft separation the vehicle pitches up so that it is at an angle of about 80 degrees in respect to the horizon. At T plus about 58 and a half minutes explosive bolts are fired on the spacecraft adapter and compressed springs push the Nimbus spacecraft away from the Agena stage at a rate of about 4.5 feet-per-second.

Retromaneuver and Secor Separation

At two seconds after separation, a simultaneous roll, yaw maneuver is executed by the Agena. This maneuver results in the Agena flying roughly parallel to the Earth with its tail end forward. The first small retro engine is then fired. This lowers the orbit of the Agena in relationship to the Nimbus satellite.

At approximately 6,385 seconds into the flight an explosive pin puller is fired freeing the SECOR from the Agena and placing it in an orbit a few miles lower than that of the Nimbus.

A second retro maneuver places the Agena in an orbit where it will maintain a minimum separation of at least 500 feet from the Nimbus spacecraft for a period of at least one year.

Launch Vehicle Fact Sheet

Thorad-Agena-D and Nimbus B2

Height on pad: 109 ft. 5 in.

Weight on pad: 201,637 lbs.

	Thorad Booster	Agena-D Upper Stage
Height:	70 ft. 6 in.	20 ft. 4 in.
Weight:	182,000 lbs.	17,517 lbs.
Propellants:	45,000 lbs. RJ-1 fuel, 100,000 lbs. liquid oxygen oxidizer	570 gallons unsymmetrical dimethyl hydrazine (UDMH) 740 gallons inhibited fuming nitric acid (IFRNA)
Thrust:	317,050 lbs. total thrust	16,000 lbs. at altitude
Propulsion:	Rocketdyne MB3 BLK 111, 170,000 lbs. thrust Three Thiokol TX-354-5, each 52,130 lbs. thrust	One regeneratively cooled engine (Bell Aerosystems)
Guidance:	Pre-programmed guidance up to 120 sec. WECO on Agena after 120 sec.	Agena IRP (inertial reference package), horizon sensors, and onboard flight programmer.
Prime Contractor:	McDonnell Douglas Corp.	Lockheed Missiles and Space Co., Sunnyvale, Calif.

NIMBUS B2 PROJECT OFFICIALS

NASA Headquarters, Washington

Leonard Jaffe	Director, Space Applications Program
Dr. Morris Tepper	Deputy Director, Space Applications Program & Dir. of Meteorology
Dr. Richard Haley	Nimbus Program Manager
Bruton B. Schardt	Deputy Nimbus Program Manager
Joseph B. Mahon	Director, Launch Vehicle & Propulsion Programs
T.B. Norris	Program Manager, Medium Launch Vehicles
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Dr. John F. Clark	Director
Mr. Harry Press	Nimbus Project Manager
Mr. Stanley Weiland	Observatory Systems Manager
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Lewis Research Center, Cleveland

Dr. Seymour C. Himmel	Assistant Director for Rockets and Vehicles
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Kennedy Space Center, Fla.

Robert H. Gray	Director, Unmanned Launch Operations
H.R. Van Goey	Manager, WTR Operations
W.S. Cortright	Manager, Agena Operations, WTR

U.S. Air Force	
List to be provided by NASA Headquarters	Deputy for Space Systems, 6595th Aerospace Test Wing
General Electric Co.	
Mr. I.S. Haas	Nimbus Project Manager Missile and Space Division
McDonnell-Douglas Corp.	
Mr. W. L. Duval	Vice President, Director, Vandenberg Test Center Huntington Beach, Calif.
Lockheed Missile & Space Co.	
Mr. Ray Gavlak	Resident Manager - Space Systems Vandenberg AF Base, Calif.
U.S. Army Corps of Engineers	
Joseph A. Bernard	Acting Special Projects Officer, Directorate of Operations, U.S. Army Topographic Command, Corps of Engineers, Engineer Topographic Laboratories
Atomic Energy Commission	
Milton Klein	Director, Division of Space Nuclear Systems

Major Spacecraft Subsystem Contractors

Company	Subsystem
ADCOLE Corp. Waltham, Mass.	Monitor of Ultraviolet Solar Energy
California Computer Products Los Angeles, Calif.	Command Clock, Medium Resolution Infrared Radiometer Electronics
General Electric Co. Missile and Space Division Valley Forge, Pa.	Nimbus B2 integration and test, stabilization and control subsystem, spacecraft structure and antennas
Hughes Aircraft Co. Culver City, Calif.	PCM (Telemetry Transmitter)
International Telephone & Telegraph, Industrial Laboratories Ft. Wayne, Ind.	High Resolution Infrared Radiometer and the Image Disector Camera
Lockheed Electronics Co. Industrial Technology Division Edison, N.J.	PCM Telemetry Tape Recorder
Radiation, Inc. Melbourne, Fla.	PCM Telemetry and the Interrogation Recording and Locations System
Radio Corporation of America Astro Electronics Division Princeton, N.J.	High Data Rate Storage System, Command Receivers, Solar Power System and the Direct Readout Infrared Transmitter
Santa Barbara Research Center Subsidiary of Hughes Aircraft Santa Barbara, Calif.	Medium Resolution Infrared Radiometer
Sperry Gyroscope Great Neck, N.Y.	Rate Measuring Package
Texas Instruments Inc. Dallas, Texas	Infrared Interferometer Spectrometer
Isotopes, Inc. Baltimore, Md.	SNAP-19

Launch Vehicle Contractors

Company	Responsibility
Bell Aerosystems Company Buffalo, N.Y.	Agena D Engine
Douglas Aircraft Company Missiles and Space Systems Division Santa Monica, Calif.	THORAD (Long Tank Thor)
Electrosolids Los Angeles, Calif.	Thor Autopilot
Minneapolis-Honeywell Minneapolis, Minn.	Thor Autopilot
Texas Instruments Dallas, Texas	Thor Autopilot
Lockheed Missiles and Space Co. Division of Lockheed Aircraft Co. Sunnyvale, Calif.	Agena D Vehicle (Airframe and Associated Electronics)
Rocketdyne Division of North American Rockwell, Inc. Canoga Park, Calif.	THORAD Engine
Thiokol Chemical Corp. Huntsville, Ala.	Solid Propellant Strap-on Boosters
Western Electric Co. Burlington, North Carolina	THORAD Guidance System

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Major Ground Equipment Contractors

Company	Responsibility
Adler/Westrex Communications Division of Litton Systems, Inc. New Rochelle, N.Y.	HRIR Facsimile Equipment
Allied Research Associates, Inc. Concord, Mass.	Operate the Nimbus Data Utilization Center
California Computer Products Los Angeles, Calif.	Ground Station Command Console
Collins Radio Co. Dallas, Texas	85-Foot Antenna Ground Electronics
Control Data Corporation Minneapolis, Minn.	Ground Station Computers
Electronic Image Systems Corp. Boston, Mass.	Medium Resolution Infrared Radiometer Film Processing Equipment
General Electric Co. Missile & Space Division Valley Forge, Pa.	Operate the Nimbus Control Center
Lear Siegler Inc. Anaheim, Calif.	Computer System for Processing Medium Resolution Infrared Radiometer Data
Photo Mechanisms, Inc. Huntington Station, N.Y.	Rapid Film Processing System for Image Disector Camera Photographs
Radiation. Inc. Melbourne, Fla.	Operate PCM Telemetry Equipment
RCA Service Co. Cherry Hill, N.J.	Operate the Nimbus Data Handling System
Rohr Corp. Chula Vista, Calif.	85-Foot Antennas

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