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Handbook of Sensor Technical Characteristics

Shelby Tanner

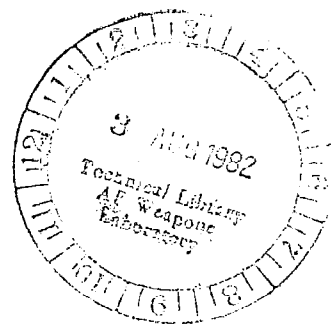
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Handbook of Sensor Technical Characteristics

Shelby Tanner
*Systematics General Corporation
Sterling, Virginia*

NASA

National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

FOREWORD

This document is a compendium of information on Space and Terrestrial Applications remote sensor systems. The sensor systems presented in this book range from those experimental systems flown on early flights to those highly sophisticated sensors currently under development or planned for future missions.

The sensor systems are presented in alphabetical order in the main section of this book. Each sheet identifies the remote sensor and includes information on its objectives, description, technical characteristics, data products obtained when appropriate, data archives location, period of operation, measurement parameters and potential derived parameters. Not all sensors have the same degree of information dependent upon the current state of development and the inability to obtain complete information for all sensors.

Each sensor in this book has been indexed in each of the following indices:

- 1) Index of Remote Sensors by Status and Spacecraft, i.e., Flight, Future Flight, and Development.
- 2) Index of Remote Sensors by Alphabetical Order and Major Derived Parameters, e.g., atmospheric trace constituents, solar constant, and earth resources phenomena.
- 3) List of Remote Sensors by Instrument Type, e.g., radiometers, spectrometers, and radars.

A list of spacecraft acronyms and a list of remote sensor acronyms are presented in the back of the book for reference purposes.

The information presented in this book was compiled by the Systematics General Corporation, Sterling, Virginia, for the Office of Space and Terrestrial Applications, NASA Headquarters, under the direction of Mr. John Kiebler and Mr. Jules Lehmann.

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ACTIVE CAVITY RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Quality
STATUS: Future Flight Mission
NASA TECH. OFFICER:
LOCATION:

ACRONYM: ACR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: Spacelab-1
CONTRACTOR: Jet Propulsion Laboratory
P.I.: Dr. R. Willson

OBJECTIVES

1. To determine the magnitude and direction of possible variations in total solar optical energy output.
2. To determine important sun-earth interactions for climatological studies.

DESCRIPTION

SUMMARY: Two instruments will be utilized for the solar irradiance and spectral distribution measurements: a radiometer and a spectrometer. The radiometer design contains three active cavity radiometers type IV (ACR IV) which are basically electrical substitution calorimeters. It measures irradiances from far UV through far IR. Using copper resistance sensors, an electronic circuit maintains a constant temperature drop across a thermal impedance connecting the cavity detector to a heat sink. This is accomplished by dissipating electrical power in the cavity heater winding. The ACR is operated in a differential mode by chopping the radiant flux to be measured at a slow rate. In the observation phase, the thermal impedance temperature drop is maintained by the combined inputs of incident radiant power and electrical power to the cavity detector. In the reference phase, all the power required for maintenance of the temperature drop is provided by electrical heating. By careful design, the only significant differences between the two phases of measurement are the presence or absence of the radiant flux to be measured and the electrical power required in the two phases is directly proportional to the radiant flux.

HERITAGE/DERIVATION: Cavity Absolute Pyrheliometer (SR&T)

REFERENCES

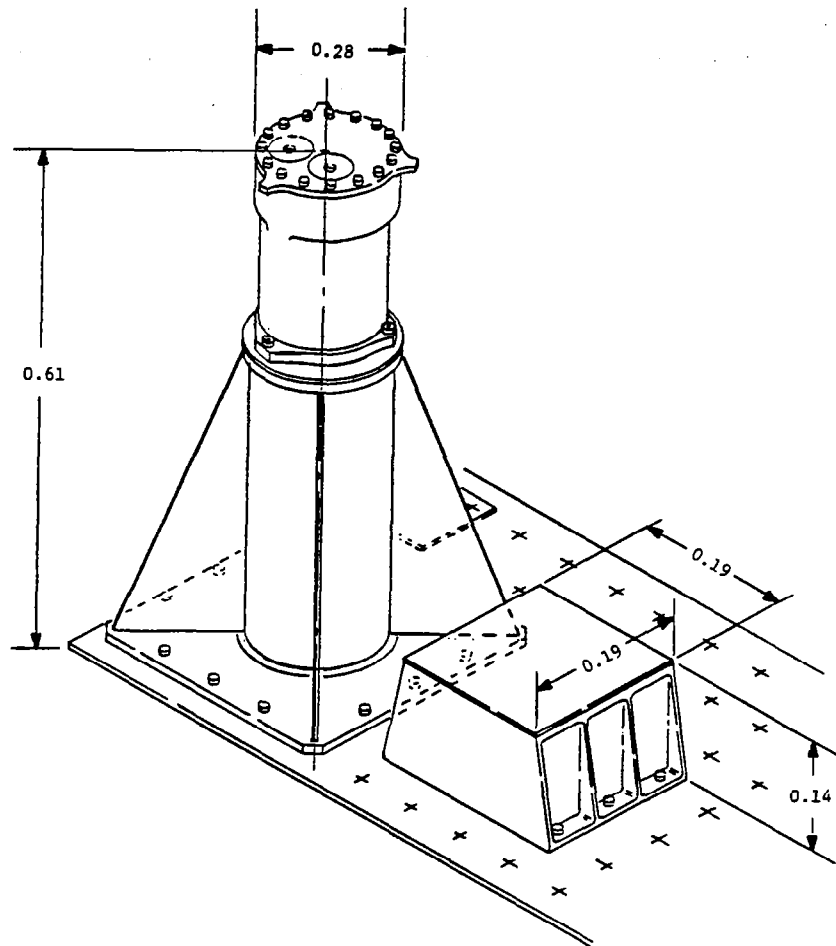
1. Spacelab Mission/Experiment Descriptions, MSFC, May 1978.
2. AEM Future Mission Model, GSFC, April 1976.

SYSTEM CHARACTERISTICS

Size: 20x20x50 cm
Weight: 18 kg
Average Power: 15 We
Data Rate: 50 bps from each instrument
Altitude Requirements: 200 nm desired.

ACTIVE CAVITY RADIOMETER (ACR) (cont.)

FUNCTIONAL DIAGRAM



MEASUREMENTS

Measure the total solar irradiance and its spectral distribution outside the earth's atmosphere.

Spectral Range: 0.18 to 6.5 μm (spectrometer will measure over 50 points)

Measurement Accuracy: $\pm 0.2\%$

Field of View: Circular 5 degree

Calibration: Black Body Source

Solar Pointing Accuracy: Radiometer, $\pm 0.5^\circ$; spectrometer $\pm 0.05^\circ$.

POTENTIAL DERIVED PARAMETERS

1. Sun's total radiation
2. Solar constant.

ADVANCED LIMB SCANNER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Mission
NASA TECH. OFFICER: Dr. James Russell, III
LOCATION: LaRC

ACRONYM: ALS
INSTRUMENT TYPE: Radiometer
SPACECRAFT: UARS
CONTRACTOR: National Center for
Atmospheric Research
P.I.: John C. Gille

OBJECTIVES

1. Determine the global distributions of several source, reservoir, and radical species for the 2 1/2 year period of the UARS missions, including O₃, NO₂, HNO₃, N₂O, CH₄, CF₂CL₂, H₂O, CO₂, and O₃N.
2. Determine the global temperature distribution from the tropopause into the lower mesosphere.
3. Use the temperatures in a low order spectral model of atmospheric dynamics, to derive winds to a higher approximation than the geostrophic approximation, and to use the data in an optimum way to derive nongeostrophic flows - e.g. the vertical motions and the meridional flow.
4. Calculate the various components of the Lorenz energy diagram for different regions of the stratosphere and low mesosphere, and the transformation between them.
5. Understand the distribution of chemical species using photochemical models, coupled photochemical models in which dynamics are parameterized, and the low order spectral model in which the dynamics and chemistry are fully interactive.

DESCRIPTION

SUMMARY: The Advanced Limb Scanner (ALS) experiment uses a multichannel scanning radiometer operating in the infrared range from 6.1 microns to 18 microns. During a vertical Earth limb scan, the incoming analog horizon radiance signal is detected by the ALS radiometer and digitized into a multiplexed serial word format for processing at 8 Kbps rate by the UARS data subsystem. The serial PCM signal is transmitted to a ground station where it is decommutated, reduced, and analyzed to provide the desired data products. The radiometer contains on-axis parabolic optics which focus the horizon energy through a modulating light chopper onto a 10-element mercury-cadmium-telluride detector array. The signal to each detector is chopped for AC detection, passes through a multilayer spectral interference filter and field of view defining aperture before being detected. Since infrared emission is being observed, there is no geographic limitation on the measurements which can be made during the night or day.

HERITAGE/DERIVATION: LRIR - NIMBUS-6
LIMS - NIMBUS-7

DATA

DATA ARCHIVES LOCATION: National Space Sciences Data Center
PERIOD OF OPERATION: Launch date in Fall 1986.

ADVANCED LIMB SCANNER (ALS)

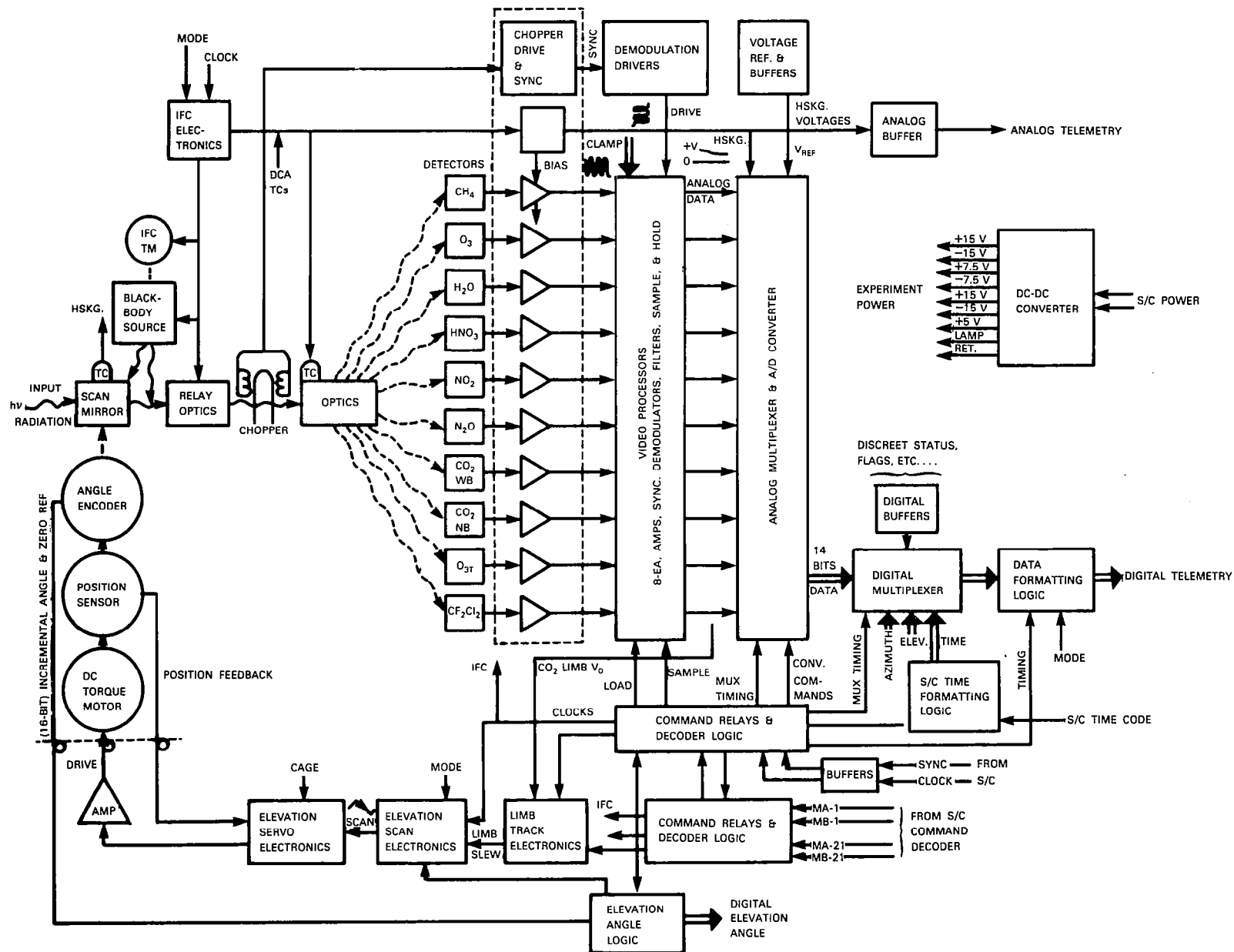
REFERENCES

1. UARS Proposal, Advance Limb Scanner Proposal for UARS Missions, National Center for Atmospheric Research, December 1978.

SYSTEM CHARACTERISTICS

Lifetime: 20,000 hours
Volume: 50 x 40 x 100 cm
Peak Power: 190 W
Average Power: 165 W
Data Rate: 8 kbps
Absolute Pointing: $\pm 1^\circ$ is required in all axes
Weight: 66 kg

FUNCTIONAL DIAGRAM



Advanced Limb Scanner Block Diagram

ADVANCED LIMB SCANNER (ALS)

MEASUREMENTS

Measure IR radiance or spectral emissions.

Spectral Range: 6.1 - 18 microns

Channels: 10

2 - CO₂ at 15 microns

1 - HNO₃ at 11.3 microns

2 - O₃ at 9.6 microns

1 - NO₂ at 6.2 microns

2 - CH₄ at 7 and 8 microns

1 - N₂O at 17 microns

1 - CF₂Cl₂ at 10.8 microns

Altitude of Measurements: 8 km to 70 km

Instantaneous Vertical FOV: 8 channels - <2 km; 2 channels - <1 km

Resolution Range: 80 to 220 cm⁻¹ (depending on channel)

POTENTIAL DERIVED PARAMETERS

Measure vertical and horizontal distribution of the following gases:

1. NO₂
2. H₂O
3. CH₄
4. O₃
5. CF₂Cl₂
6. HNO₃
7. CO₂-W
8. CO₂-N
9. N₂O
10. O₃N

ADVANCED METEOROLOGICAL TEMPERATURE SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations	ACRONYM: AMTS
STATUS: Development	INSTRUMENT TYPE: Spectrometer
NASA TECH. OFFICER: J. Theon, L. Kaplan	SPACECRAFT: Shuttle
LOCATION: NASA Headquarters	CONTRACTOR: Jet Propulsion Laboratory
Goddard Space Flight Center	P.I.: M. Chahine

OBJECTIVES

1. To recover atmospheric temperature profiles in the stratosphere and troposphere and humidity profiles.
2. Day and night cloud cover in the presence of multiple cloud formations.
3. To detect surface temperature.

DESCRIPTION

SUMMARY: The AMTS is a high spectral resolution ($\nu/\Delta\nu = 1300$) passive infrared multidetector radiometric spectrometer being designed for flight on the Space Shuttle and free flyer. The AMTS is a grating spectrometer. This sounder would consist of 28 channels which covers the range from 3.8 microns to 16.47 microns, and which are selected to sound the atmospheric temperature profile, humidity profile, surface temperature, cloud height, and percentage of cloud cover. The use of high spectral resolution permits the selection of spectral intervals whose atmospheric emission characteristics have the proper temperature and pressure dependence to produce sharp weighting functions. The AMTS is designed to retrieve atmospheric temperature with an rms accuracy of 1.0°K, even in the presence of three layers of broken clouds. It will simultaneously obtain the humidity profile, determine the location of the tropopause to ± 0.5 km, map the amount and height of clouds globally, day and night, and recover day and night sea and land surface temperatures.

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory, Goddard Space Flight Center

REFERENCES

1. STS Payload Planning Data, Volume II - OSTA Planning Data, Teledyne Brown Engineering, P179-MSFC-2327, April 1979.
2. Advanced Meteorological Temperature Sounder (AMTS) Study Proposal for FY80, June 1979, Jet Propulsion Laboratory.

ADVANCED METEOROLOGICAL TEMPERATURE SOUNDER (AMTS) (cont.)

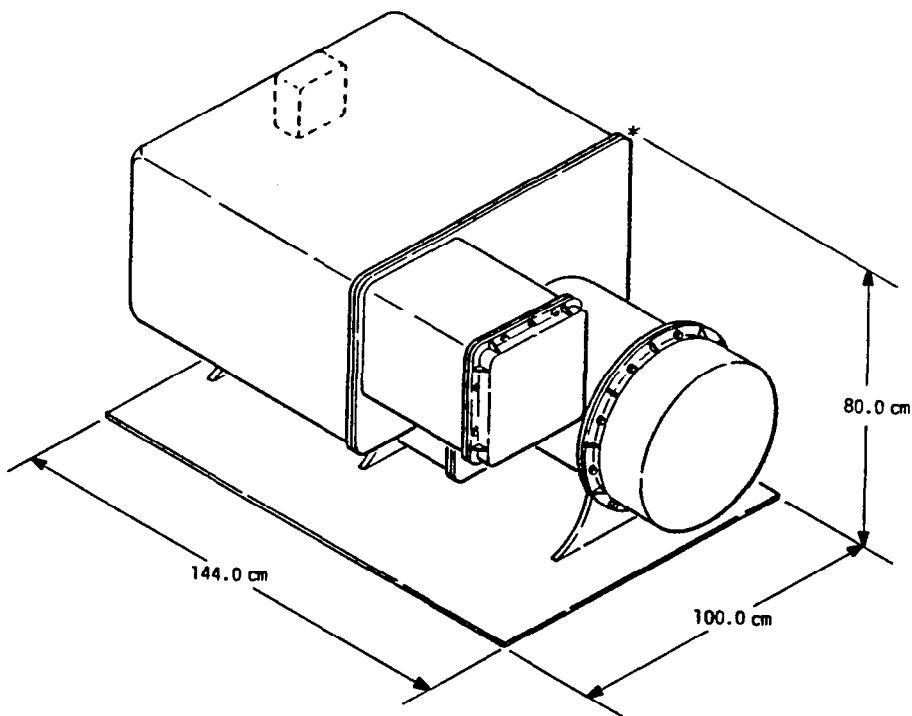
SYSTEM CHARACTERISTICS

Physical Size (m): 0.22 m³

Mass (kg): 294

Power Requirement (We): <100 (pallet), <150 (module).

FUNCTIONAL DIAGRAM



Advanced Meteorological Temperature Sounder

ADVANCED METEOROLOGICAL TEMPERATURE SOUNDER (AMTS) (cont.)

MEASUREMENTS

- Retrieve clear-column temperature profiles in the presence of up to three layers of broken clouds with an average rms accuracy of 1.5K at 8 distinct levels below 100 mb.
- Simultaneously obtain humidity profiles with an accuracy of 20% at seven distinct levels between the surface and 200 mb.
- Recover day and night surface temperature of oceans and solid earth with an average absolute accuracy of 1.5K.
- Map the fractional cover and height of multiple cloud layers globally (as seen from above) with an accuracy of ± 0.05 and 0.25 km respectively.
- Determine the location of the tropopause to within ± 0.5 km.

Number of Channels: 28

Spectral Range: 3.821 to 16.476 microns

Channel:

1 - 16.476 microns	11 - 8.313 microns	20 - 4.195 microns
2 - 16.046 microns	12 - 8.118 microns	21 - 4.191 microns
3 - 15.929 microns	13 - 5.820 microns	22 - 4.187 microns
4 - 15.765 microns	14 - 5.526 microns	23 - 4.184 microns
5 - 15.466 microns	15 - 5.437 microns	24 - 4.180 microns
6 - 15.320 microns	16 - 5.422 microns	25 - 4.176 microns
7 - 15.025 microns	17 - 5.403 microns	26 - 4.125 microns
8 - 14.996 microns	18 - 5.292 microns	27 - 3.992 microns
9 - 14.938 microns	19 - 5.181 microns	28 - 3.821 microns
10 - 14.938 microns		

Resolution: 0.50 cm^{-1} (Channel 1) to 2.50 cm^{-1} (Channel 28)

FOV at nadir: 40 km by 40 km

POTENTIAL DERIVED PARAMETERS

1. Atmospheric temperature
2. Humidity profiles
3. Day and night cloud cover, height and amount
4. Surface temperature.

ADVANCED MICROWAVE MOISTURE SENSOR

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Development

NASA TECH. OFFICER: J. Theon

LOCATION: NASA Headquarters

ACRONYM: AMMS

INSTRUMENT TYPE: Radiometer

SPACECRAFT: A/C

CONTRACTOR: Georgia Institute of Technology

P.I.: T. Wilheit

OBJECTIVES

1. To measure total water vapor.
2. To map rain over land.

DESCRIPTION

SUMMARY: The AMMS is a scanning four channel radiometer operating at 94 and 183 GHz. The three 183 GHz channels were designed to measure total water vapor profile and the 94 GHz channel was designed to map rain over land.

REFERENCES

1. RTOP 146-10-03-15, GSFC, 1981.

ADVANCED MICROWAVE SOUNDING UNIT

IDENTIFICATION

DISCIPLINE: Environmental Observations	ACRONYM: AMSU
STATUS: Development	INSTRUMENT TYPE: Radiometer
NASA TECH. OFFICER: J. Theon	SPACECRAFT:
LOCATION: NASA Headquarters	CONTRACTOR: Jet Propulsion Laboratory
	P.I.: A. L. Riley

OBJECTIVES

1. To provide atmospheric temperature and moisture profiles for weather forecasting.
2. Measurements of precipitation distribution and intensity.

DESCRIPTION

SUMMARY: The AMSU is a 20-channel microwave radiometer with operating bands from about 18 to 180 GHz. These channels will measure microwave radiation emitted near water vapor emission lines (about 22 and 180 GHz), to perform humidity sounding, and near oxygen emission lines (50-60 GHz), to perform temperature sounding. Three "window" channels (18, 31 and 90 GHz), which measure low atmospheric and surface effects, are included in the set of channels. The altitude at which a sounding is made depends on the proximity of a particular channel frequency to the resonant frequency of an emission line. The Microwave Sounding Unit (MSU) instrument is capable of sounding the temperature of the troposphere; the AMSU will be able to perform this function in both the troposphere and the stratosphere and will have the additional capability of making tropospheric humidity soundings and precipitation measurements. The instrument is to provide spatial resolution of 50 km at channels between 18 and 60 GHz and 15 km from 90 to 180 GHz. Preliminary specifications of a number of parameters, including accuracy and resolution of the radiometric temperature and frequency stability were provided as a basis for the study.

HERITAGE/DERIVATION: Microwave Sounding Unit - TIROS

REFERENCES

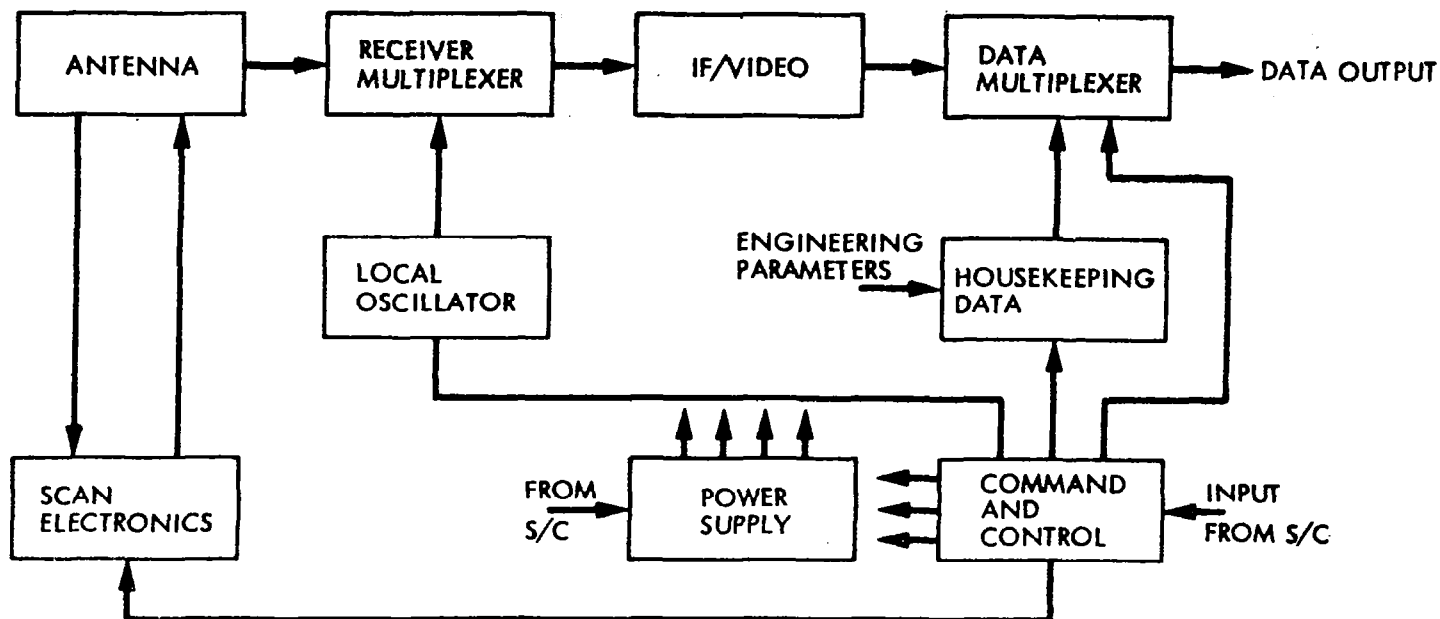
1. Advanced Microwave Sounding Unit (AMSU) System Study Report, JPL, June 1980.

SYSTEM CHARACTERISTICS

Volume: 0.8 m³
Weight: 80 kg
Power: 170 W
Data Rate: Channels 1-15 - 1200 bps
 Channels 16-20 - 3600 bps
Dynamic Range: 3°K to 340°K

ADVANCED MICROWAVE SOUNDING UNIT (AMSU)

FUNCTIONAL DIAGRAM



Advanced Microwave Sounding Unit Block Diagram

MEASUREMENTS

Measures reflected and emitted radiation.

Spatial Resolution: 50 km (Channels 1-15); 15 km (Channels 16-20) nadir view

Altitude: 870 km

Channels: 20

1 - 18.50 GHz (window)	11 - 57.97 (O ₂)
2 - 22.230 (H ₂ O)	12 - 57.97 (O ₂)
3 - 31.65 (window)	13 - 57.97 (O ₂)
4 - 50.30 (window)	14 - 57.97 (O ₂)
5 - 52.85 (O ₂)	15 - 57.97 (O ₂)
6 - 53.40 (O ₂)	16 - 90.00 (window)
7 - 54.35 (O ₂)	17 - 150.0 (H ₂ O)
8 - 54.90 (O ₂)	18 - 183.3 (H ₂ O)
9 - 55.50 (O ₂)	19 - 183.3 (H ₂ O)
10 - 57.97 (O ₂)	20 - 183.3 (H ₂ O)

POTENTIAL DERIVED PARAMETERS

1. Temperature and moisture profiles
2. Precipitation distribution and intensity.

ADVANCED VERY HIGH RESOLUTION RADIOMETER

IDENTIFICATION

DISCIPLINE: Earth Observations	ACRONYM: AVHRR
STATUS: Flight Missions & Future Flight Missions	INSTRUMENT TYPE: Radiometer
NASA TECH. OFFICER: R. Arnold	SPACECRAFT: TIROS-N, NOAA-6, NOAA-B-G
LOCATION: NASA Headquarters	CONTRACTOR: ITT
	P.I.: A. McCulloch

OBJECTIVES

1. To provide global daytime and nighttime sea surface temperature, ice, snow, and cloud formations.
2. To provide a daily basis for use in weather analysis and forecasting.

DESCRIPTION

SUMMARY: The multispectral radiometer operated in the scanning mode and measured emitted and reflected radiation in the following spectral intervals: channel 1 (visible), 0.55 to 0.9 micrometer, channel 2 (near IR), 0.725 micrometer to detector cut off around 1.3 micrometers, channel 3 (IR window), 10.5 to 11.5 micrometers, and channel 4 (IR window) 3.55 to 3.93 micrometers. All four channels had a spatial resolution of 1.1 km, and the two IR window channels had a thermal resolution of 0.12°K at 300°K. The AVHRR is capable of operating in both real-time or recorded modes. The AVHRR produces an image in each band. The satellite motion is used to provide scanning normal to the rotating mirror's cross-track scanning. Radiation is reflected off the mirror through an afocal 8" Cassegrain telescope, filtered into visible and IR components by dichroic splitters, the visible channels are then filtered by interference filters. The IR detectors are radiatively cooled to 105°K. Real-time or direct readout data is transmitted to ground stations both at low (4 km) resolution via automatic picture transmission (APT) and at high (1 km) resolution via high resolution picture transmission (HRPT). Data recorded on board were available for central processing. They included global area coverage (GAC) data, had a resolution of 4 km, and local area coverage (LAC) data, which contained data from selected portions of each orbit with a 1 km resolution.

HERITAGE/DERIVATION: VHRR in NOAA-2,5

DATA

DATA PRODUCTS:

TIROS-N

1. Global area coverage, local area coverage
2. Global daytime and nighttime sea surface temperature
3. Catalogs of products available from NESS.

NOAA-6

Data Set: Pictorial and tabular index to very high radiation radiometer data.
Paper: Digital indexes of global area coverages.

ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

DATA ARCHIVES LOCATION: NOAA/NWS, Silver Spring, Maryland.

PERIOD OF OPERATION: TIROS-N - October 1978
NOAA-6 - June 1979 to present
NOAA-B - May 1980, Failed.

REFERENCES

1. National Space Science Data Center computer printout, 1980.
2. Satellite Data Users Bulletin
3. National Environmental Satellite Service Catalog of Products, third edition.

SYSTEM CHARACTERISTICS

Physical Size (m): 0.27 x 0.37 x 0.79 m

Mass (kg): 30

Power Requirement (We): 29

Data Rate (kbps): 750

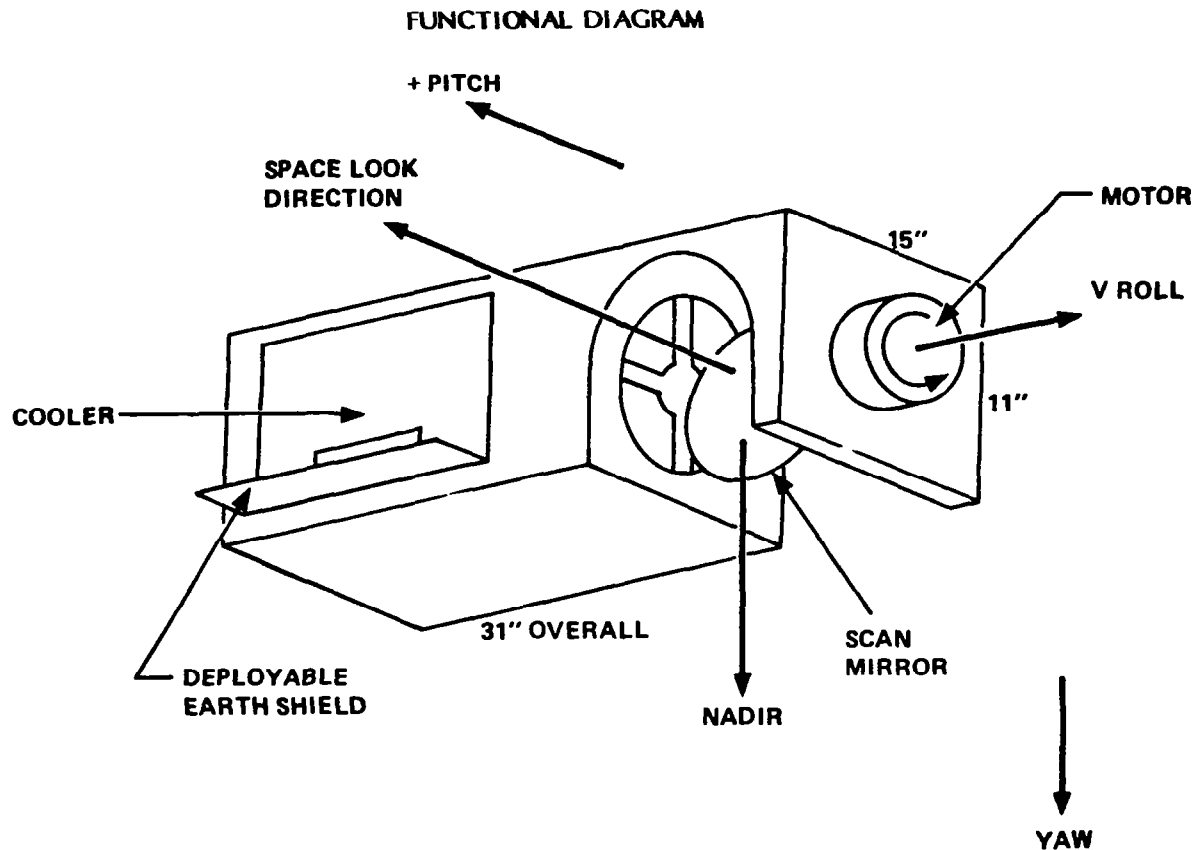
IR Detector Materials: InSb, HgCdTe

Noise Equivalent: T: 0.12K at 300K

Aperture Size: 20 cm

Focal Length: 25 cm

Scan rate of 360 rpm.



Advanced Very High Resolution Radiometer Schematic Diagram

ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

MEASUREMENTS

Measure emitted and reflected radiation.

Number of Channels: 4

Spectral Range: Channel 1 - 0.55 to 0.9 micron (visible)
Channel 2 - 0.725 to 1.3 micron (near IR)
Channel 3 - 10.5 to 11.5 microns (IR window)
Channel 4 - 3.55 to 3.93 microns (IR window)

Spatial Resolution: 1.1 km

POTENTIAL DERIVED PARAMETERS

1. Sea surface temperature
2. Ice information
3. Snow information
4. Cloud cover
5. Cloud temperature.

ADVANCED VIDICON CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. R. Burke
LOCATION: NASA Headquarters

ACRONYM: AVCS
INSTRUMENT TYPE: Imager, Wide Angle Vidicon
SPACECRAFT: ATS-2
CONTRACTOR: RCA Astro-Electronics
P.I.: H. Ostrow,
Goddard Space Flight Center

OBJECTIVES

1. To photograph the entire Earth's disk.
2. To study the utility of future photos from gravity gradient satellites at high altitudes.

DESCRIPTION

SUMMARY: The Advanced Vidicon Camera System was designed to provide nearly continuous cloud cover pictures from a medium orbit, gravity-gradient-stabilized spacecraft. The system consisted of a tape recorder and two cameras -- one low-resolution wide-angle (50°) camera and one high-resolution narrow-angle (3°) camera. The wide-angle camera (12-mm lens) was capable of viewing the full Earth disk with a ground resolution of about 18 km at nadir from a planned satellite height of 11,000 km. The narrow-angle camera (200-mm lens) viewed selected sections of the Earth with a ground resolution of about 1 km at nadir. Each camera was equipped with 2.54-cm-diameter vidicons. A video frame consisted of 6.25 seconds of scan (800 lines). Concurrent with shutter actuation, a 16-increment gray scale was included at the edge of each picture as a contrast check. The wide-angle camera was programmed to take Earth-cloud pictures at 10 minute intervals and the narrow-angle camera at 5 minute intervals. The sequencing was timed so that only a single camera operated at any one time. Data from either camera could be read out directly or stored on a four-track tape recorder. Up to 56 pictures could be stored for subsequent playback to a ground data acquisition station. ATS-2 failed to achieve its planned circular orbit. The second stage of the launch vehicle failed to ignite, thus resulting in a highly elliptical orbit and subsequently limiting the usefulness of the collected data.

HERITAGE/DERIVATION: NIMBUS-1, NIMBUS-2, ESSA-3, and ESSA-5.

DATA

DATA PRODUCTS: Limited film products. The wide-angle camera produced only 33 useful pictures, and only 19 useful pictures were obtained from the narrow-angle camera.

DATA ARCHIVES LOCATION: NASA/GSFC, Attn. Nimbus/ATS Data Utilization Center, Code 460.

PERIOD OF OPERATION: April 1967 to October 1967 - unable to reach orbit.

REFERENCES

1. Meteorological Data Catalog for the ATS, Volume 2, Goddard Space Flight Center, 1968.
2. Press Kit - Project ATS-A, NASA Release No. 67-71, NASA Headquarters, Washington, D.C., March 1967.
3. Eastman, F. H., Two Camera Advanced Vidicon Camera Subsystem (AVCS) for the Applications Technology Satellite, Presented at ATS ELIG Training Program, August 22 - September 30, 1966.
4. National Space Science Data Center computer printout 1980.

ADVANCED VIDICON CAMERA SYSTEM (AVCS)

SYSTEM CHARACTERISTICS

Weight: 135 lbs.
Avg. Power: 22 Watts
Components: 2 cameras with associated optics, electronics, tape recorder
Time Constant: 40 milsec.
Data Recovery: realtime or delayed
Frequency of Observation: 5 - 10 minutes
Telemetry Requirements: readout time 6.25 sec.

MEASUREMENTS

Photographs from reflected solar radiation.

Spectral Range: 0.45 to 0.65 microns
Video Bandwidth: 60 kHz
Measurement Range: 4 to 10,000 foot lamberts
Precision and Accuracy: resolution approximately 800 lines with 16 levels of gray

POTENTIAL DERIVED PARAMETERS

1. Photographs of the Earth
2. Cloud cover photographs
3. Severe Storms

ADVANCED VIDICON CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: AVCS
INSTRUMENT TYPE: Camera
SPACECRAFT: NIMBUS-1, 2
CONTRACTOR: RCA
P.I.: J. R. Schulman, GSFC

OBJECTIVES

1. To obtain a series of remote daytime cloud cover pictures.

DESCRIPTION

SUMMARY: The AVCS sensors consisted of three vidicon cameras mounted on the satellite sensory ring, facing earthward and displayed in a fan-like array to produce a three-segment composite picture. Each camera covered a 37° field-of-view with the center camera pointing straight down. The optical axes of the other two cameras employed an F/4 lens with a focal length of 17.0 mm. A potentiometer attached to the solar array controlled the lens opening from F/16 when the spacecraft was over the equator to F/4 when it was near the poles. The 800-scan-line, 2.54-cm-diameter vidicon pickup tubes yielded a linear resolution of better than 1 km at zero nadir angle from an altitude of 800 km. At this altitude, the camera array produced a composite picture covering an area of 830 by 2700 km, up to 192 pictures (two full orbits of data) or 64 pictures per camera could be stored on tape for subsequent playback to an acquisition station. Using a transmission frequency of 1707.5 MHz, the two orbits of pictures could be telemetered to a ground station in 4 minutes. The AVCS experiment was highly successful. It provided the first near-global, high-resolution cloud cover pictures ever assembled and confirmed the decision to use this particular camera assembly as a basis for the first operational satellite system (TOS/ESSA).

HERITAGE/DERIVATION: TIROS 1 - 10 Vidicon Camera Systems

DATA

DATA PRODUCTS:

NIMBUS-1

Film: Daytime cloud cover pictures.
3-segment composite picture.

NIMBUS-2

Data Set: AVCS photos.
AVCS world montage catalog on microfiche.

Film: Cloud photography on 35 mm positive or negative film. Available on 100-ft. reels, containing chronological picture sequence.
4 cards B/W microfiche containing daytime television pictures.
Transparent grid overlays provide geographic references.

ADVANCED VIDICON CAMERA SYSTEM (AVCS)

DATA ARCHIVES LOCATION: National Climatic Center, Asheville, North Carolina; National Weather Records Center, Asheville, North Carolina; NESR, Suitland, Maryland.

PERIOD OF OPERATION:

NIMBUS-1

August 28, 1964 - September 22, 1964

NIMBUS-2

May 1966 to August 1966

REFERENCES

1. NIMBUS-1 Users Guide.
2. NIMBUS-2 Users Guide
3. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Components: 3 vidicon cameras, associated electronics

Weight: 63 lbs.

Avg. Power: 27 Watts

Frequency of Observation: continuous daytime

Orbital Inclination: 98.7°

MEASUREMENTS

Obtain cloud cover pictures of the Earth.

Dynamic range of 14 to 11,400 footlamberts.

Field-of-View: 37.5°

Precision and Accuracy: 8 - 10 levels of gray, 833 line resolution

Spectral Range: 0.45 to 0.65 micron

POTENTIAL DERIVED PARAMETERS

1. Cloud cover pictures of the Earth
2. Severe Storms
3. Daytime Television Pictures.

ADVANCED VIDICON CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. Garbacz
LOCATION: NASA Headquarters

ACRONYM: AVCS
INSTRUMENT TYPE: Imager
SPACECRAFT: ESSA-3,5,7,9; ITOS-1; NOAA-1,2
CONTRACTOR: RCA
P.I.: J. O'Brien

OBJECTIVES

1. To obtain a series of wide-angle, high resolution television pictures of the Earth and its cloud cover during daylight.

DESCRIPTION

SUMMARY: The ITOS-1 Advanced Vidicon Camera System (AVCS) was operated in three modes -- record, playback, and direct readout. The AVCS system for ITOS-1 was essentially the same as that used on all AVCS-TOS spacecraft (ESSA 3, 5, 7, and 9). The two major elements of the system were (1) the camera sensor assembly, which contained lens, shutter, grayscale calibrator, vidicon, deflection yoke, camera electronics module, and power circuits and (2) a preamplifier for converting optical images into electrical signals. The Earth-oriented camera used a 108° wide-angle lens (5.7-mm focal length) with an F/1.8 aperture and a 2.54-cm-diameter vidicon with 833 scan lines. A video frame consisted of a 0.25-sec period of blanked video, followed by 6.25 sec of vidicon scan video (833 lines), and a final 0.25-sec intervals to cover the sunlit portion of the Earth (Sun elevation greater than 15°). The tape recorder could be read out between photographic cycles without losing a picture or interrupting a sequence. At nominal satellite altitude (1450 km), the AVCS pictures covered a 3000-by 3000-km square with a ground resolution of about 3 km at Nadir. There was a 50 percent picture overlap along the track to ensure complete coverage. The tape recorder could store up to 38 pictures (three orbits of data) in a single start-stop operation.

HERITAGE/DERIVATION: Similar to AVCS on NIMBUS-1 and 2.

DATA

DATA PRODUCTS:

ESSA-3,5,7,9

Data Set: Global daily nephanalysis of satellite cloud observations.
Catalog of meteorological satellite data - ESSA-3,5,7,9 television cloud photography.
35 mm AVCS cloud photography.

Paper: Digital indexes of cloud pictures listed by orbit number and track.
Daily map indexes.

Film: 35 mm positive or negative film of wide-angle cloud photography.

ADVANCED VIDICON CAMERA SYSTEM (AVCS)

DATA PRODUCTS (cont'd):

ITOS-1

Data Set: Catalog of meteorological satellite data - ITOS-1 Television Cloud Photography
35 mm AVCS Cloud Photography

Paper: Digital indexes of cloud pictures listed by orbit number and track
Film: 35 mm positive or negative film of wide-angle cloud photography

NOAA-1,2

Data Set: Catalog of meteorological satellite data - NOAA-1 television cloud photography.
Index of available cloud pictures.

Paper: Digital indexes of cloud pictures listed by orbit number and track.

DATA ARCHIVES LOCATION: National Climatic Center, Asheville, NC
PERIOD OF OPERATION:

ESSA-3,5,7,9

October 1966 to October 1968
April 1967 to February 1970
August 1968 to March 1970
February 1969 to November 1972

ITOS-1

January 1970 to June 1971

NOAA-1,2

December 1970 to June 1971
October 1972 to January 1975

REFERENCES

1. Final Engineering Report TOS A, Volume 1, 2, 3. RCA Astro-Electronics, Contract No. NAS 5-9034, May 5, 1967.
2. Significant Achievements in Space Applications 1966, NASA SP-156, 1967.
3. Ostrow, H.: Review of a Decade of Space Camera Systems Development for Meteorology, NASA/GSFC, August 1968.
4. National Space Science Data Center computer printout, 1980.
5. Satellite Data User's Bulletin, Vol. 1 #2, August 1979.

ADVANCED VIDICON CAMERA SYSTEM (AVCS)

SYSTEM CHARACTERISTICS

Precision and Accuracy: 833 line resolution, 15-16 levels of gray
Components: 2 TV cameras, 2 tape recorders, system electronics
Weight: 63 lbs.
Volume: 3.5 cu. ft.
Average Power: 9 Watts
Peak Power: 210 Watts
Frequency of Observation: Dayside of orbit

MEASUREMENTS

Photographs from reflected solar radiation.
Dynamic range of 200 to 10,000 foot-lambes
Spectral Range: 0.4 to 0.65 micron
FOV: 89.0 by 89.0 DES
Spatial Resolution: 1.7 nm per TV-line at the center from 750 nm alt.

POTENTIAL DERIVED PARAMETERS

1. Day/Night cloud cover pictures
2. Television pictures of the Earth
3. Storm cycles.

ALTIMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: D. Broome
LOCATION: NASA Headquarters

ACRONYM: ALT
INSTRUMENT TYPE: Altimeter
SPACECRAFT: NOSS
CONTRACTOR:
P.I.: P. J. Heffernan, GSFC

OBJECTIVES

1. To determine ocean wave height, surface currents, wind velocity, sea ice boundaries and other geophysical parameters.

DESCRIPTION

SUMMARY: The NOSS Altimeter (ALT) is an active microwave sensor which will be used to determine various parameters in a narrow swath along the satellite subtrack. While the NOSS Altimeter has essentially the same performance parameters as the unit flown on the proof-of-concept Seasat mission, it incorporates a number of modifications and improvements which significantly enhance mission operations and reliability aspects for a 3-year minimum pre-operational demonstration. These are: reprogrammable on-board microprocessor; addition of rain; increased instrument data rate to provide additional waveform samples; and improved instrument self-calibration. Each NOSS spacecraft will carry two Altimeter instruments for reliability; the instruments will be operable simultaneously for cross-calibration purposes. The Altimeter is a fixed-beam, nadir-viewing monostatic chirp radar which provides a range measurement precision of 10 cm or better with a surface resolution of less than 10 km along the satellite subtrack. The Altimeter operates at 13.56 GHz, and consists of the following major elements: 1.0m parabolic reflector; microprocessor-controlled adaptive tracker unit (ATU) and synchronization and control unit (SACU); analog and digital signal processing subsystem; and power and signal conditioning units. The Altimeter transmits extremely short chirped pulses at a power level of 2 kW and a repetition rate of 1020 per second. Return signals are processed and analyzed as to time of arrival and details signal strength and waveform signature. Series of successive returns are averaged to yield twenty-per-second smoothed data along the satellite subtrack.

HERITAGE/DERIVATION: Seasat-1 Altimeter; GEOS-C Altimeter.

REFERENCES

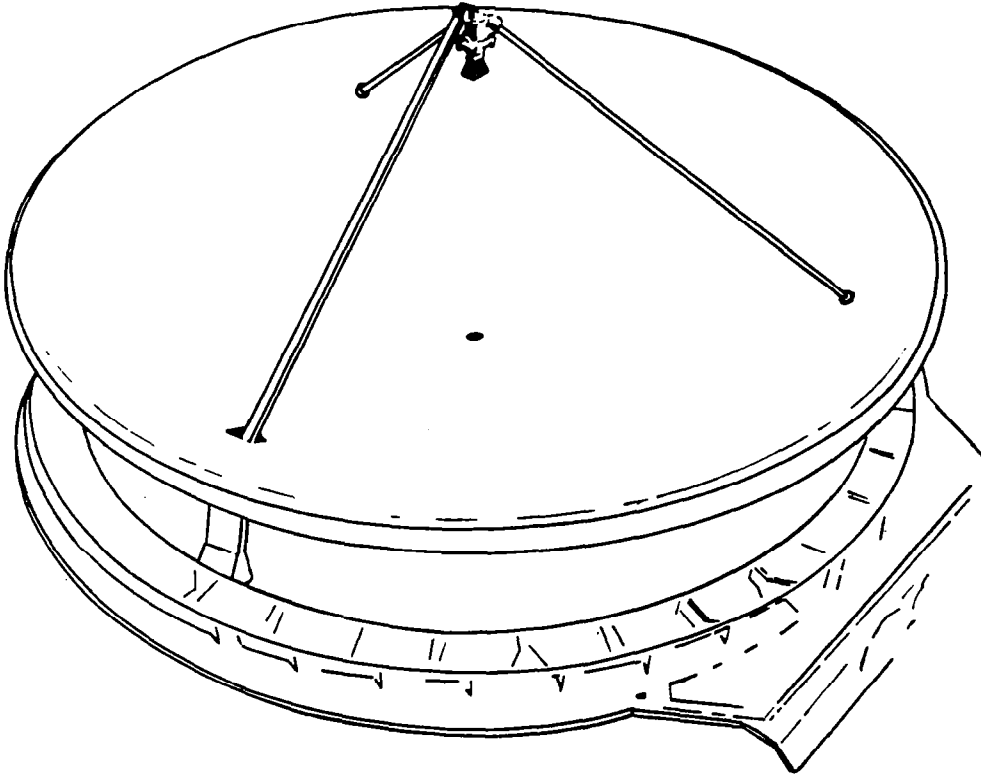
1. Report of Active and Planned Spacecraft and Experiments, August 1980, GSFC.
2. Remote Sensing Data Handbook, September 1977, MSFC.

ALTIMETER (ALT)

SYSTEM CHARACTERISTICS

Size: Single; 1 meter
Electronics Package: 0.4 m³
Weight: 164 kg
Power: 168 Watts
Data Rate: 8.5 kbits
Life: 3 to 5 years

FUNCTIONAL DIAGRAM



Altimeter Schematic Diagram

ALTIMETER (ALT)

MEASUREMENTS

Measures radar doppler shift.

Predicted Altimeter Capability

<u>Parameter</u>	<u>Range</u>	<u>Accuracy</u>	<u>Resolution</u>
1. Satellite Altitude	700 km \pm 15 km	10 cm	--
2. Ocean Waveheight	1 to 20 M	0.5 M	<10 km
3. Surface Currents 0 to 360°	15 to 250 cm/s 20°	15 cm/s	<10 km

POTENTIAL DERIVED PARAMETERS

1. Satellite Altitude
2. Ocean Waveheight
3. Surface Currents
4. Winds
5. Sea State
6. Ice

ATMOSPHERE GENERAL CIRCULATION EXPERIMENT

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: J. Theon
LOCATION: NASA Headquarters

ACRONYM: AGCE
INSTRUMENT TYPE:
SPACECRAFT: Shuttle
CONTRACTOR:
P.I.: W. Fowlis, MSFC

OBJECTIVES

1. To obtain more accurate measurements of baroclinic flow associated with the earth's atmosphere to aid in predicting general circulation.
2. To understand the major forces on the earth's general atmosphere circulation.

DESCRIPTION

SUMMARY: In a convection type apparatus, a dielectric fluid will be contained between two concentric and co-rotation spheres. A voltage will be maintained across the spheres. Motions will be driven by a latitudinal temperature gradient applied to the inner sphere, and the outer sphere will be held at a temperature warmer than any inner sphere temperature. These imposed conditions provide the correct essential configurations for the forces of buoyancy and rotation which drive the general circulation of the atmosphere. With this setup, it is planned to make flow measurements by photographing the movement of streaks made in the fluid by exciting a photochromic dye. The thermal structure of the fluid will be measured using a Moire fringe technique. Other similar techniques, such as shadowgraphs and schlieren, are also being examined.

HERITAGE/DERIVATION: Geophysical Fluid Flow Cell

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory, NASA/Goddard Space Flight Center

REFERENCES

1. Atmospheric General Circulation Experiment, W.W. Fowlis, G.H. Fichtl, J. Guida, MSF, June 1978 in response to PSTA AMPA-TIB.

POTENTIAL DERIVED PARAMETERS

1. General circulation of the atmosphere
2. Baroclinic flow associated with earth's atmosphere
3. Momentum and energy transports of instabilities
4. Polar and equatorial circulations.

ATMOSPHERIC TRACE MOLECULES OBSERVED BY SPECTROSCOPY

IDENTIFICATION

DISCIPLINE: Environmental Observations	ACRONYM: ATMOS
STATUS: Future Flight Missions	INSTRUMENT TYPE: Interferometer
NASA TECH. OFFICER: J. Talbot	SPACECRAFT: Spacelab-3
LOCATION: NASA Headquarters	CONTRACTOR: Jet Propulsion Laboratory
	P.I.: B. Farmer, L.L. Simmons

OBJECTIVES

1. Identify and measure on a global scale the volume mixing ratios to levels of 10^{-12} of known and newly discovered molecular species.
2. Determine vertical profiles of concentration of the trace constituents to a height resolution of 2 km or less.
3. Clarify the nature of the stratosphere infrared spectral background to optimize the design of future instrumentation to monitor specific species.

DESCRIPTION

SUMMARY: The ATMOS instrument views the Sun through the stratosphere and measures the spectral absorption of solar energy. Each data-taking run is initiated prior to the Sun emerging from or disappearing behind the Earth. Data from the instrument for these sunrise and sunset limb encounters are interferograms that, when processed on the ground, provide absorption spectra for scientific analysis.

The instrument consists of the optical sensor and the electronics package. The Sun tracker automatically locks onto the Sun and corrects for any orientation change within predetermined limits. The energy from the Sun tracker is directed into the optical system and is collected by an infrared detector. The detector signal is amplified and sent to the electronics. These data in conjunction with engineering and housekeeping data are converted into a serial PCM bit stream in a format compatible with the Spacelab high-rate multiplexer.

REFERENCES

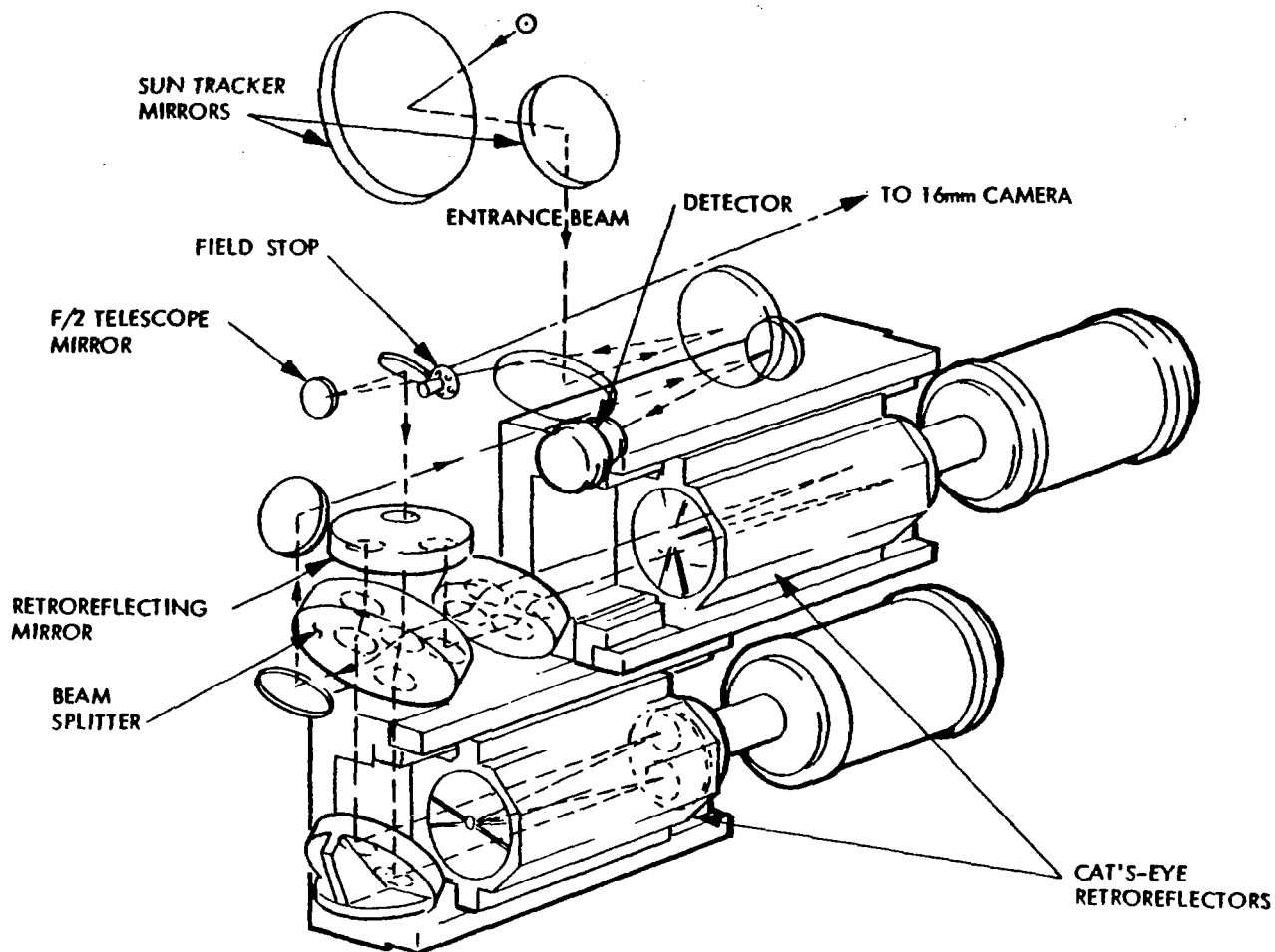
1. Spacelab Mission Experiment Description, MSFC, May 1978.
2. Spacelab-3 Mission Investigators Working Group Report, May 1980.

SYSTEM CHARACTERISTICS

Size: 1.5 m³
Mass: 250 kg
Power: 135 Watts
Data Rate: 16 kbps

ATMOSPHERIC TRACE MOLECULES OBSERVED BY SPECTROSCOPY (ATMOS) (cont.)

FUNCTIONAL DIAGRAM



ATMOS: Interferometer Optical Path

MEASUREMENTS

Measures spectral absorption of solar energy.

Range: 2-16 microns

Stratospheric Altitude of Measurements: 20 to 80 km

Vertical Resolution: 2 km

POTENTIAL DERIVED PARAMETERS

1. Atmospheric trace species
2. Sources of trace species
3. Flow patterns of species
4. Decay mechanisms
5. Atmospheric radiative, chemical, and dynamic processes.

ATMOSPHERIC X-RAY IMAGING SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: AXIS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS
CONTRACTOR: University of Texas
P.I.: Dr. J. David Winningham

OBJECTIVES

1. To determine the global input of charged-particle energy into the Earth's stratosphere, mesosphere, and thermosphere and the predicted atmospheric responses.

DESCRIPTION

SUMMARY: The AXIS is one of three sensors which make up the Particle Environment Monitor (PEM). The other two sensors are the High Energy Particle Spectrometer (HEPS) and the Medium Energy Particle Spectrometer (MEPS). In addition to this system there will be a central command and data handling package (CDHP) for handling the interface of the PEM with the UARS spacecraft. AXIS will be comprised of four identical units each containing two cadmium telluride (CdTe) solid-state sensor systems. Pulse height analysis of the output pulses from each of the CdTe sensor systems will provide the X-ray spectra. From the X-ray spectra the incident electron spectra can be derived from well-established techniques. Each of the eight telescopes will be mounted at different angles with respect to the nadir with their fields of view contiguous in order to obtain an X-ray image as the spacecraft moves in the orbital plane. Active anticoincidence scintillators in conjunction with passive aluminum and tungsten shielding will be used in AXIS to discriminate against background radiation. Passive cooling by appropriate placement of AXIS on the spacecraft will be used to lower the noise of the CdTe sensors and hence achieve low energy photon measurements.

HERITAGE/DERIVATION: AXIS is based heavily on the Lockheed GEMS (Gamma Ray Environment Monitor System) instrumentation in the ARPA-301 payload to be flown on the USAF P78-1 satellite in 1979.

DATA

DATA ARCHIVES LOCATION:

PERIOD OF OPERATION:

REFERENCES

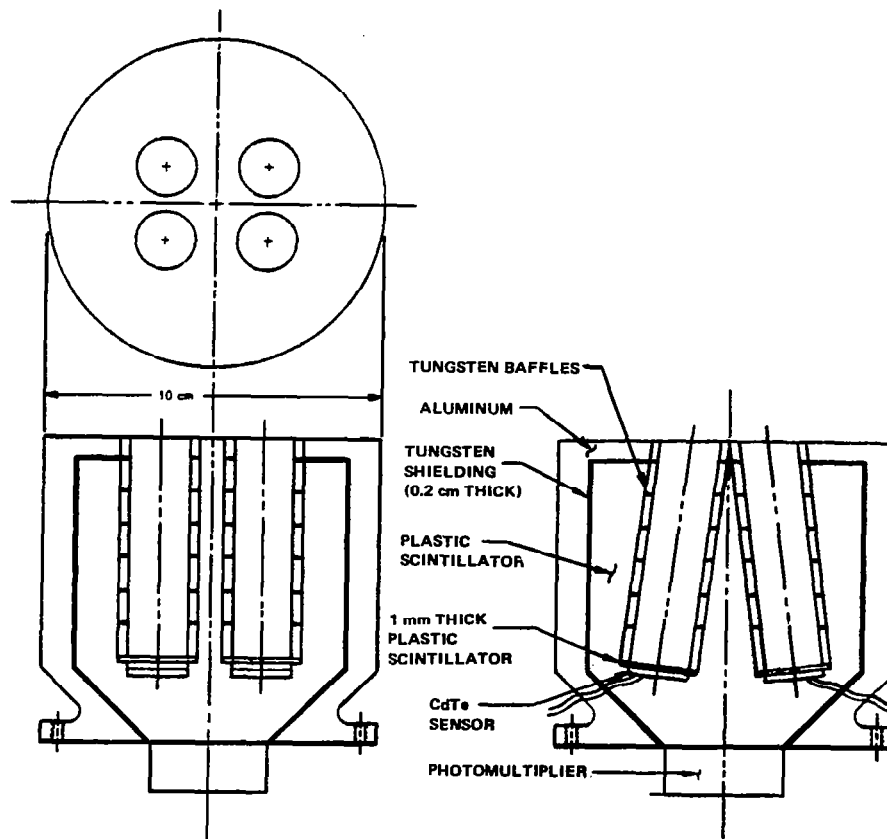
1. UARS Proposal, Particle Environment Monitor, University of Texas, December 1978.

SYSTEM CHARACTERISTICS

Mass: 14 kg
Power: 17.2 W
Data rate: 832 bps
Energy channels: 6
Dimensions: 21.0 x 11.4 x 12.1 cm
Temperature range: -20°C to +35°C. 0°C desired.

ATMOSPHERIC X-RAY IMAGING SPECTROMETER (AXIS)

FUNCTIONAL DIAGRAM



Atmospheric X-Ray Imaging Spectrometer Schematic Diagram

MEASUREMENTS

Measures the bremsstrahlung X-rays produced in the atmosphere by precipitating electrons.

Field of View: 15° each detector

Resolution: One spectral image per orbit.

Temporal X-rays from 6 keV to 150 keV.

POTENTIAL DERIVED PARAMETERS

1. Total intensities and energy spectra of electrons impinging on the atmosphere.
2. Role of particle precipitation in atmosphere on a global scale.

BACKSCATTER ULTRAVIOLET SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Mission
NASA TECH. OFFICER: A. J. Krueger
LOCATION: NASA/Goddard Space Flight Center

ACRONYM: BUV
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-4
CONTRACTOR: Beckman Inst.
P.I.: D. F. Heath, NASA/GSFC

OBJECTIVES

1. To monitor the vertical distribution and total amount of atmospheric ozone and global scale by measuring the intensity of ultraviolet radiation backscattered by the Earth/atmosphere system during day and night in the 2500 to 3400-Å spectral band.

DESCRIPTION

SUMMARY: The primary instrumentation consisted of a double monochromator containing all reflective optics and a photomultiplier detector. The double monochromator was composed of two fastie-ebert-type monochromators in tandem. Each monochromator had a 64- by 64-mm grating with 2400 lines per mm. Light from a 0.05-sr solid angle (subtending approximately a 222-km-square area on the Earth's surface from a satellite height of approximately 1100 km) entered the nadir-pointing instrument through a depolarizing filter. A motor-driven cam step rotated the gratings to monitor the intensity of 12 ozone absorption wavelengths. The detector was a photomultiplier tube. For background readings, a filter photometer measured the reflected ultraviolet radiation in an ozone-free absorption area near 3800 Å. Signals from both units were read by separate range-switching electrometers with seven ranges. The BUUV experiment cycle required 6144 sec. each cycle, in turn, was divided into 192 BUUV frames of 32 sec. duration. The monochromator measured the intensity of the ultraviolet radiation in each of the 12 wavelength bands while the photometer measured the ultraviolet intensity in a single wavelength band. The dwell time at each of the 12 wavelength bands while the photometer measured the ultraviolet intensity measurements were taken at 400-ms intervals in addition to an integrated pulse count measurement of the ultraviolet intensity and energetic particle flux. Once each orbit, the field-of-view was changed to monitor the sun or moon directly. The measurement range of the signal current was from 0.2 to 3000 microamps. The vertical distribution of ozone was obtained by mathematical inversion techniques.

DATA

DATA PRODUCTS:

Data Set: Derived Total Ozone Content vs. Earth Location on Microfilm

Film: 23 reels of microfilm of Total Ozone Content.

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: April 1970 - December 1971

REFERENCES

1. NIMBUS IV Users Guide, GSFC, March 1970.
2. National Space Science Data Center computer printout, 1980.

BACKSCATTER ULTRAVIOLET SPECTROMETER (BUV)

SYSTEM CHARACTERISTICS

Precision and Accuracy: wavelength to 0.5Å; intensity to 2%

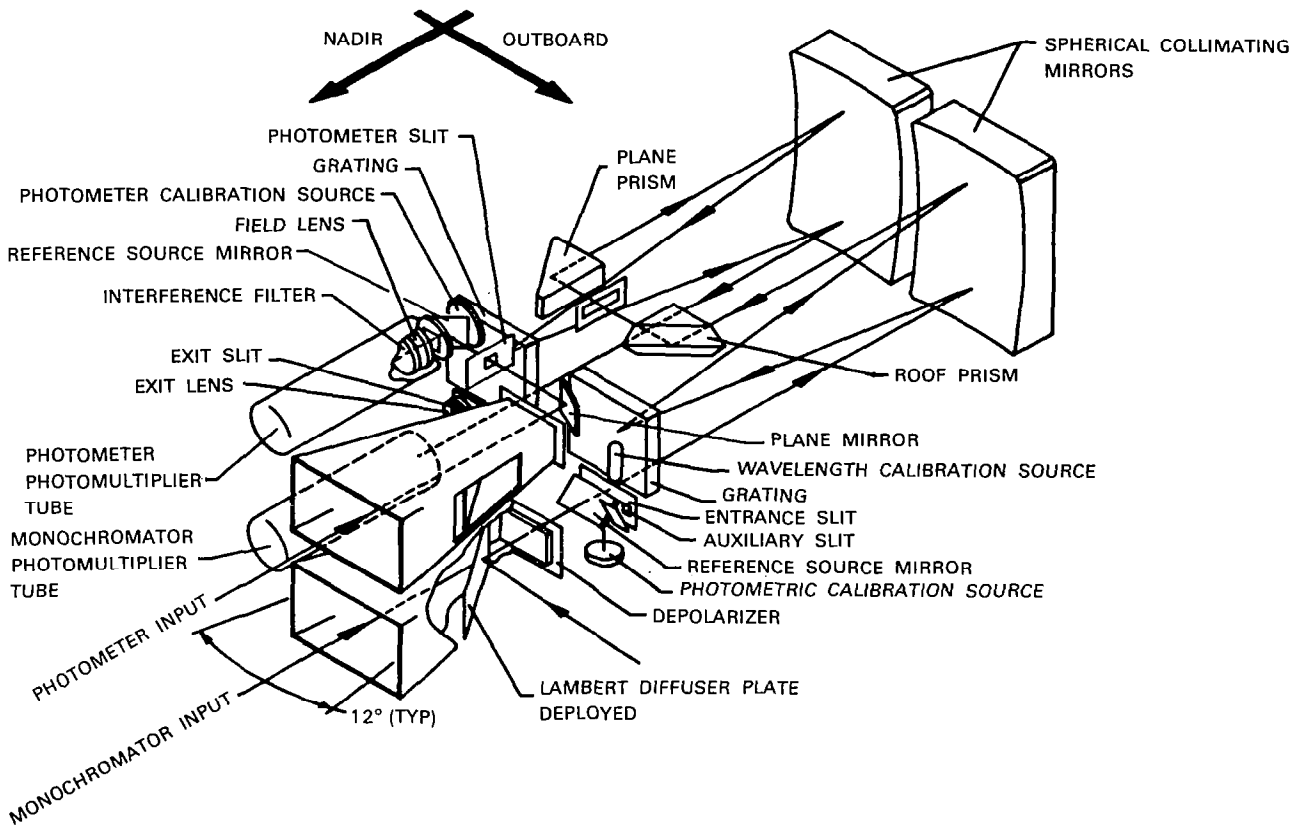
Components: spectrometer, photometer, electronics

Weight: 32 lb

Volume: 0.78 cu. ft.

Avg. Power: 7 Watts

FUNCTIONAL DIAGRAM



Optical Diagram of the BUV Photometer and Monochromator

BACKSCATTER ULTRAVIOLET SPECTROMETER (BUV)

MEASUREMENTS

Measure backscattered ultraviolet radiation.

Measurement Range: 1. Ozone distribution above 30 km at wavelengths less than 3000Å.
2. Total ozone amount at wavelengths longer than 3000Å.
3. Ozone distribution below 30 km from longer wavelengths.

Spectral Range: 2500 to 3400 Å

Spectral Bands:

2555Å

2735Å

2830Å

2876Å

2922Å

2975Å

3019Å

3058Å

3125Å

3175Å

3312Å

3398Å

Field-of-View: 13°

Spatial Resolution: 126 nm diameter from 600 nm altitude.

POTENTIAL DERIVED PARAMETERS

1. Vertical distribution and total amount of ozone.

BOUNDARY LAYER LIDAR SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Development
NASA TECH. OFFICER: J. Spinhirne
LOCATION: Goddard Space Flight Center

ACRONYM: BLLS
INSTRUMENT TYPE: LIDAR
SPACECRAFT: A/C
CONTRACTOR:
P.I.: S. Melfi, GSFC

OBJECTIVES

1. To make synoptic and mesoscale observations of the planetary boundary layer (PBL).
2. To observe the thickness and structure of the PBL entrainment zone.
3. To establish utility of boundary layer height observations by lidar.

The PBL tends to be a well mixed region of the atmosphere that has a relatively high concentration of aerosols. Above the PBL the aerosol concentration tends to drop markedly. By using aerosol backscatter, one can therefore detect the surface of the PBL and its structure.

DESCRIPTION

SUMMARY: The LIDAR will be an aircraft-borne, nadir pointing system observing aerosol backscatter with approximately 20m horizontal and 20m vertical resolution. The system will be a modification of a GSFC airborne lidar by adding a high repetition rate Nd-YAG laser and a 1.06 micron detector. The data will be recorded on magnetic tape; then processed to allow reconstruction of a vertical slice of the PBL using gray scales.

HERITAGE/DERIVATION: GSFC Cloud Lidar System

DATA

DATA ARCHIVES LOCATION: Goddard Space Flight Center
PERIOD OF OPERATION: Scheduled first flight - Late FY82.

REFERENCES

1. RTOP 146-30-02-11.

CLOUD LIDAR SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Flight Mission
NASA TECH. OFFICER: Louis Caudill
LOCATION: Goddard Space Flight Center

ACRONYM: CLS
INSTRUMENT TYPE: LIDAR
SPACECRAFT: A/C
CONTRACTOR:
P.I.: Mark Hansen and James Spinhirne, GSFC

OBJECTIVES

1. To measure cloud top parameters. These parameters include cloud top height, water phase, and backscatter cross section. These measurements are subsequently used in the analysis of severe storm and cloud structure and as truth measurements for passive instruments.

DESCRIPTION

SUMMARY: The CLS is a dual frequency monostatic lidar with one wavelength in the visible (.53 micron) and one in the near infrared (1.06 micron). The system has been flown on four separate flight series in the nose of the WB-57F aircraft. On these flights it operated looking downward from a nominal 19 km altitude. The laser fires at 3 Hz which corresponds to 70 meter resolution in the horizontal. The vertical resolution is approximately 10 meters due to the digitization rate. A seven-inch telescope detects the return signal. The 0.53 micron return is split into its two orthogonal polarization components for water phase analysis. The 1.06 micron signal is an independent channel using a photodiode instead of PMTs and supplies correlative data on backscatter. The entire return signal from the aircraft to the surface is digitized and stored on an analog flight recorder tape at 200 kHz. Subsequent data reduction is performed at GSFC.

DATA

DATA PRODUCTS:

1. Cloud top ranges
2. Cloud top backscatter magnitude
3. Cloud top backscatter depolarization
4. Cloud structure images

DATA ARCHIVES LOCATION: Goddard Space Flight Center
PERIOD OF OPERATION: First flown, 1979.

REFERENCES

1. RTOP 146-10-03-15, GSFC, 1981.
2. 10th International Laser Radar Conference, Abstracts 1980.

CLOUD TOP SCANNER

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Development
NASA TECH. OFFICER:
LOCATION: NASA Headquarters

ACRONYM: CTS
INSTRUMENT TYPE: Radiometer
SPACECRAFT: A/C
CONTRACTOR:
P.I.: Robert Curran, K. Brown, GSFC

OBJECTIVES

1. To measure cloud parameters such as cloud and surface radiance.
2. To determine cloud amounts, types and top heights.
3. To determine water vapor content of upper troposphere and cloud top ascent rates.

DESCRIPTION

SUMMARY: The CTS is a 3 channel scanning radiometer developed by GSFC and flown on the NASA WB 57 aircraft.

The CTS is a scanning radiometer with an instantaneous field of 0.1 km and a swath of 63 km when flown at 18 km altitude. There are 3 channels: a visual channel, 0.5 to 0.7 micron, measures albedo; the 6.5 to 7.0 microns channel, senses upper tropospheric moisture; and 10.5 to 12.5 microns infrared channel, measures surface radiance, either from clouds or the terrestrial background.

The CTS was flown on the first operational flights in support of SESAME in June, 1979. Data from that mission characterized severe storm cloud top features. In particular, results from the June 7th flight determined cloud top ascent rates and top temperatures with unprecedented horizontal resolution.

REFERENCES

1. RTOP 146-10-03-GSFC, 1981
2. RTOP 146-50-02-GSFC, 1981

POTENTIAL DERIVED PARAMETERS

1. Cloud and surface radiance.
2. Water vapor content.

COASTAL ZONE COLOR SCANNER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: Carder
LOCATION: NASA Headquarters

ACRONYM: CZCS
INSTRUMENT TYPE: VIS/IR Spectroradiometer
SPACECRAFT: NIMBUS-7
CONTRACTOR: Ball Brothers
P.I.: W. Hovis, NOAA

OBJECTIVES

1. To map chlorophyll concentration in water, sediment distribution, gelbstoffe concentrations as a salinity indicator.
2. Temperature of coastal waters and ocean currents.

DESCRIPTION

SUMMARY: The CZCS is a conventional six-channel scanning radiometer utilizing a rotating plane mirror at a 45° angle to the optic axis of a Cassegrain telescope. The rotating mirror scans 360°, however, only ±40° of data centered on the spacecraft Nadir is collected for ocean color measurements. During the rest of the scan, the instrument acquires a view of deep space and of internal instrument sources for calibration of the various channels. The radiation collected by the telescope is divided into two portions by a dichroic beam splitter. One portion is transmitted to a field stop that is also the entrance aperture of a small polychromator. The radiant energy entering the polychromator is disbursed and reimaged in five wavelengths on five silicon detectors in the focal plane of the polychromator. The portion of the beam reflected off of the dichroic mirror is directed to a cooled mercury cadmium telluride detector sensing in the 10.5 to 12.5 microns region. The CZCS utilizes a radiative cooler that cools the mercury cadmium telluride detector to approximately 120°K during spacecraft flight.

HERITAGE/DERIVATION: Similar to NIMBUS-5 Surface Composition Mapping Radiometer (SCMR).

DATA

DATA PRODUCTS:

1. CRCST (Calibrated Radiance, Pigment, Diffuse Attenuation Coefficient and Temperature Tape)
2. CAT (Catalog Tape)
3. Film (241 mm by 341 mm (9.5 inch) black and white image stock).
4. Data available from CZCS Data Catalog and the Satellite Data User's Bulletin, June 1979.

DATA ARCHIVES LOCATION: Satellite Data Services Branch, Environmental Data Information Services, National Oceanographic & Atmospheric Administration.

REFERENCES

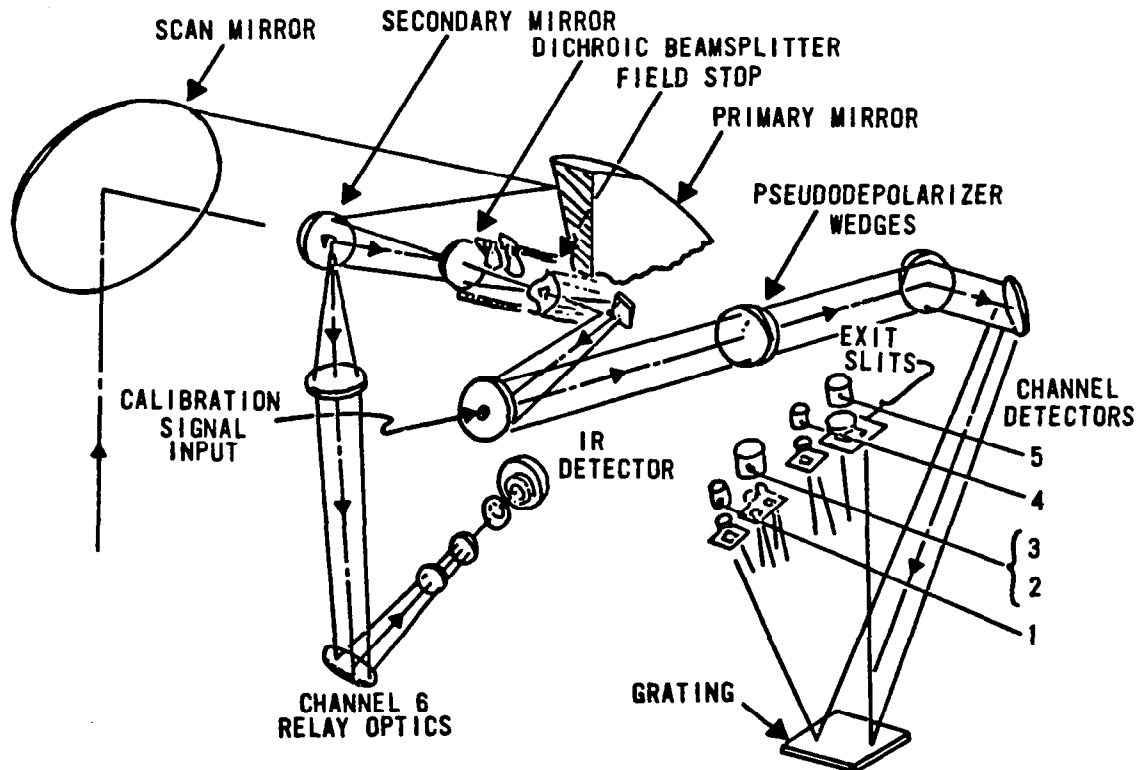
1. The NIMBUS-7 User's Guide, NASA/GSFC, August 1978.
2. National Space Science Data Center computer printout, 1980.

COASTAL ZONE COLOR SCANNER (CZCS)

SYSTEM CHARACTERISTICS

Performance Parameters	Channels					
	1	2	3	4	5	6
Center Wavelength λ Micrometers	0.443 (blue)	0.520 (green)	0.550 (yellow)	0.670 (red)	0.750 (far red)	11.5 (infrared)
Spectral Bandwidth $\Delta\lambda$ Micrometers	0.433 – 0.453	0.510 – 0.530	0.540 – 0.560	0.660 – 0.680	0.700 – 0.800	10.5 – 12.5
Instantaneous Field of View (IFOV)	← 0.865 x 0.865 Milliradians (0.825 x 0.825 km at sea level) →					
Co-registration at NADIR	<0.15 Milliradians					
Accuracy of Viewing Position Information at NADIR	<2.0 Milliradians					
Signal to Noise Ratio (min.) at Radiance Input $N < (mW/cm^2 \cdot \text{STER} \cdot \mu m)$	>150 at 5.41	>140 at 3.50	>125 at 2.86	>100 at 1.34	>100 at 10.8	NETD of 0.220°K at 270°K
Consecutive Scan Overlap	25%					
Modulation Transfer Function (MTF)	1 at 150 km target size, 0.35 min. at 0.825 km target size					

FUNCTIONAL DIAGRAM



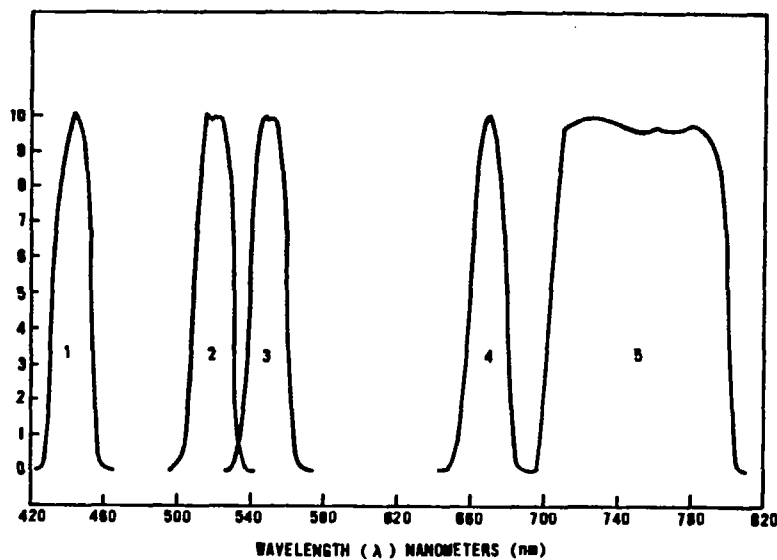
Coastal Zone Color Scanner Optical Arrangement

COASTAL ZONE COLOR SCANNER (CZCS)

MEASUREMENTS

Measures reflected radiation from water.

Scan Width: 1566 kilometers
Data Rate Sampling: 39.34 degrees
Ground Resolution: 0.825 kilometer
Channels: 6
Visible: 0.433 to 0.453 micron
0.51 to 0.53 micron
0.54 to 0.56 micron
0.66 to 0.68 micron
0.7 to 0.8 micron
Infrared: 10.5 to 12.5 micron



Coastal Zone Color Scanner
Spectral Response for Channels 1 Through 5

POTENTIAL DERIVED PARAMETERS

1. Determine the specific nature of the contents of water as quantitatively as possible and to carry out such measurements over large areas in short periods of time.
2. Discriminate between organic and inorganic materials in the water.
3. Determine the quantity of these materials in the water sample to the best degree possible, and
4. Attempt identification of organic particulates such as discriminating between various types of red tide organisms.

The specific observations include:

- 1) chlorophyll concentration
- 2) sediment distribution
- 3) gelbstoffe concentrations as a salinity indicator, and
- 4) temperature of coastal waters and the open ocean.

COASTAL ZONE COLOR SCANNER/2

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: D. Broome
LOCATION: NASA Headquarters

ACRONYM: CZCS/2
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NOSS
CONTRACTOR:
P.I.: W. Paroby, GSFC

OBJECTIVES

1. To measure the abundance or density of chlorophyll at or near the sea surface. This will reveal the abundance of phytoplankton or planktonic plants which contain chlorophyll and are at the bottom of the oceanic food chain.
2. To map the location and measure the density of the plankton on a temporal or time scale.
3. To provide information to marine biologists and the fishing industry.
4. To measure sediment in coastal waters, diffuse attenuation coefficient, and the measurement of sea-surface temperature.

DESCRIPTION

SUMMARY: The Coastal Zone Color Scanner (CZCS/2) is the same as one flown on NIMBUS-7 with three additional channels and will monitor chlorophyll concentration and water turbidity distributions. The multispectral imaging coastal zone color scanner is an Earth-scanning nine-channel radiometer using a classical Cassegrain telescope and a wadsworth-type grating spectrometer. All nine detectors observe the same area on the Earth's surface at the same time and differ only in the spectral range that they detect. The CZCS optical system separates the scan scenes into two spectral ranges, the visible (including solar infrared) and the thermal infrared by a dichroic beam splitter. The visible light is depolarized and then dispersed by the diffraction grating. Each of the eight wavelengths or colors is sensed by a separate silicon photodiode detector. Co-registration of the detectors is assured by the use of a single common field stop prior to the spectrometer. The infrared radiance is directed to a photoconductor detector mounted to the inner stage of a radiative cooler. A continuously rotating mirror scans a nominal 1.13-mrad (0.065°) instantaneous field-of-view (IFOV) across the Earth's surface perpendicular to the orbit tract at 8.52 revolutions per second. The spacecraft's orbital velocity provides the other direction. At the orbital altitude of 700 km, this results in an instantaneous view of the Earth's surface of 0.794 sq. km. An unobstructed scan angle of 39.36° on either side of nadir produces a scan width on the ground of 1148 km. The rotation of the earth under the spacecraft allows for total surface coverage in the temperature and polar zones and approximately 80% coverage in the tropics every day.

HERITAGE/DERIVATION: NIMBUS-7 CZCS

REFERENCES

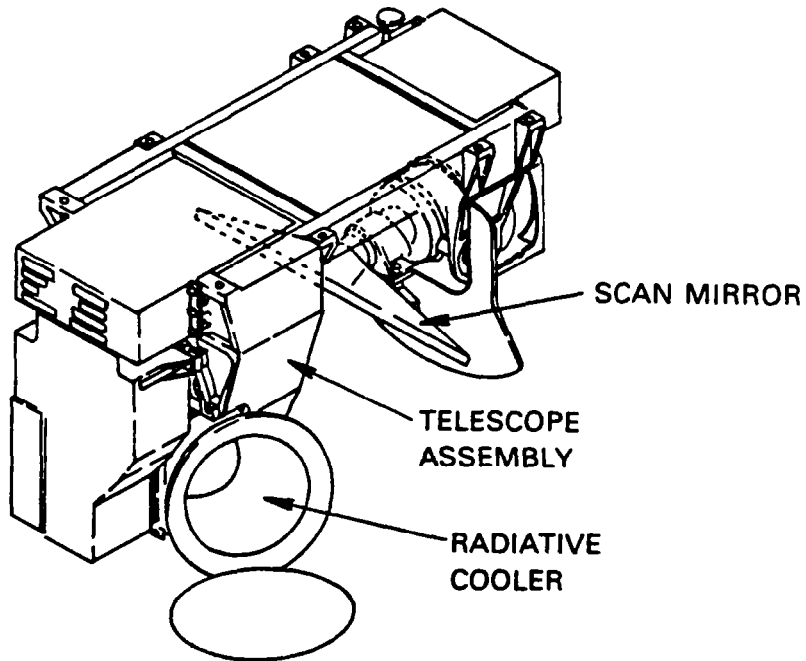
1. National Space Science Data Center computer printout, 1980.

COASTAL ZONE COLOR SCANNER/2 (CZCS/2)

SYSTEM CHARACTERISTICS

Mass (kg): 40
Power requirement (We): 50
Data rate (kbps): 1.8 Mbps
Channels: 0.4, 0.44, 0.52, 0.56, 0.64, 0.685, 0.750, 0.88 microns and 10.5-12.5 microns (IR)
IFOV: 0.794 sq. km at 700 km altitude
Scan width on ground: 1148 km
Detectors: silicon, photodiode
Aperture size: 17.78 cm
Focal length: 71.12 cm
IFOV: 0.865 x 0.865 mrad
Scan rate: 480 rpm

FUNCTIONAL DIAGRAM



Coastal Zone Color Scanner Schematic Diagram

COASTAL ZONE COLOR SCANNER/2 (CZCS/2)

MEASUREMENTS

PREDICTED NOSS SYSTEM CAPABILITY

<u>Sea-Surface Temp.</u>	<u>Sensitivity</u>	<u>Range</u>	<u>Accuracy</u>	<u>Resolution</u>
Local	1.0°C	-2 to 35°C	2.0°C	0.8 km
<u>Water Mass Definition</u>				
Chlorophyll	10%(mg/m ³)	0.1 to 100 mg/m ³	Within factor of 2	0.8 km
Diffuse Attenuation Coefficient (K)	0.01 m ⁻¹	0 to 6 m ⁻¹	Within factor of 2	0.8 km

POTENTIAL DERIVED PARAMETERS

1. Abundance of phytoplankton or planktonic plants which contain chlorophyll and are at the bottom of the oceanic food chain.
2. Detect cold water upwellings which provides the nutrients necessary for plankton "blooms".
3. Sea surface temperature of coastal waters.

CRYOGENIC LIMB ARRAY ETALON SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: CLAES
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS
CONTRACTOR: Lockheed
P.I.: Dr. Aidian Roche

OBJECTIVES

To obtain global synoptic measurements of the concentrations of:

1. Source, radical, and sink species of the ozone destructive nitrogen family (N_2O , NO , NO_2 and HNO_3).
2. Some of the ozone-destructive chlorine family species (CF_2Cl_2 , $CFCl_3$, HCl , ClO , and $ClONO_2$).
3. The minor constituents O_3 , H_2O , CH_4 , and CO_2 .
4. Temperature.

DESCRIPTION

SUMMARY: The CLAES operates over the 3 to 12 micron range. It collects light by the primary mirror and brings it to a first focus where a field stop minimizes light scattering into the spectrometer cavity. In the vicinity of the first focus, a filter wheel sequentially inserts up to eight discrete blocking filters into the narrow optical bundle, each filter designed (in conjunction with the appropriate narrowband etalon) for detection of a specific specie or species in the 3 to 12 micron range. The light is next recollimated by the telescope secondary mirror and is directed by a folding flat through any one of four solid etalons, each one of which can be programmed for a unique tilt scan routine. An achromatized reimaging lens finally brings the light to focus on the detector arrays via a second folding flat.

The focal plane assembly consists of two linear arrays, an 18-element array with open spectral response from 3 to 12 microns designed for high spatial resolution (3 km vertical at the limb) measurements and a 3-element array (15 km vertical resolution) with permanent overlaid filters designed specifically for detection of HCl and O_3 in the 3.5 micron region.

DATA

DATA PRODUCTS: Tapes of calibrated and actual Earth-limb spectra.

DATA ARCHIVES LOCATION: National Space Science Data Center

PERIOD OF OPERATION: Launch date in Fall 1986.

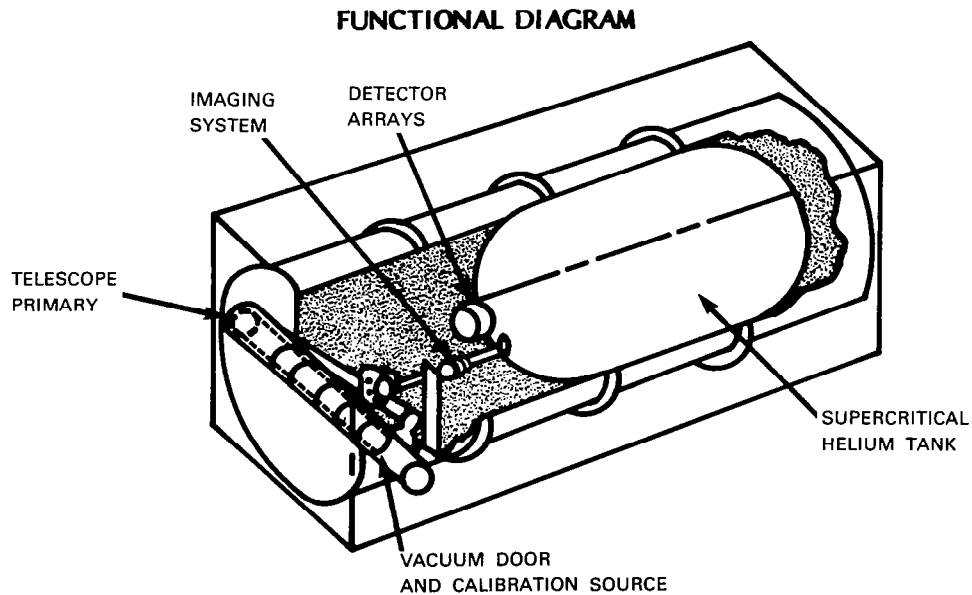
REFERENCES

1. UARS Proposal Altitude Distribution of Atmospheric Minor Species and Temperature, Lockheed Palo Alto Research Laboratory, Utah State University, December 1978.

CRYOGENIC LIMB ARRAY ETALON SPECTROMETER (CLAES)

SYSTEM CHARACTERISTICS

- Telescope
Aperture: 6-in. diameter, f/3
Off-Axis rejection: 10^{-6} at 0.6°
- Spectrometer
Aperture: 2 in.
Number of etalons: 4
Number of blocking filters: 8
Optics throughput: 0.2
NESR: 3×10^{-12} W/cm²-sr-cm⁻¹ at 1000 cm⁻¹
Integration time: 0.1 to 5 s (selectable)
- Detectors
Type: Gallium doped silicon
Number: Main array, 18
HCL array, 3
- Cryogenics
Type: Supercritical Helium
Temperatures: Baffles, 130°K
Telescope, 130°K
Spectrometer, 55°K
Detectors, 10°K
Orbit design lifetime: 2 years
- System
Volume: 1.2-m diam. x 2.5-m long
Weight: 400 kg
Power: 20-W
Data rate: 3 Kbps average



Cryogenic Limb Array Etalon Spectrometer Schematic Diagram

CRYOGENIC LIMB ARRAY ETALON SPECTROMETER (CLAES)

MEASUREMENTS

Measure limb emission spectra.

Spectral Range: 3.5 to 12 microns

Bands: 3.5-4 microns

5-6.5 microns

7-8.8 microns

10-12 microns

Spectral Resolution: 0.5 to 0.25 cm^{-1}

Vertical Coverage: 10-60 km

Vertical Resolution: 2 km

POTENTIAL DERIVED PARAMETERS

Obtain concentrations of sources, radical and sink of the following species:

HCl, O₃, NO, NO₂, N₂O, ClONO₂, CF₂Cl₂, HNO₃, CO₂, ClO, H₂O, CH₄

CRYOGENIC LIMB SCANNING INTERFEROMETER RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: R. Seals
LOCATION: NASA Headquarters

ACRONYM: CLIR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: Shuttle
CONTRACTOR:
P.I.: R. Drummond

OBJECTIVES

1. To obtain data on global trace gas distribution and mixing ratios versus altitude, longitude and latitude.

DESCRIPTION

SUMMARY: The cryogenic limb scanning interferometer radiometer (CLIR) is an instrument assembly combining a Michelson interferometer spectrometer and Ebert multichannel radiometer with 21 narrow and medium band channels and four wide band channels. Both instruments share the same narrow field-of-view (4 arc min) through a baffled off-axis spherical telescope of low scatter and high off-axis rejection. Both instruments can operate simultaneously. The cooling of the telescope, instruments, and optics will limit the noise level from the instrument to the detector-preamplifier noise level. Hence quantum fluctuations in the source and/or background radiation become the limiting factor to attaining near maximum sensitivity. The basic mode of operation will be limb scanning with an altitude resolution of 2 km from Shuttle orbit.

REFERENCES

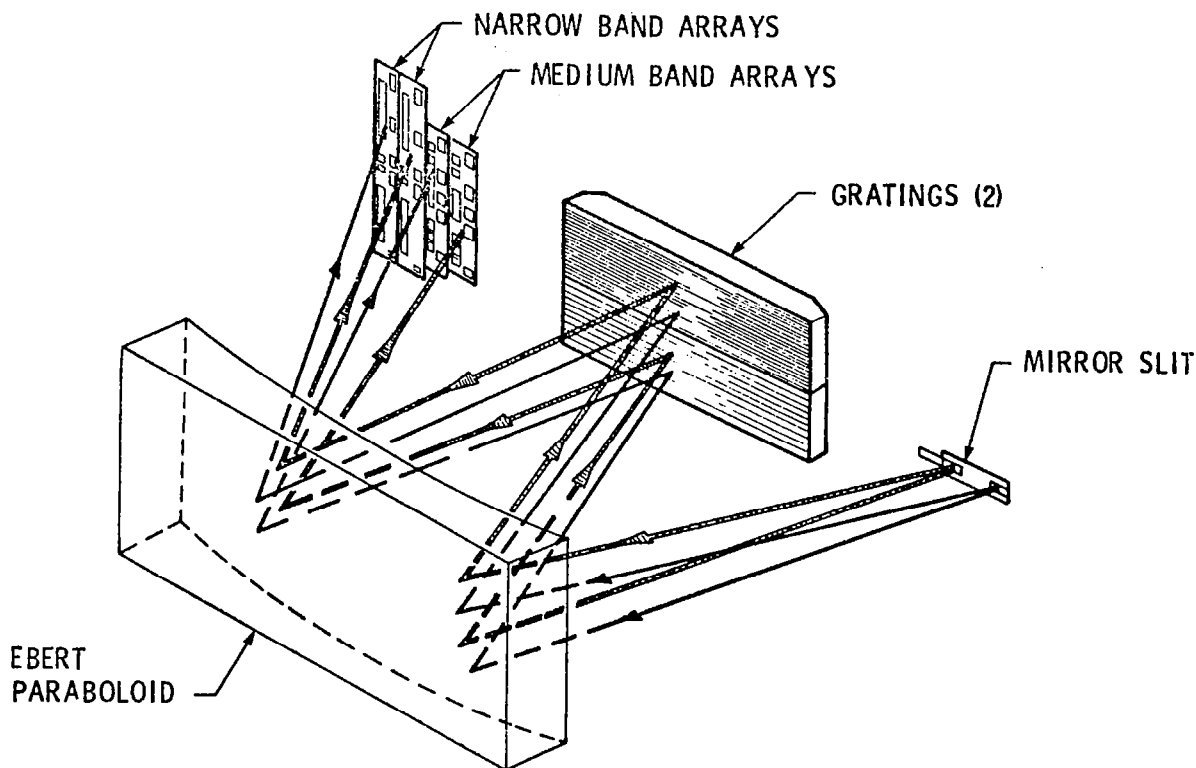
1. Cryogenic Limb-Scanning Interferometer and Radiometer (CLIR) NASA/Goddard Space Flight Center, April 28, 1978.
2. STS Payload Data Collection and Accommodations Study, MSFC, August 1978.

SYSTEM CHARACTERISTICS

Physical Size (m): 4.8 x 1.4
Mass (kg): 780
Power Requirement (We): 120
Data Rate: 524 kbps

CRYOGENIC LIMB SCANNING INTERFEROMETER RADIOMETER (CLIR)

FUNCTIONAL DIAGRAM



Cryogenic Limb Scanning Interferometer Radiometer Dual Grating Radiometer System

MEASUREMENTS

Measures emissions from trace constituents in stratosphere, troposphere, and lower thermosphere.

IFOV: 1.0 vertical x 2.0 horizontal mrad

Resolution: 0.1 cm^{-1} to 1.0 cm^{-1}

Dynamic Range: 10^5

Sensitivity: $10^{-12} \text{ W/cm}^2/\text{sr/cm}^{-1}$ at 400 cm^{-1}

Spectral Range: 2.5 - 25 microns

Channels: 25

POTENTIAL DERIVED PARAMETERS

1. Atmospheric temperature structure
2. Atmospheric chemistry, dynamics and energy
3. Particle density
4. Solar terrestrial coupling.

CRYOGENIC UPPER ATMOSPHERE LIMB EMISSION RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: CULER
INSTRUMENT TYPE: Radiometer
SPACECRAFT: UARS
CONTRACTOR: NCAR
P.I.: J.C. Gille

OBJECTIVES

1. To determine temperature and distribution of a large number of gases from the tropopause to the lower thermosphere.

DESCRIPTION

SUMMARY: The CULER instrument is a cryogenically cooled telescope of 15 cm aperture with a limb scanning mirror feeding a 24-channel radiometer and a circular variable filter (CVF) spectrometer. The fixed radiometric channels, selected by grating-filter combinations between $370\text{-}7000\text{ cm}^{-1}$, are tailored to specific measurements, such as temperature sounding, concentration of predetermined chemical species, or emissions from specific excitation mechanisms. The spectrally selective CVF has 1% resolution between $660\text{-}5000\text{ cm}^{-1}$, and is used to pick out emissions from trace species in the presence of stronger interfering bands, to determine rotational temperatures in non-LTE regions, and to search for unexpected emissions.

The extrinsic silicon detectors are maintained at their 10K operating temperature by a solid hydrogen cryogen, which also cools the entire optical system to reduce the background noise. This results in noise equivalent radiances in the range $2\text{-}10 \times 10^{12}\text{ watts cm}^{-2}\text{ ster}^{-1}$, allowing accurate measurements in most channels up to or above 100 km. The fields-of-view for radiometer and CVF are 2 km x 11 km at the horizon.

HERITAGE/DERIVATION: NIMBUS-6 LRIR, NIMBUS-7 LIMS

DATA

DATA PRODUCTS: The data will go into the UARS data bank according to the UARS schedule. It will be available to go to the NSSDC on a schedule agreed upon by the UARS team for all UARS data.

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

1. UARS Proposal, the Cryogenic Upper Atmosphere Limb Emission Radiometer, National Center for Atmospheric Research, December 1978.

CRYOGENIC UPPER ATMOSPHERE LIMB EMISSION RADIOMETER (CULER)

SYSTEM CHARACTERISTICS

Spectrometer speed: f/4.0

Vertical temperature: above 120 km

Length: 2.84 m

Diameter: 1.48 m

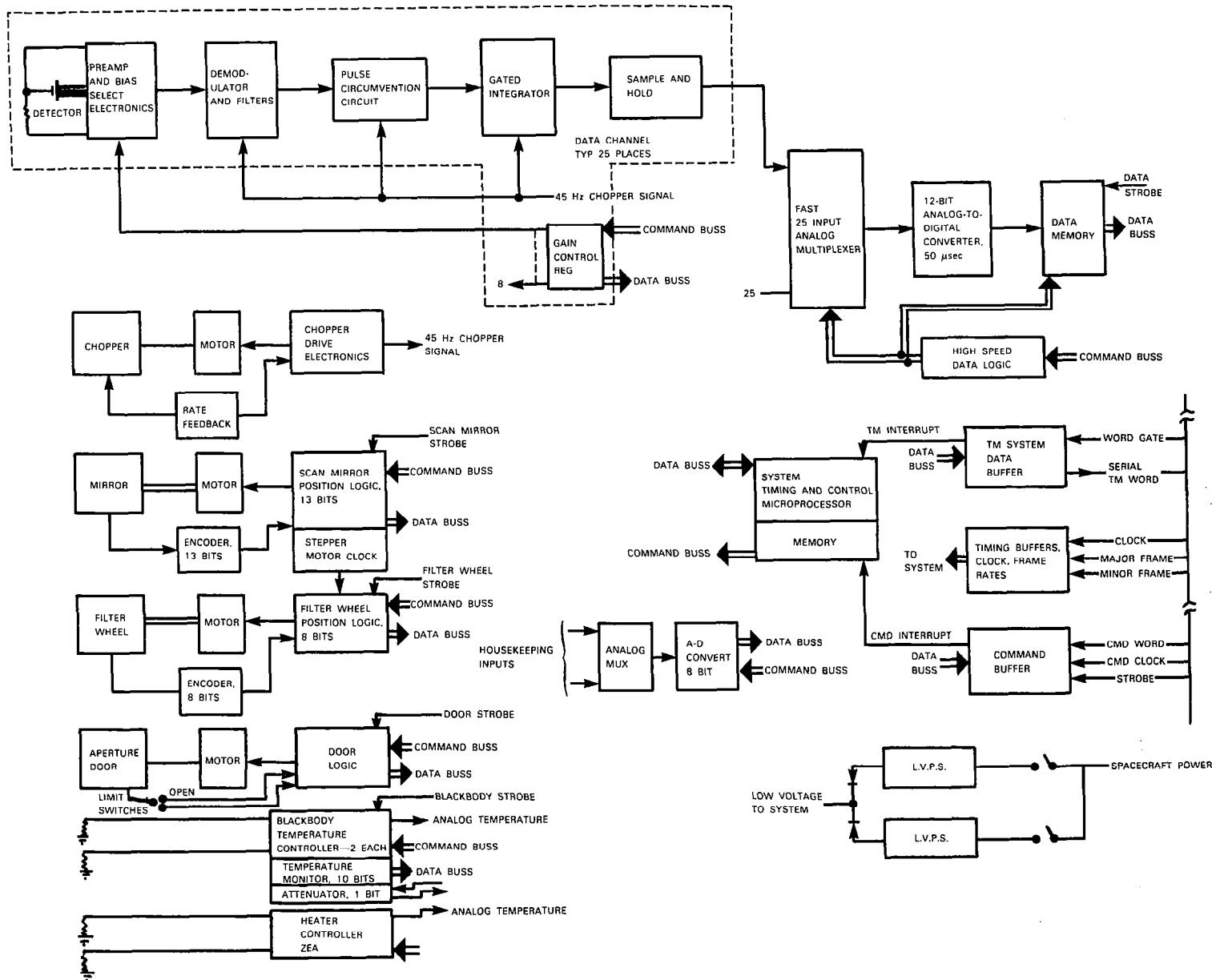
Mass: 529kg (decreasing by 91 kg over 2 year life of cryogen)

Power: 30 W average; 45 W peak

Data rate: 20 kbps

Scan rate: 50 km/sec

FUNCTIONAL DIAGRAM



Cryogenic Upper Atmosphere Limb Emission Radiometer Block Diagram

CRYOGENIC UPPER ATMOSPHERE LIMB EMISSION RADIOMETER (CULER)

MEASUREMENTS

Measure infrared emissions from a number of thermally and non-thermally excited gases from the Earth's limb.

Spectrometer FOV (two each) .75mr x 4.0mr

Altitude measurement range: 50-120 km

Channels: 25

Bands:

<u>Band</u>	<u>Species</u>	<u>Band Limits cm⁻¹</u>
1	OH	6500-7000
2	O ₂	6250-6410
3	OH	5500-6250
4	OH	4440-5400
5	OH	3550-3750
6	CO ₂	3450-3500
7	OH, NO	3200-3413
8	CO ₂	2300-2390
9	CO	2142-2170
10	NO	1850-1960
11	NO ₂	1579-1587
12	H ₂ O	1400-1560
13	CH ₄	1210-1250
14	N ₂ O	1180-1210
15	O ₃	1000-1140
16	CO ₂ , O ₃	920-980
17	F12	915-935
18	HNO ₃	870-905
19	Window	820-900
20	F11	835-860
21	CO ₂	635-680
22	CO ₂	580-705
23	N ₂ O	588-593
24	H ₂ O	425-370
25	Variable	5000-666

POTENTIAL DERIVED PARAMETERS

1. Temperature soundings in the tropopause and lower thermosphere
2. Concentration of chemical species in troposphere and lower thermosphere
3. Ozone concentrations
4. Thermosphere energy budget
5. Airglow and energy balance.

DAY/NIGHT CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. R. Burke
LOCATION: NASA Headquarters

ACRONYM: DNCS
INSTRUMENT TYPE: Imager,
2-inch Visible Image Orthicon
SPACECRAFT: ATS-4
CONTRACTOR: RCA
P.I.: J. C. Moody, GSFC

OBJECTIVES

1. To extend viewing of Earth's cloud cover on a regular basis to include nighttime imaging.
2. To examine overall feasibility of a high resolution continuous surveillance camera system operating from synchronous altitude.

DESCRIPTION

SUMMARY: In the Day/Night Camera System, the incoming light is reflected from the primary mirror, collected at the objective lens and passed through a beam-splitter. It is then simultaneously incident on a photomultiplier tube (PMT) and the image orthicon tube. A retractable sunshade is available to prevent stray light from entering the camera's field-of-view while imaging nighttime scenes. The image orthicon saturates under nominal full moon conditions. When the scene illumination is above this level, attenuation, in the form of two tapered, double cycle, counter rotating neutral density filters, is introduced into the optical path. The PMT generates a signal proportional to the average scene illumination over the area viewed by the camera. The signal from the PMT feeds an automatic light control circuit which varies the filters until the PMT signal reaches the desired value. The optics are steerable by means of ground command. Steps of 0.1° through an angle of plus-minus 12.5° in both pitch and roll are possible. Thus, the camera is able to track areas of meteorological interest knowing the spacecraft attitude and the location of the desired viewing area. Full Earth coverage can be achieved by taking a series of overlapping pictures.

DATA

PERIOD OF OPERATION: August 10, 1968 - October 17, 1968 (Failed to reach orbit)

REFERENCES

1. Ostrow, H. and Weinstein, O.: A Review of a Decade of Space Camera Systems Development for Meteorology, Presented at Society of Photo-Optical Instrumentation Engineers 13th Annual Technical Symposium, August 1968.
2. Shaw, D. B., The Image Orthicon Camera, Presented at ATS Systems Engineers Training Program, Goddard Space Flight Center, September 1966.

DAY/NIGHT CAMERA SYSTEM (DNCS)

SYSTEM CHARACTERISTICS

Weight: 56 lbs
Avg. Power: 21 Watts
Peak Power: 48 Watts
Frequency of Observation: continuous
Data Recovery: realtime recovery
Precision Accuracy: 800 lines horizontal resolution,
620 lines vertical resolution

MEASUREMENTS

Visible light reflected from Earth and cloud cover.

Spectral Range: 0.3 to 0.7 microns
Field-of-View: 4.25°

POTENTIAL DERIVED PARAMETERS

1. Day and night imaging of Earth.
2. Cloud cover pictures.

DIFFERENTIAL CORRELATION RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Development

NASA TECH. OFFICER:

LOCATION:

ACRONYM: DCR

INSTRUMENT TYPE: Radiometer

SPACECRAFT:

CONTRACTOR:

P.I.: L. Korb, GSFC

OBJECTIVES

1. To measure vertical concentration profiles of tropospheric trace species such as CH₄, CO, NO₂ and non-methane hydrocarbons.

DESCRIPTION

SUMMARY: The DCR is a new pollution monitor being developed at GSFC.

REFERENCES

1. RTOP 146-20-08, GSFC, 1981.

EARTH RADIATION BUDGET

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: ERB
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-6, 7
CONTRACTOR: Eppley Lab
P.I.: A.J. Drummond, Eppley Lab
H. Jacobowitz, NOAA/NESS

OBJECTIVES

1. To ascertain the Earth's radiation budget by measuring incoming solar radiation between 0.2 to >40 microns;
2. To measure outgoing Earth reflected and emitted radiation in the same spectral bands;
3. To provide highly accurate (1% or better) radiation measurements of the Sun and Earth from which the terrestrial radiation budget can be determined on both the synoptic and planetary scales.

DESCRIPTION

SUMMARY: The ERB experiment measured the incoming solar radiation in 10 spectral channels as the satellite orbits over the Antarctic, just before it starts its northward trip on the daylight side of the earth.

Earth-emitted infrared radiation and reflected solar radiation are measured with fixed, wide-angle FOV (approximately 130°) sensors. The four wide-angle channels (11 through 14) instantaneously view the entire earth disc (of 3330 km in radius when viewed from 1112 km) and provide a direct measure of the total terrestrial flux passing through a unit area at the satellite altitude. An integration of these measurements over the entire globe, together with the solar constant observations, provide a measure of the net radiation balance for the earth-atmosphere system. Measurements of the radiation flux reflected in the short wave region (0.2 microns to 5 microns), in addition to those of the total earth radiation flux (0.2 microns to > 50 microns), permit separation of the planetary albedo and long wave flux components of the observed net radiation flux.

An earth flux channel (channel 14) and a solar flux channel (channel 5) measure radiation in the 0.7 microns to 3 microns interval enabling the planetary albedo to be defined for the spectral subregions <0.7 microns and >0.7 microns. These two spectral regions separate the molecular-plus-aerosol contribution from the aerosol-dominant spectral contribution to the total backscattered radiation.

The ERB also obtains measurements of the earth-reflected solar radiation (0.2 microns to 4 microns) with channels 15 through 18 and earth-emitted long wave radiation (4 microns to > 50 microns) with channels 19 through 22. These scanning channels, which have a rectangular FOV of 0.25° x 5.12°, are needed to observe the worldwide radiation budget in sufficient detail for use in synoptic scale numerical weather prediction models.

EARTH RADIATION BUDGET (ERB)

DATA

DATA PRODUCTS:

- Magnetic Tapes
- ERB Map Products on 16 mm Film
- Tabular Listings on 16 mm Film

DATA ARCHIVES LOCATION: NOAA/NESS, National Space Science Data Center
PERIOD OF OPERATION: October 1973

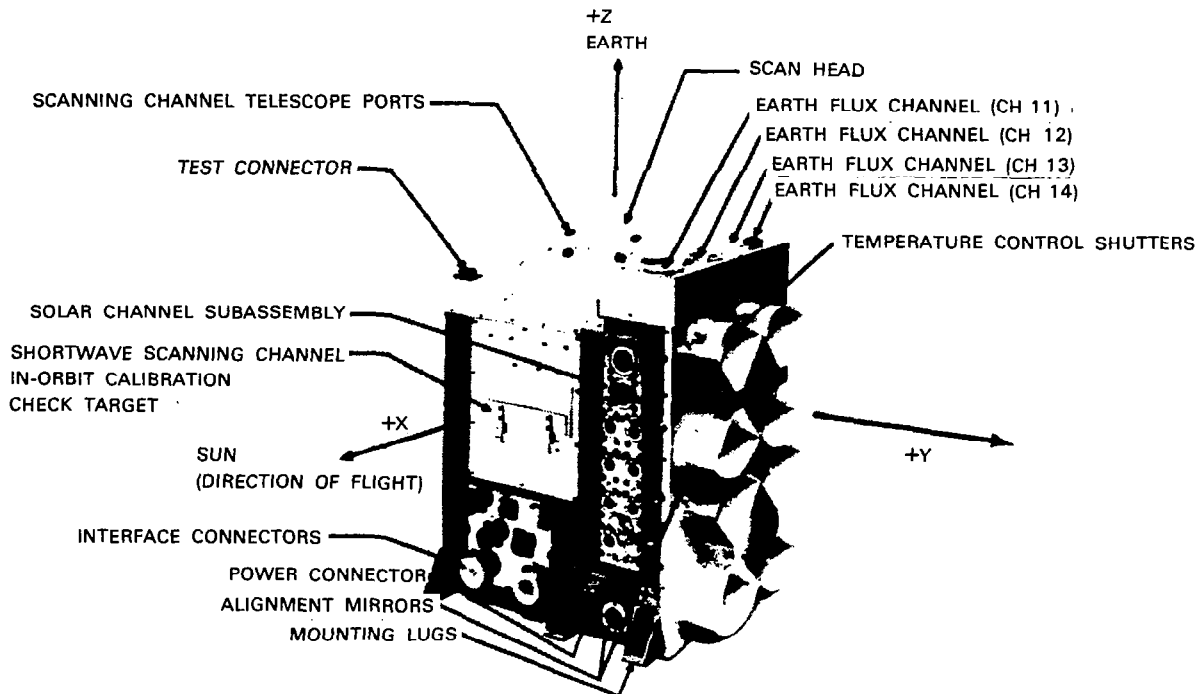
REFERENCES

1. NIMBUS-6,7 User's Guide, Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 56 lbs.
Volume: 2.5 cu. ft.
Avg. power: 30 Watts
Components: radiometer, optics, electronics

FUNCTIONAL DIAGRAM



Earth Radiation Budget Schematic Diagram

EARTH RADIATION BUDGET (ERB)

MEASUREMENTS

Measures incoming solar radiation (solar channels); earth emitted IR radiation and reflected solar radiation (fixed, wide-angle FOV channels); and earth reflected solar radiation and earth emitted long wave radiation (narrow angle FOV channels).

Channels: 10 solar; 4 fixed wide-angle FOVs; 8 narrow-angle FOVs

Bands:

1 - 0.2-5.0 microns	9 - 0.264-0.340 micron
2 - 0.2-5.0 microns	10 - 0.243-0.312 micron
3 - <0.2->50 microns	11 - <0.2 to >50 microns
4 - 0.530-3.0 microns	12 - <0.2 to >50 microns
5 - 0.695-3.0 microns	13 - 0.2 to 5.0 microns
6 - 0.394-0.505 micron	14 - 0.695 to 3.0 microns
7 - 0.345-0.460 micron	15-18 - 0.2 to 5.0 microns
8 - 0.300-0.408 micron	19-22 - 4.5 to 50 microns

POTENTIAL DERIVED PARAMETERS

1. The solar "constant", necessary for earth heat budget computations, and of solar energy in spectral subdivisions in the ultraviolet and visible regions.
2. Earth-emitted infrared radiation and earth-reflected solar radiation. An integration of these measurements over the entire globe, together with the solar constant observations, provide a measure of the net radiation balance for the earth-atmosphere system.
3. The radiance of earth-reflected solar radiation (0.2 to 4.8 microns) with Channels 15 through 18 and earth-emitted long wave radiation (5 to 50 microns). Characteristic angular distribution models are derived for a variety of reflecting surface conditions from a composite of the scanning channel observations of each area. These models are used with the scanning channel observations to specify radiation budgets on a scale of about 500 km.

EARTH RADIATION BUDGET EXPERIMENT

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: D. Diller, T. Anderson
LOCATION: NASA Headquarters, GSFC

ACRONYM: ERBE
INSTRUMENT TYPE: Radiometer
SPACECRAFT: ERBS
CONTRACTOR: Gulton Industries
P.I.: W. Smith, National Oceanographic and Atmospheric Administration

OBJECTIVES

1. To gather the required radiation budget data and apply these data so that we can better understand climate and determine its predictability.

DESCRIPTION

SUMMARY: The Earth Radiation Budget Experiment (ERBE) instrument consists of eight channels distributed within two instrument packages. One instrument package is the Wide and Medium Field of View (W/MFOV) instrument and the other is the Scanner instrument. Conceptual designs for these instrument packages are described in the following sections.

The ERBE W/MFOV instrument contains five channels. Four of these channels are primarily Earth viewing nadir pointing channels; however, they are mounted on a single axis gimbal which, upon command, when coupled with orbital motions, provides the net motions necessary for observing the Sun for periodic calibration. The fifth channel is not gimballed and provides a reference observation of the Sun and measurement of the solar constant periodically throughout the mission. The four gimballed sensors differ mainly in the spatial and spectral scales of their observations when viewing the Earth. Two of the sensors view the entire Earth disc from limb-to-limb and are designated wide field-of-view (WFOV) channels. The baseline concept assumes the detectors are wire-wound thermopiles which have a broadband spectral response of from about 0.2 microns to over 50 microns. The detector of one of the WFOV channels is placed under a Suprasil-W hemispherical dome filter which provides spectral isolation for this channel since the filter cuts off at 5 microns. Hence, one WFOV channel (channel 1) makes broadband or total radiation measurements and the other WFOV channel (channel 2) makes measurements over the shortwave spectral band characterized by the Suprasil-W dome. The other two gimballed sensor channels have a regional scale view of the Earth of about 10° Earth Central Angle (ECA) and are designated medium field of view (MFOV) channels. Their fields of view are approximately equivalent to a Texas sized footprint and, like the WFOV channels, one FMOV channel (channel 4) is placed under a Suprasil-W hemispherical dome to make measurements over the shortwave spectral band while the other MFOV channel (channel 3) measures total radiation. For both WFOV and MFOV, the Earth emitted longwave radiation component is determined by subtracting the shortwave (Earth reflected radiation) channel measurement from the total radiation channel measurement.

The ERBE Scanner instrument is a small spatial resolution (IFOV = 3° diameter), scanning package contains three separate channels. Channel 6 isolates the SW spectral interval (0.2 to 5 μm), channel 7 covers the LW spectral region (5 to 50 microns), and channel 8 provides total radiation (0.2 to 50 microns) to aid in ERB (Nimbus 6 and 7) scanning channels except for the total radiation channel 8. In a conceptual design all three channels are located within a continuously rotating scan drum which scans the boresighted IFOV's sequentially from horizon to horizon, and, for calibration purposes, to a space view and then within the instrument to diffuse reflectors illuminated by the Sun (SW and total channels), or a precision blackbody (LW and total channels).

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

SUMMARY (cont'd)

The scan drum is oriented to perform cross-track scanning (i.e., perpendicular to the satellite ground track). Each channel consists of a two-mirror telescope, field stop, bandpass filter, and pyroelectric detector-preamplifier assembly. The channels are all mounted within a single, temperature-controlled housing and are aligned to view the same Earth area.

HERITAGE/DERIVATION: NIMBUS 6, 7

DATA

DATA PRODUCTS: Tapes of radiation data at various spatial scales suitable for scientific analysis. Monthly averages for spatial scales ranging from global to 250 km regions will be available.

DATA ARCHIVES LOCATION: National Space Science Data Center.

REFERENCES

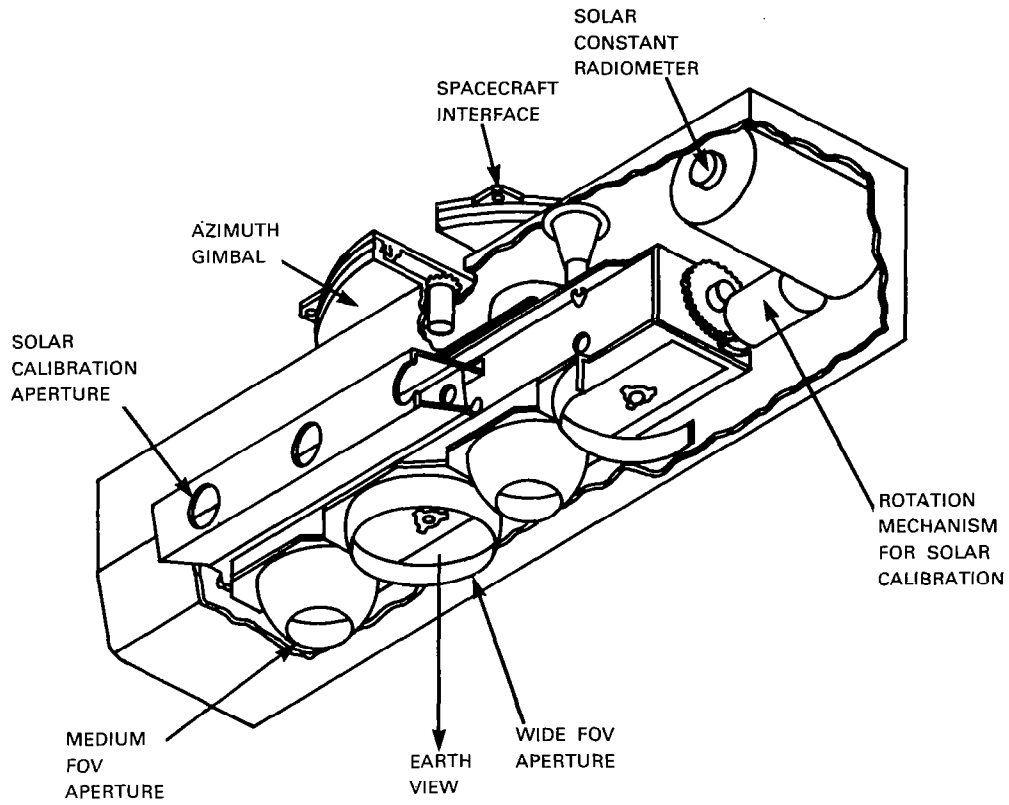
1. Execution Phase Project Plan Earth Radiation Budget Experiment (ERBE), Stratospheric Aerosol and Gas Experiment II (SAGE II), Halogen Occultation Experiment (HALOE), On-Earth Radiation Budget Satellite Experiments, Langley Research Center, February 1979, Appendix B.
2. Goddard Space Flight Center, Nimbus-F Observatory, X-430-7433, 1974.

SYSTEM CHARACTERISTICS

Envelope:	-W/MVOF (46 diameter x 42 height, cm (ERBS) and 57 height, cm (TIROS) -Scanner (36 x 33 x 30 cm) (ERBS) and 36 x 33 x 50 cm (TIROS)
Weight:	-55 kg (M/FOV - 30 kg; Scanner - 25 kg)
Average Power:	-50 watts (M/FOV - 15 watts; Scanner - 35 watts)
Data Rate:	-1120 bps (W/MFOV - 240 bps; Scanner - 880 bps)

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

FUNCTIONAL DIAGRAM



Earth Radiation Budget Experiment Schematic Diagram

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

MEASUREMENTS

Measure incoming and outgoing reflected and emitted radiation. Measure solar constant to 1 percent, the spectral solar irradiance in several spectral bands, the albedo, and the emitted longwave radiation.

Spectral Range: 0.2 - 50+ microns

Channels: 8

Band: 1 - 0.2-50 microns
2 - 0.2-5 microns
3 - 0.2-50 microns
4 - 0.2-5 microns
5 - 0.2-50 microns
6 - 0.2-5 microns
7 - 5.0-50 microns
8 - 0.2-50 microns

Scanner IFOV: 3 degrees

POTENTIAL DERIVED PARAMETERS

1. Analysis of Earth flux data.
2. Investigation of regional heat flux input/output.
3. Investigation of diurnal and longer time variation of radiation budget parameters on different spatial scales.
4. Investigation of equator-to-pole gradients.
5. Analysis of solar constant variation seasonally and geographically.
6. Correlation with other climate parameters available from ERBS or NOAA satellites, i.e., cloudiness, humidity, atmospheric oceanic temperatures, albedo, and aerosols.
7. Validation of models which predict radiation budget variation.
8. Polar heat budgets; oceanic heat budgets.
9. Relationship to stratospheric warmings.
10. Correlation between radiation budget and planetary waves.
11. Verification of radiative calculations and parameterizations.

EARTH TERRAIN CAMERA

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Development
NASA TECH. OFFICER: J. Talbot
LOCATION: NASA Headquarters

ACRONYM: ETC
INSTRUMENT TYPE: Camera
SPACECRAFT: Shuttle-4
CONTRACTOR: JSC
P.I.:

OBJECTIVES

1. To provide high resolution photographs of land areas that can be used for urban and regional planning.
2. The revision of maps with scales of 100,000 to 10,000,000.

DESCRIPTION

SUMMARY: The ETC is tentatively proposed to fly as part of the Shuttle Mission No. 4. It will be rigidly fixed on the pallet. It will be operated from 443 kilometers (239 nautical miles) altitude and 48 degrees inclination and it will point towards the nadir with pointing accuracy nadir ± 2 degrees.

The ETC is a mapping camera and is equipped with a f/4 lens with a focal length of 45.7 centimeters (18 inches). Its field-of-view of 14.2 degrees across flats providing ground coverage of about 111 kilometers (60 nautical miles) square surface coverage. The camera compensates for spacecraft forward motion through programmed camera rotation. Sequence photography rates up to 25 frames per minute are possible, thus providing up to 85% overlap between frames providing stereo photography. Shutter speeds are selectable at 5, 7 and 10 milliseconds with a curtain velocity 292 cm/sec (115 inches/seconds). Photographs of the land areas will be obtained in the summer hemisphere when the Sun elevation angle is greater than 30 degrees, and in the winter hemisphere when the Sun elevation is greater than 20 degrees and cloud coverage of less than 30 percent.

HERITAGE/DERIVATION: Skylab (S 190)

DATA

DATA PRODUCTS: Latent image on photographic film.

Film	Film Type	Wavelength	Wratten Filter No.
S0242	Aerial Color High Resolution	0.4-0.7 microns	Neutral
EK3414 or EK3400	Black and White High Definition Aerial Black and White	0.5-0.7 microns	W-12
EK3443	Aerochrome IR, Color	0.5-0.88 microns	W-12

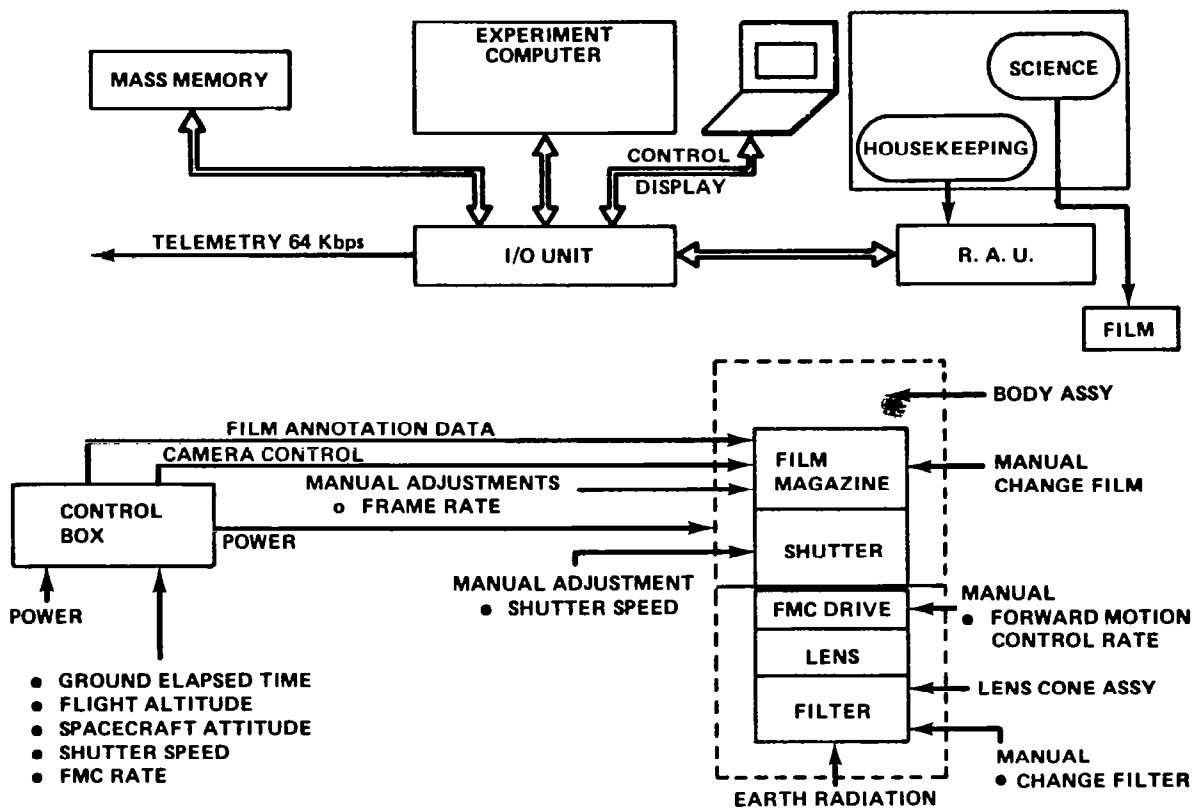
The expected ground resolution for the proposed film and filter combination will vary from 10 meters to 46 meters (37 feet to 150 feet).

EARTH TERRAIN CAMERA (ETC)

REFERENCES

1. Remote Sensing Data Handbook, September 1977.

FUNCTIONAL DIAGRAM



Earth Terrain Camera Block Diagram

MEASUREMENTS

Resolution - 10 meters to 46 meters

POTENTIAL DERIVED PARAMETERS

1. Land maps for area planning.

ELECTRICALLY SCANNING MICROWAVE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: ESMR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-5
CONTRACTOR: Space General Corporation
P.I.: T. Wilheit, Jr., NASA/GSFC

OBJECTIVES

1. Map globally and continuously the thermal radiation emitted by the Earth's surface and atmosphere at a frequency of 19.35 GHz.
2. Demonstrate the feasibility of deployed phased-array antennas.
3. Test the feasibility of inferring surface composition and soil moisture.

DESCRIPTION

SUMMARY: The ESMR is capable of continuous global mapping of the 1.55-cm (19.36 GHz) radio thermal (microwave) radiation emitted by the Earth/atmosphere system and could function even in the presence of cloud conditions that block conventional satellite infrared sensors. A 90- by 90-cm radiometer antenna system, deployed after launch, scanned the Earth successively at various angles in a plane perpendicular to the spacecraft orbital track, producing a brightness temperature map of the surface of the Earth and its atmosphere. The scanning process was controlled by a computer on board and consisted of 78 symmetrically distributed independent scan spots extending 50° to either side of nadir. Angular separation of the scan spots allowed for an 8.5% overlap between view positions. From a mean orbital height of 1100 km, the radiometer had an accuracy of about $\pm 1^\circ\text{C}$ with a spatial resolution of about 25 km. The ESMR data were stored on magnetic tape for transmission to ground acquisition stations.

DATA

DATA PRODUCTS:

Data Set Name: Electrically Scanning Microwave Radiometer (ESMR) Data Tapes
Selected ESMR Color Images
ESMR 70 mm Photofacsimile Film
Satellite-Derived Global Oceanic Rainfall Atlas (1973-1974)

Tapes: 468 reels of magnetic tape. Available on 9-track, 1600 BPI Binary Tapes. "These data are held by the experimenter, but can be ordered through NSSDC."

Film: 43 frames color composites consist of false color images for certain select days and areas.
9094 frames available on 70 mm photofacsimile film. Available in uniform density exposure in either transparencies or paper prints.
6 cards of B/W microfiche.

DATA ARCHIVES LOCATION: National Space Science Data Center

PERIOD OF OPERATION: August 1972 - February 1975

ELECTRICALLY SCANNING MICROWAVE RADIOMETER (ESMR)

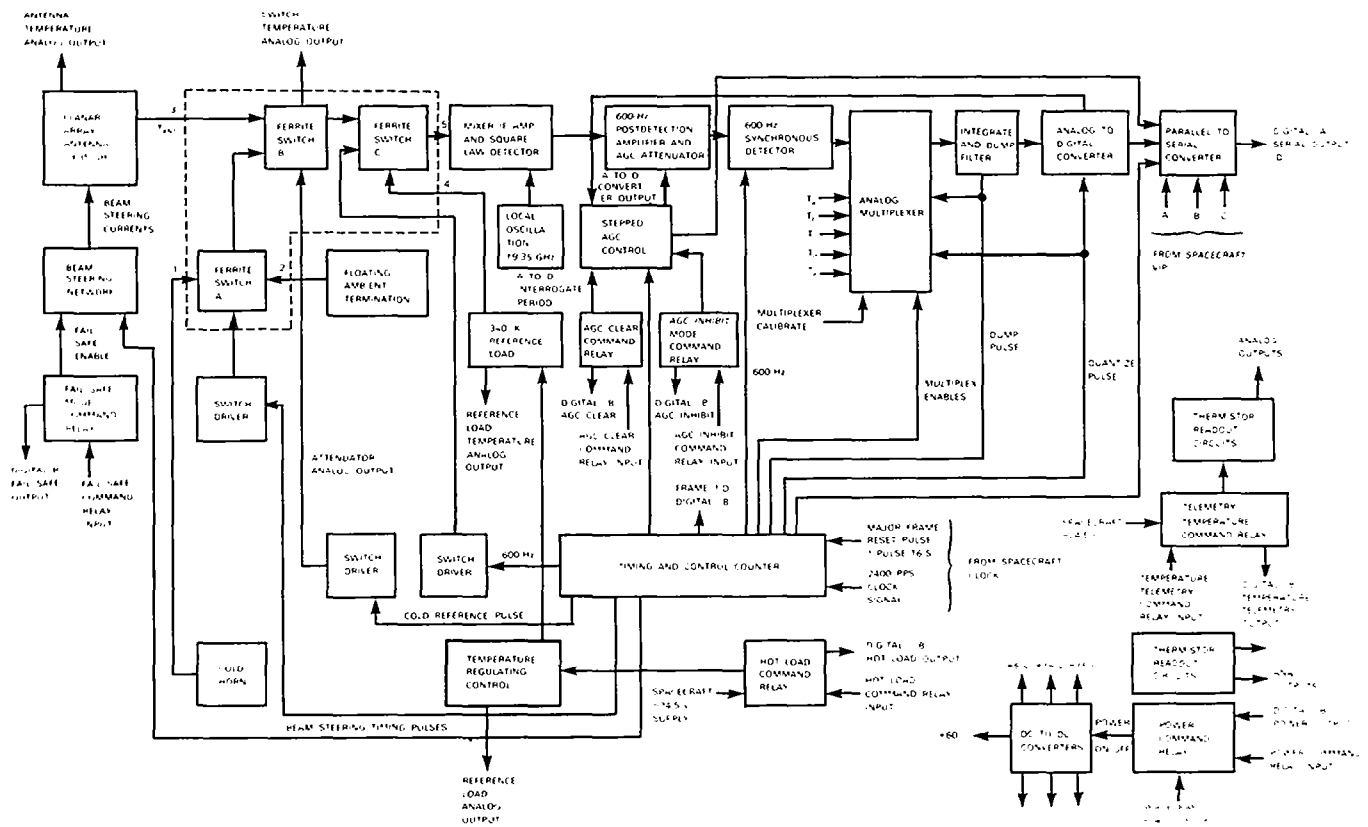
REFERENCES

1. NIMBUS-5 Users Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 55 lbs.
 Volume: 4.5 cu. ft.
 Avg. Power: 42 Watts
 Data Recovery: delayed telemetry
 Precision and Accuracy: rms temp w/in 1.0°K; absolute temperature w/in 2.0°K
 Dynamic Range: 50-330°K
 Scan Rate: 78 steps in 4 seconds.

FUNCTIONAL DIAGRAM



Electrically Scanning Microwave Radiometer Block Diagram

ELECTRICALLY SCANNING MICROWAVE RADIOMETER (ESMR)

MEASUREMENTS

Measures emitted thermal radiation from the Earth.

Dynamic Temperature Range: 50 to 330°K

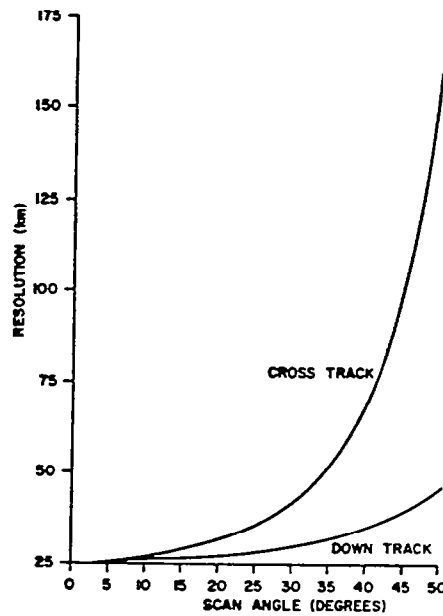
Center Frequency: 19.35 GHz

Field of View: 100 by 1.28°

Resolution: 25 km x 25 km near nadir

Beamwidth: 1.4° x 1.4° near nadir

Polarization: horizontal component



Electrically Scanning Microwave Radiometer Resolution

POTENTIAL DERIVED PARAMETERS

1. Horizontally polarized thermal emissions at 19.35 GHz.
2. Map liquid water content of clouds from brightness temperatures over oceans.
3. Map sea ice and open sea over the polar caps.

ELECTRICALLY SCANNING MICROWAVE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Mission
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: ESMR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-6
CONTRACTOR:
P.I.: T. Wilheit, NASA/GSFC

OBJECTIVES

1. Measure liquid water content of clouds.
2. Measure distribution and variation of sea-ice cover.
3. Gross characteristics of land-surface (vegetation, soil moisture, and snow cover).

DESCRIPTION

SUMMARY: The NIMBUS-6 Electrically Scanning Microwave Radiometer (ESMR) measured the Earth's microwave emission at 37 GHz. The liquid water content of clouds, the distribution and variation of sea ice cover, and gross characteristics of land surfaces (vegetation, soil moisture, and snow cover) were obtained from these measurements. The dicke-type radiometer consisted of a single time-sharing receiver and an electrically scanning phased array antenna operating at 0.8 cm (37 GHz). The antenna beam array, a 90- by 20- by 12-cm box-like structure, was mounted on top of the spacecraft sensory ring and was pointed in the direction of the spacecraft's forward motion and tilted down 40° from the satellite velocity vector. The antenna beam scanned the Earth in 100 discrete steps for various angles extending up to 35° on either side of the orbital plan. The deduced brightness temperatures were expected to be accurate to within 2°K.

HERITAGE/DERIVATION: NIMBUS-5 ESMR

DATA

DATA PRODUCTS:

Data Set Name: Electrically Scanning Microwave Radiometer Data on Magnetic Tape (data at another center).
ESMR Data on 70 mm Film.
Other data information is discussed in the NIMBUS-6 Data Catalog.

Film: 8 frames are displayed as an image at full vertical scale or at partial vertical scale.

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: June 1975 to August 1977

REFERENCES

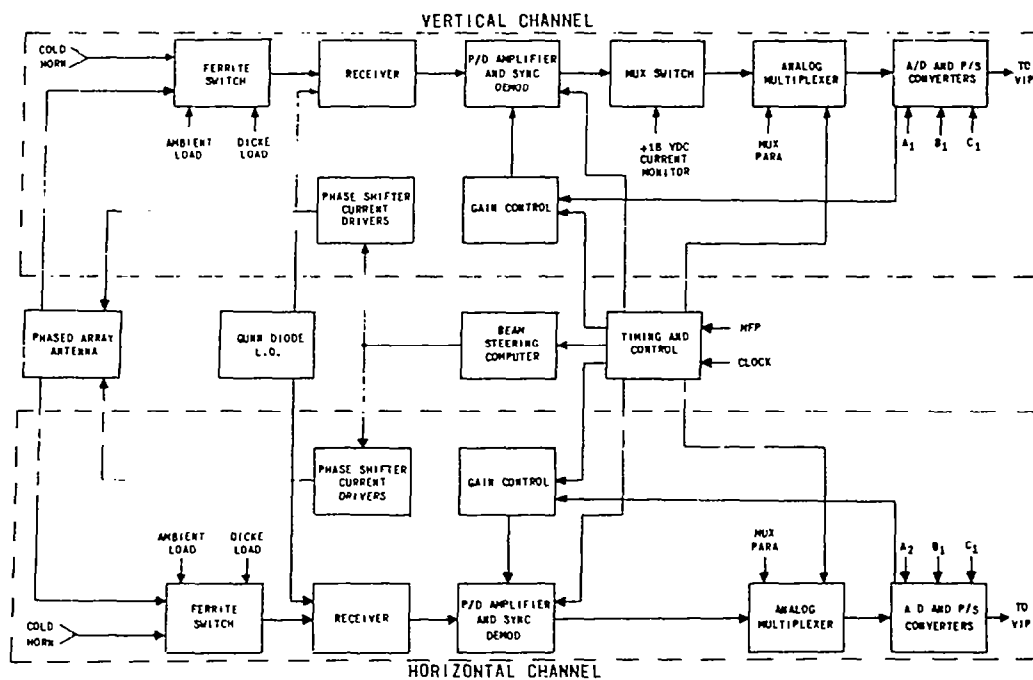
1. NIMBUS-6 Users Guide, Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

ELECTRICALLY SCANNING MICROWAVE RADIOMETER (ESMR)

SYSTEM CHARACTERISTICS

Weight: 80 lbs.
Volume: 5.1 cu. ft.
Avg. Power: 65 Watts
Scan Rate: 71 steps in 5-1/3 seconds.

FUNCTIONAL DIAGRAM



Electrically Scanning Microwave Radiometer Block Diagram

MEASUREMENTS

Measures thermal microwave radiation emission from Earth and clouds.

Measurement: Vertical and Horizontal polarizations

Center Frequency: 37 GHz (0.81 cm)

Field-of-View: 0.75°

Ground Swath: 8 nm x 840 nm from 600 nm orbit.

POTENTIAL DERIVED PARAMETERS

1. Map liquid water content of the clouds.
2. Map sea ice cover and snow cover on the ice.
3. Vegetation, soil moisture, and snow cover of the earth.

FEATURE IDENTIFICATION AND LOCATION EXPERIMENT

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. Talbot
LOCATION: NASA Headquarters

ACRONYM: FILE
INSTRUMENT TYPE: Camera
PAYLOAD: OSTA
CONTRACTOR:
P.I.:

OBJECTIVES

1. To develop and evaluate an instrument capable of spectrally sensing and classifying Earth views into the four categories of water, vegetation, bare Earth, and ice/snow/cloud cover.
2. To develop optimum thresholds for the system to discriminate each category.
3. To obtain realistic contrast data between these features in the spectral bands used to aid in the further laboratory development of an advanced landmark identification and tracking device.

DESCRIPTION

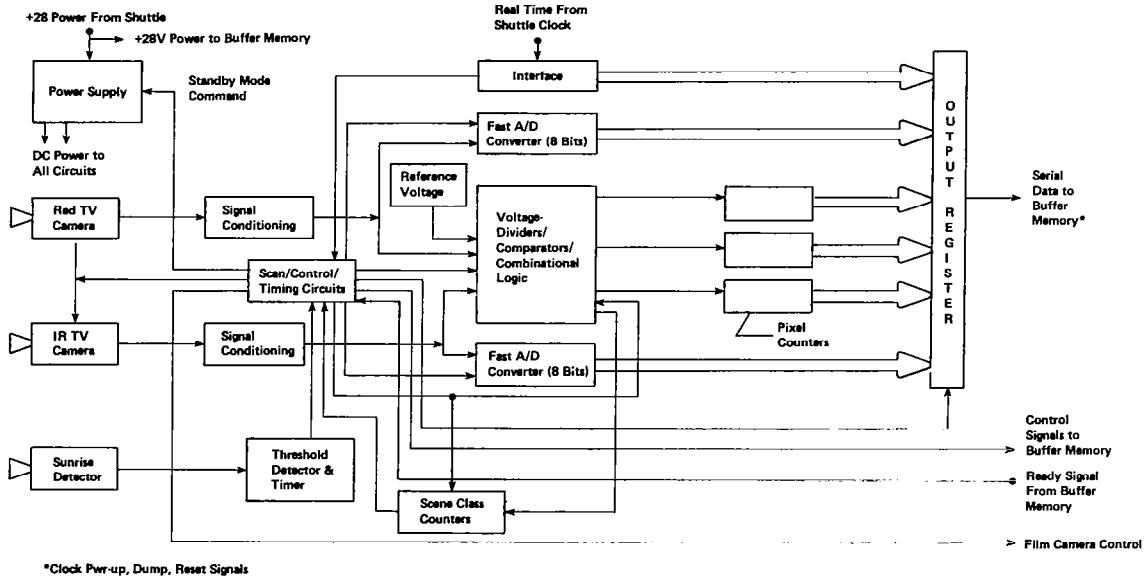
SUMMARY: The FILE includes a sunrise sensor that, by way of an internal timer, activates the experiment when the sun is approximately 60° or less from the Orbiter's zenith. Thus, FILE will be active approximately 30 minutes per orbit. FILE's sensor system consists of a sunrise sensor (mentioned above); two boresighted, solid-state CCD television cameras; and a Hasselblad 70 mm camera with color IR film. The two TV cameras are equipped with optical filters for the two required wavelengths. During the operational phase of each orbit, a timer on FILE will activate the CCD cameras. The output of these cameras is conditioned and then input to analog comparators. The analog comparators and associated logic determine the ratio of the TV camera measurements for each picture element (pixel). A counter for each category counts the total number of each type of pixel found. The video signal and these digital data are recorded on a Lockheed Mark V tape recorder. For each frame of TV data there will be a corresponding color IR photograph taken by the Hasselblad 70 mm camera. GMT timing signals from the pallet/Orbiter will also be recorded on the Lockheed recorder. To ensure that a variety of scenes will be analyzed, FILE will contain scene class counters. These counters and their inhibitor circuits will determine when an adequate number of certain types of scenes have been analyzed and suppress the data storage and photography operations when similar scenes are viewed later. In any case, the timer on the FILE will not allow the Hasselblad camera to operate more than once every 2.75 minutes during the operational period of each orbit. The FILE experiment package will interface with the OFT pallet power control box 28 vdc prime power feeder line connector.

REFERENCES

1. Office of Space and Terrestrial Applications-1, Handout, 1980.

FEATURE IDENTIFICATION AND LOCATION EXPERIMENT (FILE)

FUNCTIONAL DIAGRAM



Feature Identification and Location Experiment

POTENTIAL DERIVED PARAMETERS

1. The automatic acquisition of specific landmarks and/or generic-type surface features such as coniferous or deciduous forests, grass lands, lakes, etc.
2. Providing the pointing coordinates of those surface features for scientific sensors without reliance on precise knowledge of spacecraft attitude and ephemeris data, Earth-map coordinates, or ground track data.
3. The suppression of data acquisition during periods when there are no science observables or when excessive cloud cover exists, thus reducing data management costs.
4. Providing the more timely availability of data to the users.

FILTER-WEDGE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: FWS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-4
CONTRACTOR: ITT
P.I.: Dr. W.A. Hovis

OBJECTIVES

1. Determine the lateral distribution of the total water vapor content per unit vertical column.
2. Determine the vertical distribution of water vapor content in any particular unit vertical column, and the lateral variation of the vertical distribution.

DESCRIPTION

SUMMARY: The NIMBUS-4 Filter Wedge Spectrometer (FWS) experiment was designed to accurately determine the radiance from the earth-atmosphere system as a function of wavelength by measuring the emitted and reflected infrared radiation in the 1.2-2.4 and 3.2-6.4 micron bands. The instrumentation consisted of (1) a telescope, (2) a rotating disc chopper, (3) a rotating (3.75 rpm) circular interference filter wheel, and (4) a lead selenide detector. The filter wheel was a two-segment (one per passband) (180°) 100-layer interference filter with the layer thickness linearly increasing as a function of angular position, causing the bandpass to shift toward longer wavelengths. Incoming radiation was reflected off a surface mirror and was collected by a telescope oriented normal to the earth's surface. The telescope had a 3° field-of-view directly below the satellite, and a pole-to-pole strip approximately 57 km wide was viewed on each satellite pass with a 2461 km separation between successive strips at the equator. The telescope focused the collected radiation onto the edge of the multitoothed chopper wheel that chopped the energy at 333 Hz. After passing through the chopper, the energy was refocused onto the edge of the circular variable filter at an aperture that acted as both spectrometer slit and a system field stop. The energy was then reimaged on a lead selenide detector radiatively cooled to 175°K. The incident radiation was sampled 20 times per second, resulting in a spectral intensity plot of 15 points for each passband per revolution. On June 8, 1970, the FWS suffered mechanical failure when the drive motor on the chopper wheel failed.

DATA

DATA PRODUCTS: No useful data was collected from this experiment.

PERIOD OF OPERATION: April 1970 to June 1970

REFERENCES

1. The NIMBUS-4 User's Guide, GSFC, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

FILTER WEDGE SPECTROMETER (FWS)

SYSTEM CHARACTERISTICS

Weight: 13 lbs.

Volume: 0.3 cu. ft.

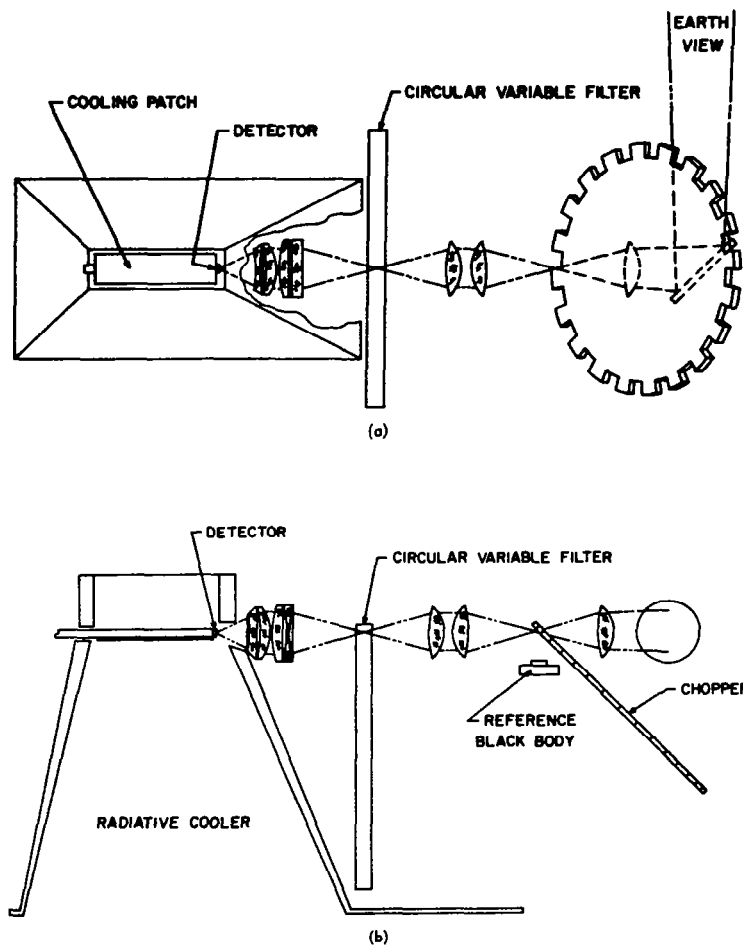
Avg. Power: 6 Watts

Components: spectrometer, telescope, 2 detectors, electronics

Data Recovery: delayed telemetry

Scan Rate: 8 seconds per region.

FUNCTIONAL DIAGRAM



Nimbus 4 Filter Wedge Spectrometer (a) Side View (b) Bottom View

FILTER-WEDGE SPECTROMETER (FWS)

MEASUREMENTS

Measures thermal and reflected radiation.

Spectral Range: 1.2 to 6.4 microns

Bands: 1.2-2.4 microns; 3.2-6.4 microns

Field-of-View: 3.0 degrees

Spatial Resolution: 30 nm from 600 nm altitude.

POTENTIAL DERIVED PARAMETERS

1. Total water vapor content.

FLAT PLATE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. Garbacz
LOCATION: NASA Headquarters

ACRONYM: FPR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: ESSA-1,3,5,7,9; ITOS-1, NOAA-1
CONTRACTOR: University of Wisconsin
P.I.: Dr. R. J. Parent

OBJECTIVES

1. Gather data to aid in determining the geographic distribution of energy radiated from the Earth.
2. The relationship of this energy to incoming energy from the Sun.
3. The reflection and scattering of solar radiation by the Earth-atmosphere system.

DESCRIPTION

SUMMARY: The radiometer is divided into two basic components: a flat plate radiometer with a 180° FOV, and a flat plate radiometer employing a cone shield to minimize or remove any response due to direct solar radiation (70° FOV). The heart of each sensor is a thin aluminum disk thermally and radiatively isolated from its mounts. The disk temperature is sensed by two thermistors mounted on the back surface of the disk. The housing temperatures and the cone temperatures are separately sensed and recorded. Two spectral responses are provided for the disks by the use of anodized aluminum or black paint. The black painted surface will respond to the sum of the reflected solar, direct solar, and reradiated long wave radiation. The anodized aluminum sensor disks reflect in the visible range but absorb IR radiation in the 7 to 30 micron range. These respond to the radiated energy from the Earth and exclude to a high degree the direct and reflected solar radiation. Both disk types are used with both radiometers so that four radiometers are needed to complete a set. Two such sets are mounted 180° apart on the spacecraft but isolated thermally and radiatively from it.

DATA

DATA PRODUCTS:

ESSA-1, 3, 5, 7, 9

Data Set: Low Resolution Infrared (LRIR) data tapes from all missions.

Tape: Magnetic tapes of LRIR data.

ITOS-1

Data Set: Flat Plate Radiometer data tapes.

Tape: 7-track magnetic tape from the 4 sensing elements, spacecraft.

NOAA-1

Data Set: Flat Plate Radiometer data tape.

Tape: Magnetic tape of radiometer data.

FLAT PLATE RADIOMETER (FPR)

DATA ARCHIVES LOCATION: NESc, ESSA, Washington, DC; NOAA NESS, Suitland, Maryland.
PERIOD OF OPERATION:

ESSA-1, 3, 5, 7, 9

October 1966 to October 1968
April 1967 to February 1970
August 1968 to March 1970
February 1969 to November 1973.

ITOS-1

February 1970 to June 1971

NOAA-1

December 1970 to May 1971

REFERENCES

1. Final Engineering Report TOS A METSAT System, Volume 1, RCA Astro-Electronics Contract No. NAS5-9034, May 5, 1967.
2. Rubin, L.: Operational Processing of Resolution IR (LRIR) Data from ESSA Satellites, ESSA Technical Report NESc-42, February 1968.
3. ESSA News Release No. ES 66-54, September 19, 1968.
4. National Space Science Data Center Computer Printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 7 lbs.
Volume: 0.75 cu. ft.
MTBF: 1 year
Components: 8 sensors (thermistors), electronics, recorder
Precision and Accuracy: 5°K in thermal IR
Instrument is broad range, low accuracy type.

MEASUREMENTS

Measure reflected solar and long wave radiation.

Spectral Range: 0.3 to 30.0 microns.
Channels: 2 - Visible: .3-7.0 microns; Infrared: 7-30 microns
Field-of-View: 180°
Scan Rate: 32 seconds

POTENTIAL DERIVED PARAMETERS

1. Earth albedo - energy radiated to space by Earth.

FLUXGATE MAGNETOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: Dr. Robert Langel
LOCATION: GSFC

ACRONYM: FMAG
INSTRUMENT TYPE: Magnetometer
SPACECRAFT: Shuttle
CONTRACTOR:
P.I.: Dr. J. Sry, GSFC

OBJECTIVES

1. To measure the global vector magnetic field in a near-earth orbit to an accuracy of approximately ± 5 gamma on a temporal and spatial basis.

DESCRIPTION

SUMMARY: The FMAG's will be delivered via Shuttle and deployed as a system of 3 satellites in 400 km circular orbits phased 4 hours apart in local time (120° separation) and operating simultaneously for 12 months.

The Triaxial FMAG is boom mounted on a satellite that is stabilized with respect to a 3-axis earth centered coordinate system and measures the local magnetic field to an accuracy of ± 5 gamma over the range of $\pm 15K - 60K$ gamma.

In the sensor, the gating field is driven by a 30 kHz oscillator and drive coil. The presence of the ambient field induces asymmetry into the induction cycle when the core is saturated to maximum magnetic induction. The asymmetry is a measure of the ambient field and is detected as a second harmonic of the fundamental gating frequency. The sampling rate is 8 to 25 samples per second and provides for an approximate 600 bps data rate to the Tracking and Data Relay Satellite. Four bits representing an offset bias plus the 12 bit resolution from the A/D converter provide a 16 bit measurement of each axis for each sample.

HERITAGE/DERIVATION: IMP, OGO, Explorer, Skylab

REFERENCES

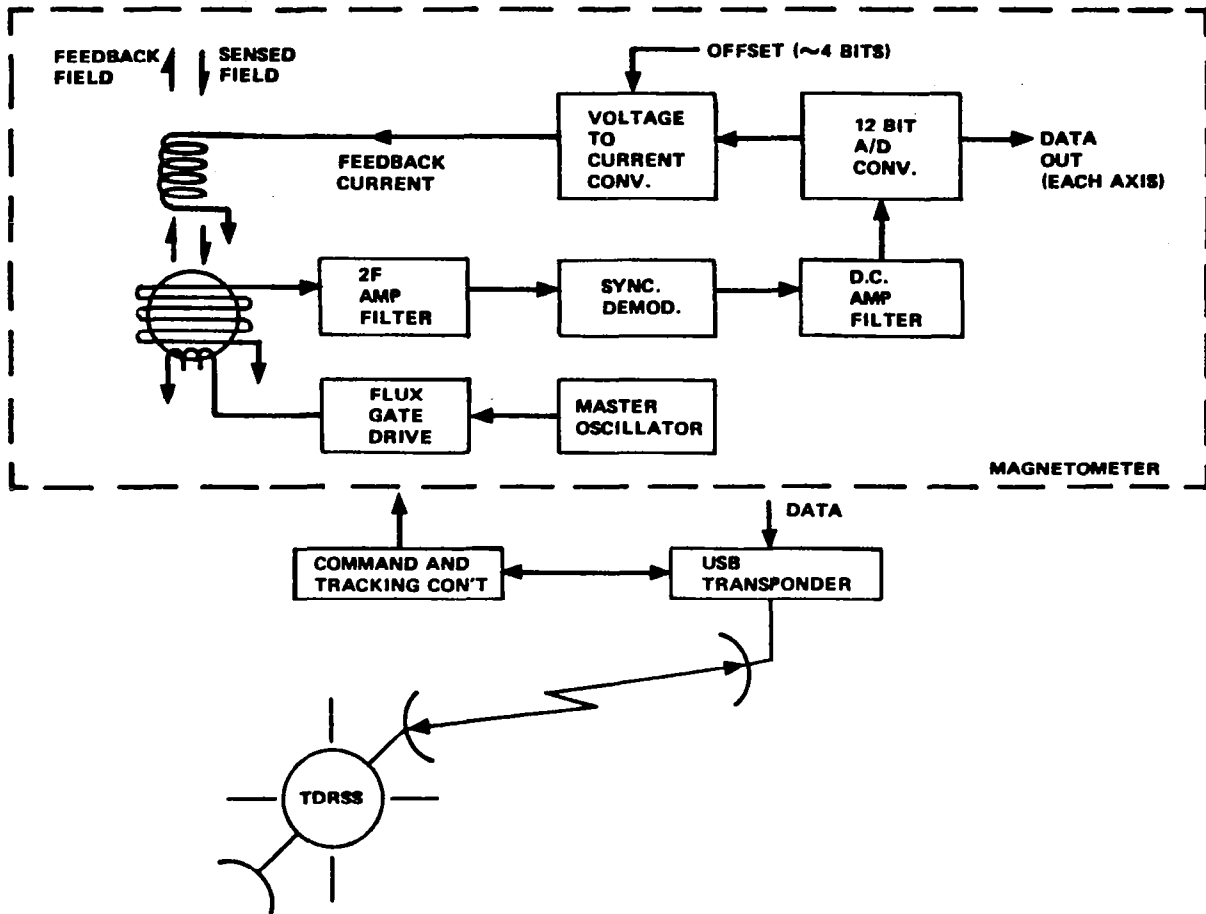
1. Remote Sensing Data Handbook, September 1977, Marshall Space Flight Center.

MEASUREMENTS

The magnetic flux induced in the core by the gating field is modified by the external magnetic field which generates even harmonics on the output winding as a function of the magnitude of the external field. The discriminated second harmonic is calibrated to yield the magnitude of the field component parallel to the sensor axis, while the phase indicates the direction.

FLUXGATE MAGNETOMETER (FMAG)

FUNCTIONAL DIAGRAM



Fluxgate Magnetometer Block Diagram

POTENTIAL DERIVED PARAMETERS

1. Earth's magnetic field.

FOUR-CHANNEL INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: S. Tilford
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: IR Radiometer
SPACECRAFT: Solar Mesosphere Explorer
CONTRACTOR: Jet Propulsion Laboratory
P.I.: C.A. Barth, University of Colorado

OBJECTIVES

1. Measure temperature/pressure in the 50-70 km region.
2. Measure water and ozone concentrations.

DESCRIPTION

SUMMARY: This four-channel IR radiometer, operating from 6.1 microns to 17.2 microns, will provide comprehensive data on atmospheric ozone and the processes which form and destroy it. This will be one of five instruments to be carried on the SME spacecraft which will measure the ozone density and altitude distribution, monitor the incoming solar radiation, and measure other atmospheric constituents which affect ozone. The four-channel radiometer/telescope has two filter-detector combinations operating in the micrometer regions 6.1-7.2, 8.6-10.6, 14.7-15.7, and 13.2-17.2. It views normal to the spin axis. The field of view sweeps through the limb sampling a succession of 20 elements of the atmosphere, each approximately 3.5 km in height at the earth's limb.

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory and National Center for Atmospheric Research

REFERENCES

1. Project Plan for Solar Mesosphere Explorer 1981 Mission, Jet Propulsion Laboratory 629-1, September 1978.
2. Report of Active and Planned Spacecraft and Experiments, August 1980, GSFC.

SYSTEM CHARACTERISTICS

Physical Size (m): 0.60 x 0.25 (diam.)
Mass (kg): 9.07
Power Requirement (We): 10
Data Rate: 128.0 kbps

FOUR-CHANNEL INFRARED RADIOMETER

MEASUREMENTS

Determine temperature/pressure from measurements of CO₂ line radiances and emissions from ozone and H₂O.

Spectral range: 6.1 - 17.2 microns

Number of channels: 4

Spectral bands: 17.2 - 13.2 microns
15.7 - 14.7 microns
10.6 - 8.6 microns
7.2 - 6.1 microns

POTENTIAL DERIVED PARAMETERS

1. Temperature/pressure
2. Ozone density
3. Altitude mixing ratio profiles for water and ozone.

HALOGEN OCCULTATION EXPERIMENT

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Future Flight Missions
NASA TECH. OFFICER: D. Diller
LOCATION: NASA Headquarters

ACRONYM: HALOE
INSTRUMENT TYPE:
SPACECRAFT: ERBS, UARS, Spacelab-3
CONTRACTOR: TRW Systems
P.I.: Dr. James Russell, LaRC

OBJECTIVES

1. To measure stratospheric concentrations such as HCl, HF, CH₄, NO, COS, H₂O, CF₂Cl₂, O₃, HNO₃, and CO₂.
2. To produce horizontal and vertical maps of gas concentration.
3. To determine annual variations in measured species.

DESCRIPTION

SUMMARY: The instrument consists of an optics unit, supported on a two-axis gimbal, and an electronics unit. The optics unit contains the optics, modulators, detectors, and preamps for the gas detection channels and radiometer channels. The gimbal assembly provides azimuth and elevation rotation of the optics unit, with ± 185 degrees azimuth range and a 38 degrees range of elevation angle control, and is controlled by coarse and fine Sun sensors included in the optics unit. The electronics unit provides signal processing, motor drives, sequence timing, mode control, power conditioning, and data handling. A 16 cm diameter reflective Cassegrain telescope collects energy for the gas detection channels. The Instantaneous Field of View (IFOV) is determined by a field stop at the focal point of the telescope, and the energy is modulated by a chopper similar to that of the Monitoring Air Pollution from Satellites (MAPS) instrument. A hot reference blackbody source is used to approximately balance the solar energy levels when the chopper disc is in the closed (reflective) position. An optical signal provided and processed in a similar manner as the MAPS instrument is used to maintain gain balance of the detector branches. The optical beam is separated by beamsplitters into the gas correlation and radiometer modules. The output signals from the gas correlation modules are sent to the signal processor, which is similar to the MAPS signal processor design. The output signals from the radiometer modules are sent to a standard radiometer signal processor. A stepper-driven calibration wheel is provided in front of the telescope field stop to provide measurements of gas response, radiometric calibration, and instrument balance, using the exoatmospheric Sun as an energy source. The calibration wheel contains three gas cells and a neutral density filter for these measurements. The signal processing and motor drive electronics are similar to those of the MAPS instrument. The remaining electronics are conventional and straight forward with no critical design areas.

HERITAGE/DERIVATION: MAPS - Monitoring Air Pollution from Satellites.

REFERENCES

1. Execution Phase Project Plan, LaRC, February 1979.
2. Spacelab-3 Mission Payload Specialist, Technical and Professional Qualifications, May 1980.
3. UARS PROPOSAL, Halogen Occultation Experiment proposal for UARS Missions. Langley Research Center, December 1978.

HALOGEN OCCULTATION EXPERIMENT (HALOE)

SYSTEM CHARACTERISTICS

Instrument Size

Optics Unit: 28 x 45 x 75 cm
Electronics Unit: 22 x 22 x 20 cm

Instrument Mass

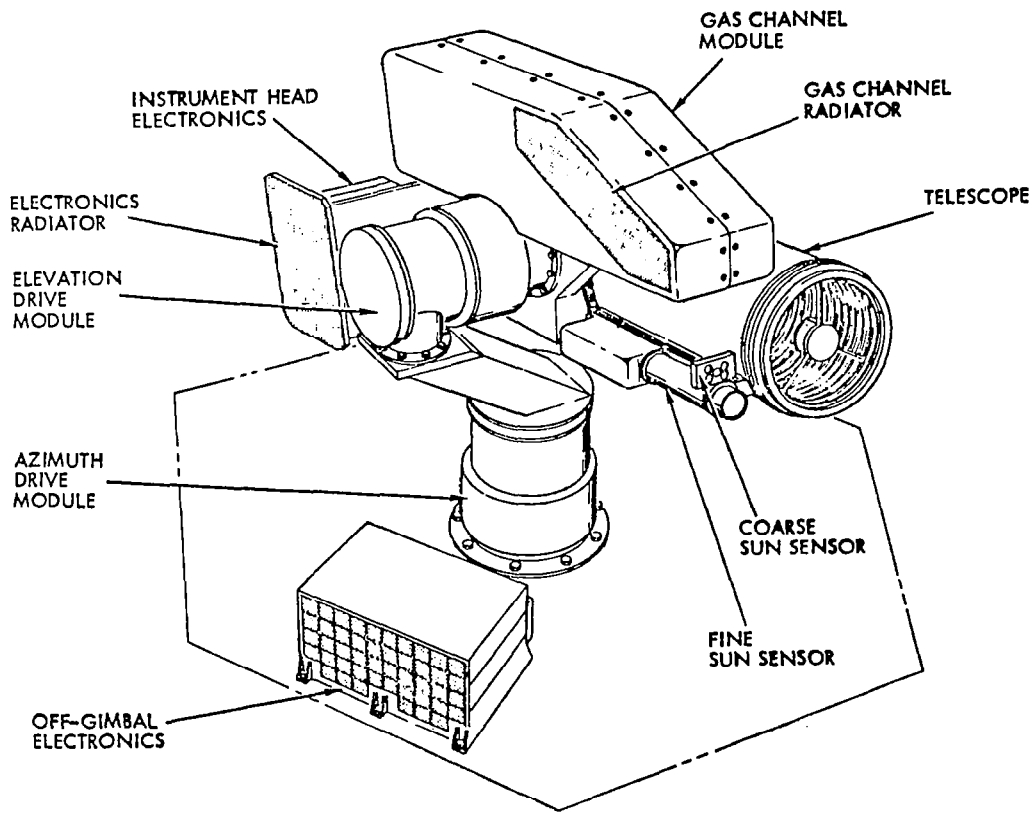
Optics Unit: 30 kg
Electronics Unit: 10 kg
Gimbals: 35 kg
Total (including cables, etc.): 75 kg

Power Consumption

Peak: 75 W
Operating: 60W
Standby: 40 W
Orbit Average: 45 W
Essential: 25 W

Operating Temp. in Vac: Min: -23°C, Max: +60°C

FUNCTIONAL DIAGRAM



Halogen Occultation Experiment Instrument Concept

HALOGEN OCCULTATION EXPERIMENT (HALOE)

MEASUREMENTS

Measures the absorption of solar energy during sunrise and sunset events by the constituents of interest.

Spectral Coverage: 2.4, 3.4, 3.5, and 5.9 microns
Vertical Resolution: 2 km
Data Rate: 4296 bits/second
Modulation Dynamics Range: 3500
Sampling Rate: 5/sec.

POTENTIAL DERIVED PARAMETERS

1. Chlorine source
2. Validation of chemical and dynamic models
3. Global estimates of ozone depletion
4. Seasonal and latitudinal dependence of gas concentrations by measurements made during chlorofluoromethane regulation period.
5. Analysis of latitude and longitude behavior to determine stratospheric dispersion processes.
6. Difference in hemispheric concentrations.

HEAT CAPACITY MAPPING RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: Dr. John C. Price
LOCATION: NASA/Goddard Space Flight Center

ACRONYM: HCMR
INSTRUMENT TYPE: VIS/IR Spectroradiometer
SPACECRAFT: AEM
CONTRACTOR: ITT
P.I.: W. Hovis, NOAA

OBJECTIVES

1. To investigate the feasibility of using the thermal inertia characteristics of different materials to discriminate between different surface materials and to identify different states, such as degree of soil moisture.
2. To acquire repetitive thermal data on a time basis consistent with both maximum surface temperature variation and minimum changes in local conditions.

DESCRIPTION

SUMMARY: The Heat Capacity Mapping Radiometer (HCMR) was derived from a modified spare of the Nimbus 5 Surface Composition Mapping Radiometer (SCMR). The two channel radiometer acquires high spatial resolution daytime reflected and thermal infrared data. One spectral channel covers the reflectance band from 0.5 to 1.1 micrometers while the other views the thermal band between 10.5 and 12.5 micrometers. The HCMR has a geometric instantaneous field-of-view (IFOV) of 0.83 milliradians, high radiometric accuracy, and a wide coverage swath on the ground so that selected areas received repeated coverage within a 12-hour period corresponding to the minimum and maximum of the diurnal temperature cycle.

HERITAGE/DERIVATION: Nimbus 5 Surface Composition Mapping Radiometer (SCMR)

DATA

DATA PRODUCTS:

Image and computer compatible tape (CCT) of daytime reflectance, day and night thermal infrared.

Limited quantities of temperature difference and apparent thermal inertia.

Images are available in positive and negative prints and transparencies.

Catalogs available.

Predicted world maps.

DATA ARCHIVES LOCATION: National Space Science Data Center/Goddard Space Flight Center

PERIOD OF OPERATION: May 13, 1978 - June 30, 1979

REFERENCES

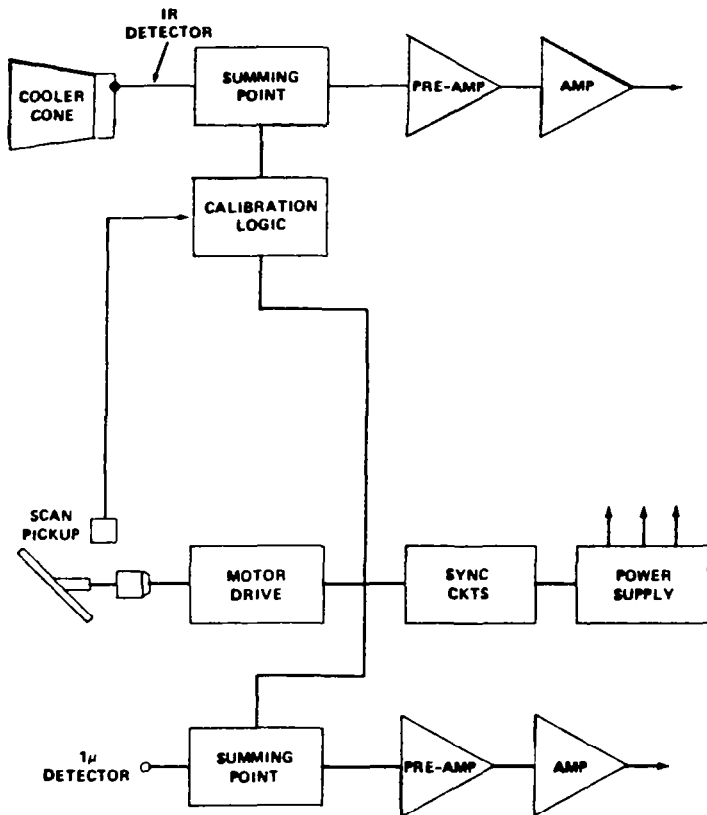
1. HCMM Users Guide, December 1978, GSFC.
2. Image Processing Facility Interface Control Documents, 1978.

HEAT CAPACITY MAPPING RADIOMETER (HCMR)

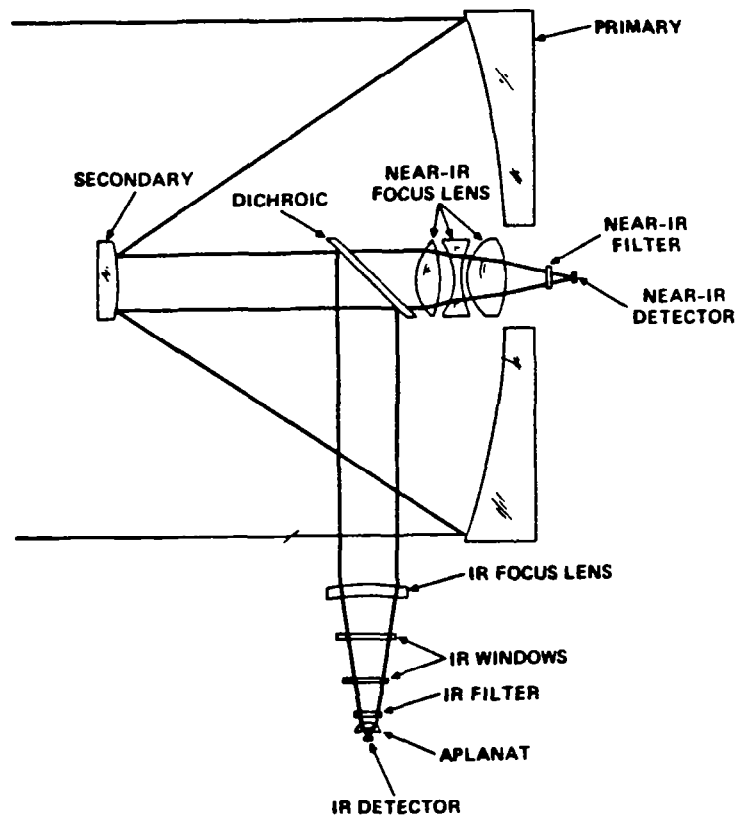
SYSTEM CHARACTERISTICS

Orbital altitude: 620 kilometers
 Angular resolution: 0.83 milliradians
 Resolution: 0.6 km x 0.6 km at nadir (infrared)
 0.5 km x 0.5 km at nadir (visible)
 Scan angle: 60 degrees (full angle)
 Sampling interval: 9.2 microseconds
 Swath width: 716 kilometers
 Experiment information bandwidth: 53 kHz/channel
 Thermal channel: 10.5 to 12.5 micrometers; NEDT = 0.4°K at 280°K
 Usable range: 260° to 340°K
 Visible channel: 0.55 to 1.1 micrometers; SNR = 10 at 1% albedo
 Dynamic range: 0 to 100% albedo
 Scan mirror: 45 degree elliptical flat
 Nominal telescope optics diameter: 20 cm
 Calibration: Infrared: View of space, seven-step staircase electronic calibration, and blackbody calibration once each scan.
 Visible: Pre-flight calibration assumed valid.

FUNCTIONAL DIAGRAMS



Heat Capacity Mapping Radiometer Block Diagram



Optical Diagram for Heat Capacity Mapping Radiometer

HEAT CAPACITY MAPPING RADIOMETER (HCMR)

MEASUREMENTS

Measures thermal and reflected daytime IR data.

Number of channels: Two

Reflectance band: 0.5 to 1.1 micrometers

Thermal infrared band: 10.5 and 12.5 micrometers

Spatial resolution: 600 x 600 meters at nadir

Reflectance resolution: 500 x 500 meters

POTENTIAL DERIVED PARAMETERS

1. Discrimination of rock types and mineral resource locations.
2. Measuring soil moisture effects by observing the temperature cycle of soils.
3. Measuring plant canopy temperatures at frequency intervals to determine the transpiration of water and plant stress.
4. Coverage of snow fields for water runoff prediction.
5. Measuring effects of urban heat islands.
6. Mapping surfaces thermal gradients on land and in water bodies.

HIGH ENERGY PARTICLE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Future Flight Missions

NASA TECH. OFFICER: R. J. McNeal

LOCATION: NASA Headquarters

ACRONYM: HEPS

INSTRUMENT TYPE: Spectrometer

SPACECRAFT: UARS

CONTRACTOR: University of Texas

P.I.: Dr. J. David Winningham

OBJECTIVES

1. To determine the global input of charged-particle energy into the earth's stratosphere, mesosphere and thermosphere and the predicted atmospheric responses.

DESCRIPTION

SUMMARY: The HEPS is one of three sensors which make up the Particle Environment Monitor (PEM). The other two sensors are the Medium Energy Particle Spectrometer (MEPS) and the Atmospheric X-Ray Imaging Spectrometer (AXIS). In addition to this system there will be a Central Command and Data Handling Package (CDHP) for handling the interface of the PEM with the UARS spacecraft.

The HEPS consists of two stacks of surface-barrier silicon detectors arranged in a telescopic manner and located behind collimators that define the angular and a real acceptance to particles. The two telescopes have a real acceptance that differs by a factor of 100 to cover the wide dynamic range of fluxes encountered at the electron energies >30 keV measured by the instrument. The smaller telescope will have a geometric factor of 4×10^{-3} cm²-sr to cover the electron fluxes from 30 - 150 keV. The larger telescope will have a geometric factor of 4×10^{-1} cm²-sr to cover the fluxes from 30 - 250 keV in weak precipitation events and the fluxes from 150 - 5100 keV at all times.

HERITAGE/DERIVATION: HEPS will be identical to the Lockheed SC-3 spectrometer to be flown on the USAF-SCATHA satellite (P78-2) in January 1979 with the exception that a dual telescope will be included in this design.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

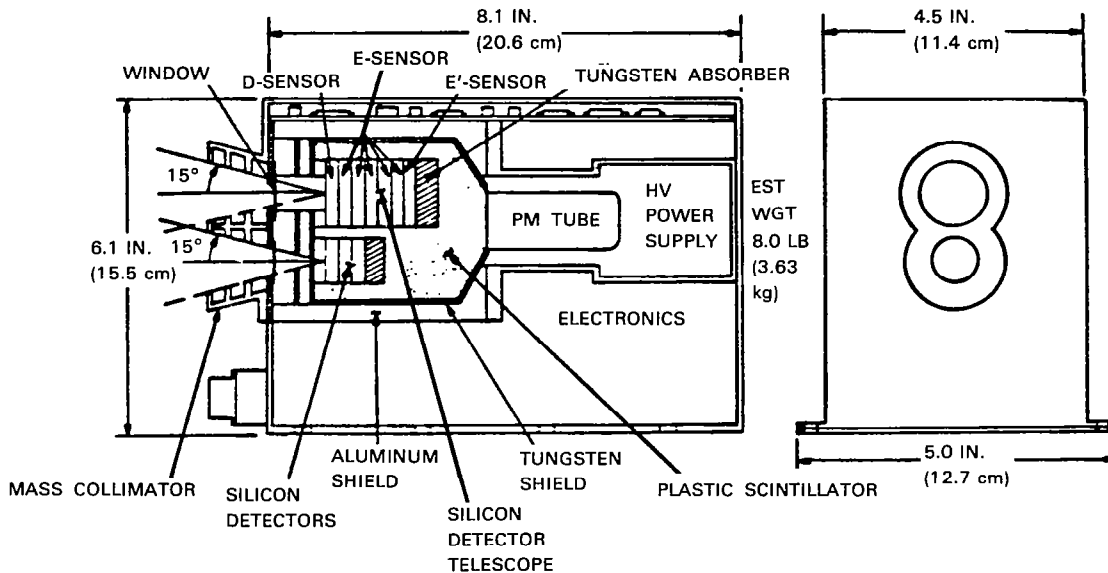
1. UARS Proposal, Particle Environment Monitor, University of Texas, December 1978.

HIGH ENERGY PARTICLE SPECTROMETER (HEPS)

SYSTEM CHARACTERISTICS

Weight: 7.26 kg
Power: 5.8 W
Dimensions: 20.6 x 11.4 x 15.5 cm
Telemetry Data Rate: 720 Bps
Channels: 19
Energy Modes: 8

FUNCTIONAL DIAGRAM



High Energy Particle Spectrometer Schematic Diagram

MEASUREMENTS

Measures particle fluxes in the energy range where significant influences on the atmosphere occur.

FOV of each detector: 30°

Range: Protons: .5 to 100 MeV

Electrons: 30 KeV to 5 MeV

Temporal resolution: <4 sec

Number of energy channels: 12 differential, 7 integral

Particle and energy range measured: e: 30-5,100 KeV differential
5,100-10,000 KeV integral

p: 0.5-100 MeV differential
6-60 MeV integral

POTENTIAL DERIVED PARAMETERS

1. Measure energetic particles in the atmosphere
2. Determine chemistry of stratosphere and atmosphere.

HIGH RESOLUTION DOPPLER IMAGER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions, Development
NASA TECH. OFFICER: R. J. McNeal
LOCATION: NASA Headquarters

ACRONYM: HRDI
INSTRUMENT TYPE: Interferometer
SPACECRAFT: UARS, Shuttle
CONTRACTOR: University of Michigan
P.I.: Paul B. Hays

OBJECTIVES

1. To utilize sharp features in the spectrum of light emitted or scattered from the earth's atmosphere.
2. To obtain the temperature and vector wind field directly.
3. To study problems associated with the dynamics of the atmosphere and the transport of minor constituents within the atmosphere.

DESCRIPTION

SUMMARY: The main portion of the HRDI is a triple etalon Fabry-Perot interferometer. This instrument detects simultaneously twenty wavelength intervals of spectral width 20 mK (0.008 Å) which are selected in a particular free spectral range of the high resolution etalon by tuning the lower resolution etalons and selecting a dielectric pre-filter. The optical path viewed by the Fabry-Perot can be switched from the aft (135°) baffle to the forward (45°) baffle by means of an azimuthal motion of the zenith scan mirror. The sky image is scanned using the zenith mirror in the zenith scan mode. The Sensor portion of the HRDI consists of two baffles, fore and aft, and a single imaging telescope. A calibration lamp provides spectral and sensitivity calibrations inflight. The Scene Selector chooses between the two baffles. The Scene Selector mirror also is used to scan the sky scene through either of the two baffle systems. An eight position filter wheel optically prefilters the incoming light. The triple etalon arrangement provides spectral separation. The wavelength will be selected by means of piezoelectric control with capacitive feedback. A twenty element concentric ring image plane detector is used to detect the spectral light signal. The Sensor Electronics provide control and position readout for the various sensor elements. Scene select, scene scan and filter wheel are all positioned by stepper motors and position readback is provided by light emitting diode-transistor position detectors.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center
PERIOD OF OPERATION: Launch date in Fall 1986.

REFERENCES

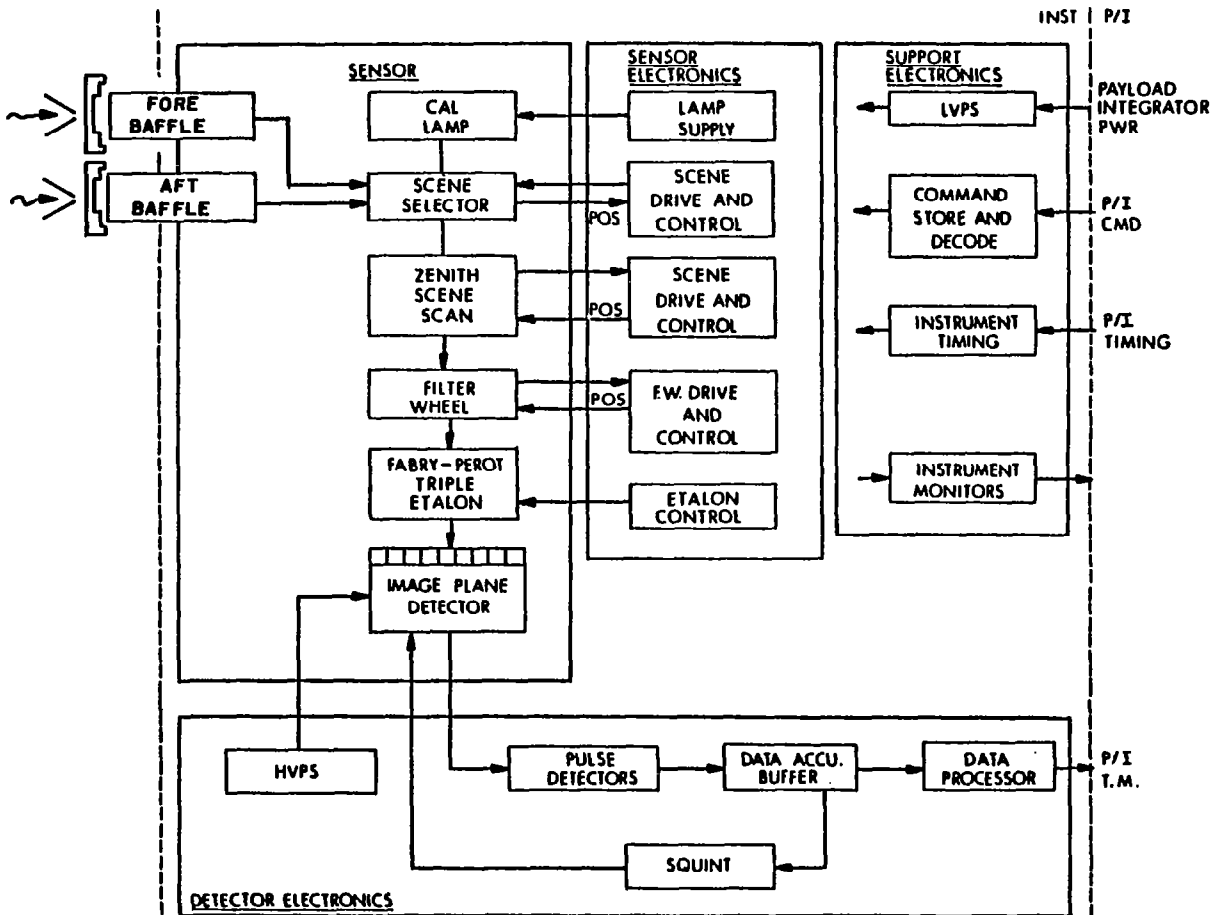
1. UARS Proposal, High Resolution Doppler Imager, University of Michigan, December 1978.
2. High Resolution Doppler Imager, Part I: Technical Section, University of Michigan, November, 1978.
3. Payloads for Environmental Observations handout, 1980.

HIGH RESOLUTION DOPPLER IMAGER (HRDI)

SYSTEM CHARACTERISTICS

Weight: 25kg
 Size: Approx. .6m x .45
 Power: 14W
 Data Rate: 2.5kb/s

FUNCTIONAL DIAGRAM



High Resolution Doppler Imager Block Diagram

HIGH RESOLUTION DOPPLER IMAGER (HRDI)

MEASUREMENTS

Detect sharp features in the spectrum of light emitted and scattered from the atmosphere to obtain vector wind field and temperature directly.

Twenty spectral wavelength intervals of spectral width 0.008\AA centered around 6500\AA .

Spectral resolution: $= 0.02\text{ cm}^{-1}$ (0.008\AA)

Stability: $= 2.5 \times 10^{-4}\text{ cm}^{-1}$

FOV: 2.5° half angle

POTENTIAL DERIVED PARAMETERS

1. The temperature and vector wind field.
2. The dynamics of the atmosphere and the transport of minor constituents within the atmosphere.
3. Emphasis on the regions of our atmosphere where the geostrophic approximation is suspect.
4. Comparison of winds and thermal winds.
5. Contribution of planetary and gravity wave propagation into the middle atmosphere from below to note the importance of zonal wind structure.
6. Breakdowns associated with sudden warmings in the polar stratosphere.
7. Coupling between the stratosphere, mesosphere and thermosphere.
8. The role of Joules heating and the auroral energy source on the upper mesosphere.

**HIGH RESOLUTION GLOBAL MEASUREMENTS OF ATMOSPHERIC OZONE
(GLIMPSE: GLOBAL LIMB PHOTOMETRIC SCANNING EXPERIMENT)**

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R. J. McNeal
LOCATION: NASA Headquarters

ACRONYM: GLIMPSE
INSTRUMENT TYPE: Photometer
SPACECRAFT: UARS
CONTRACTOR: Jet Propulsion Laboratory
P.I.: R. W. Carlson

OBJECTIVES

1. To obtain three-dimensional maps of global ozone (i.e., latitude, longitude, altitude).

DESCRIPTION

SUMMARY: The proposed instrumentation consists of an eight-channel visible/near uv limb scanning photometer and a four-channel down-looking cross-track scanning photometer necessary for ground/cloud albedo input to the data inversion. The source of radiation for the limb scan is the atmosphere itself, through scattered solar flux. Absorption by ozone in the Chappuis and Hartley bands modified the relative shape of the limb profiles, which can be inverted to give the vertical ozone profile. The high flux levels and available sensitivities in this region of the spectrum allow precise measurements to be made in short integration times. Thus, one can perform both azimuth and elevation scans, enhancing the amount of global coverage.

Eight optical channels are planned, since retrieval of the ozone profile requires that one also obtain the contribution to the source function and attenuation due to Rayleigh scattering and aerosols, their refractive indices, and the wavelength dependence (or size distribution parameter).

The present instrument is a simple implementation of previously developed flight photometers.

DATA

DATA PRODUCTS: Global ozone maps
General circulation studies
Harmonic analyses to determine phase shift
Ozone trend studies

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

1. UARS Proposal, High Resolution Global Measurements of Atmospheric Ozone from the Upper Atmosphere. Research Satellites, Jet Propulsion Laboratory. December, 1978.

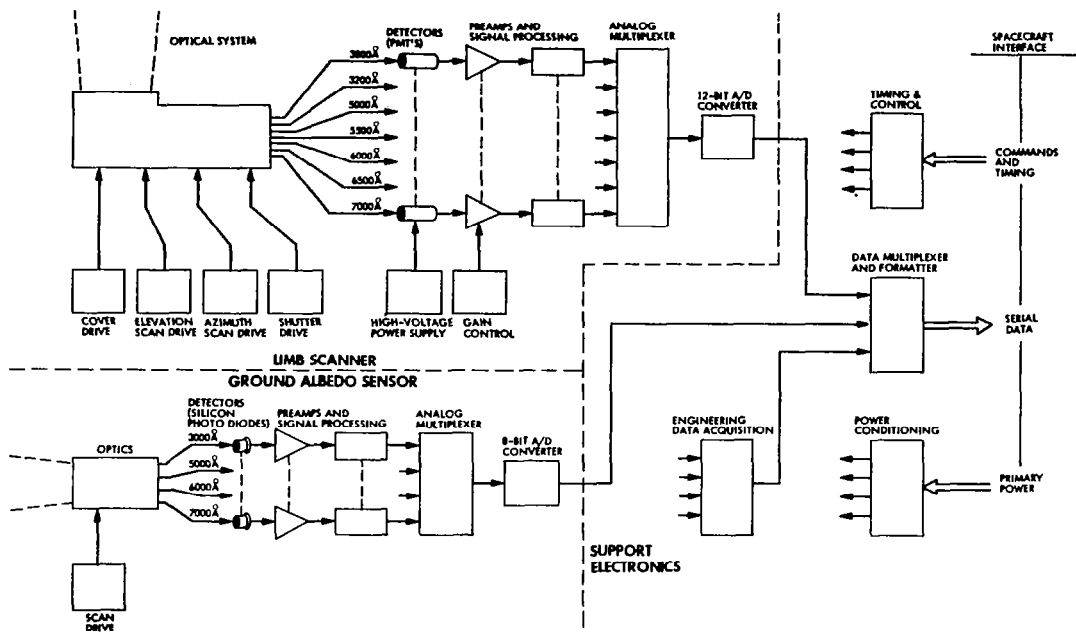
**HIGH RESOLUTION GLOBAL MEASUREMENTS OF ATMOSPHERIC OZONE
(GLIMPSE: GLOBAL LIMB PHOTOMETRIC SCANNING EXPERIMENT)**

SYSTEM CHARACTERISTICS

Altitude range: 10-50 km	Temperature: -10 to +30°C
Precision: 5%	Power: 75 watts (peak)
Global mapping in 1 day	Voltage: 28-35 Vac
Volume: 005m ³	Current: 2-3 Amperes (peak)
Mass: 25 kg	Channels: 8
Azimuth Scan	
Implementation	Rotating mirror
Scan Range	0 - 360°
Scan Increments	10°
Scanning Time	360° (36 steps) in 72 seconds
Stop Time	1.5 sec (limb scan time)
Positioning Time	0.5 sec
Horizontal Resolution	500 km
Elevation (Limb Scan)	
Implementation	Wobbling secondary mirror
Scan Range	3°
Scan Angles	21 - 24° below local horizontal
Scan Increments	0.03°
Scan Time	1.5 sec (100 steps) + 0.5 sec retrace
Altitude Range	-10 ->+90 km
Resolution @ 2800 km	1 km
Telescope	
Type	Aplanatic, cassegrain configuration
Aperture	10 cm diameter
EFL	1500 mm
Mirrors	two-hyperbolic; secondary "wobbles".
Field Stop	
Diameter	0.53mm
Angular Size	350 urad
Dispersion	
Element	Concave diffraction grating
Grating Constant	1300 λ /mm
Radius of Curvature	30 cm
Angle of Incidence	46°
Band Pass Selection	
Implementation	Grating dispersion and interference filters
Filter Band Pass	50 - 250 \AA depending upon channel
Detectors	
Number	8
Type	Ceramic photomultipliers
Photocathodes	Bialkali, Trialkali (E, N type)
Type	EMR 510
Encoding	12 bits/channel
Data Rate	6,067 BPS

HIGH RESOLUTION GLOBAL MEASUREMENTS OF ATMOSPHERIC OZONE (GLIMPSE: GLOBAL LIMB PHOTOMETRIC SCANNING EXPERIMENT)

FUNCTIONAL DIAGRAM



MEASUREMENTS

Map vertical ozone profiles in the 10-50 km range by limb scans of the atmospheric radiances.

Instrument:

Limb Scan Photometer

Wavelength Channels	5000 Å, 5500 Å, 6000 Å, 6500 Å, 7000 Å, 8000 Å, 3000 Å, 3200 Å
Spectral Band Passes	50-250 Å, depending upon channel
Projected Field of View	1 km diameter (circular)
Limb Scan Range	3°
Limb Scan Time	1.5 sec (100 steps) + 0.5 sec (retrace)
Azimuth Scan Range and Increments	360° in 36 steps (10° per step)
Azimuth Scan Time	72 sec for 36 10° steps
Detectors	Photomultipliers

**HIGH RESOLUTION GLOBAL MEASUREMENTS OF ATMOSPHERIC OZONE
(GLIMPSE: GLOBAL LIMB PHOTOMETRIC SCANNING EXPERIMENT)**

MEASUREMENTS (cont.)

Ground/Cloud Albedo Photometer

Wavelength Channels	5000 Å, 6000 Å, 7000 Å, 3200 Å
Spectral Band Passes	100 Å
Projected Field of View	50 - 80 km
Scan Angle	100° cross-track scan
Scan Time	12 sec
Detectors	Silicon photodiodes
Data Rate	6 kbps
Mars	25 kg
Volume	$5 \times 10^4 \text{ cm}^3$
Power	75 w (peak)
Mounting Accuracy	0.01°

POTENTIAL DERIVED PARAMETERS

1. Global ozone concentration
2. Vertical ozone profiles
3. Study ozone distribution and photochemical processes.

HIGH-RESOLUTION INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. B. Schardt
LOCATION: NASA Headquarters

ACRONYM: HRIR
INSTRUMENT TYPE: Radiometer, Single Channel
SPACECRAFT: NIMBUS-1 & 2
CONTRACTOR: ITT
P.I.: L. L. Foshee, GSFC

OBJECTIVES

1. To map the Earth's cloud cover at night.
2. To measure the radiative temperature of cloud tops and terrain features.

DESCRIPTION

SUMMARY: The NIMBUS-1 High-Resolution Infrared Radiometer (HRIR) was designed (1) to map the Earth's nighttime cloud cover and the radiometer measured thermal radiation in the 3.5 to 4.1 microns "window" region. The HRIR subsystem consisted of (1) an optical system, (2) an infrared detector (lead selenide photoconductive material), (3) electronics, (4) a magnetic tape recorder, and (5) a filter to minimize attenuation effects of water vapor and carbon dioxide. In contrast to the AVCS camera, no image was formed within the radiometer. The HRIR sensor merely transformed the received radiation into an electrical voltage, which was recorded on the tape recorder for subsequent playback when the satellite came within range of an acquisition station. The radiometer had an instantaneous field-of-view of about 1.5°, which at a nominal spacecraft altitude corresponded to a ground resolution of approximately 8 km at nadir. Since the radiometer operated in the 3.5 to 4.1 microns region, the daytime pictures include reflected solar radiation in addition to the emitted surface IR radiation. However, the reflected solar radiation did not saturate the instrument, and a usable output was still obtained. In spite of a short operational lifetime (3.5 weeks), the HRIR system successfully demonstrated the feasibility of complete surveillance of surface and cloud features on a global scale during nighttime. With its improved spatial resolution, the radiometer yielded more detailed visual data on the structure of the intertropical convergence zone (ITCZ) and on the formation of tropical storms and frontal systems than had previously been possible.

DATA

DATA PRODUCTS:

NIMBUS-1:

Data Set: HRIR Meteorological Radiation Data
HRIR Photofacsimile Film Strips
HRIR Data Catalog, Photofacsimile Film on Microfiche
Data Catalogs of Radiation Tapes

1. 238 reels magnetic tapes of radiation emitted in 3.5 - 4.1 microns atmospheric window.
2. Film - 186 frames of nighttime cloud cover and Earth surface temperature.
3. 6 cards of black and white microfiche of radiation data.

HIGH-RESOLUTION INFRARED RADIOMETER (HRIR)

DATA PRODUCTS (cont'd):

NIMBUS-2:

Data Set: HRIR Meteorological Radiation on Tape
HRIR Photofacsimile Film Strips
HRIR World Montage Catalog on Microfiche

1. 1760 reels of magnetic tape containing documentation records and information describing the orbit.
2. 70 mm photofacsimile film containing temperature from radiating cloud tops.
3. 4 cards on black and white microfiche representing nighttime HRIR data obtained during 24-hour period.

DATA ARCHIVES LOCATION: NASA Space Science Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: August 29, 1964 to September 22, 1964

REFERENCES

1. NIMBUS High Resolution Radiation Data Catalog and Users Manual, Volume 1, Goddard Space Flight Center, January 1965.
2. Significant Achievements in Space Applications 1966, NASA SP-156, 1967.
3. Goldberg, I. L.: Meteorological IR Instruments for Satellites, Presented at 13th Annual Technical Symposium of Society of Photo-Optical Engineers, August 23, 1967.

SYSTEM CHARACTERISTICS

Weight: 12 lbs.

Avg. Power: 4 Watts

Peak Power: 12 Watts

Components: radiometer, recorder, electronics

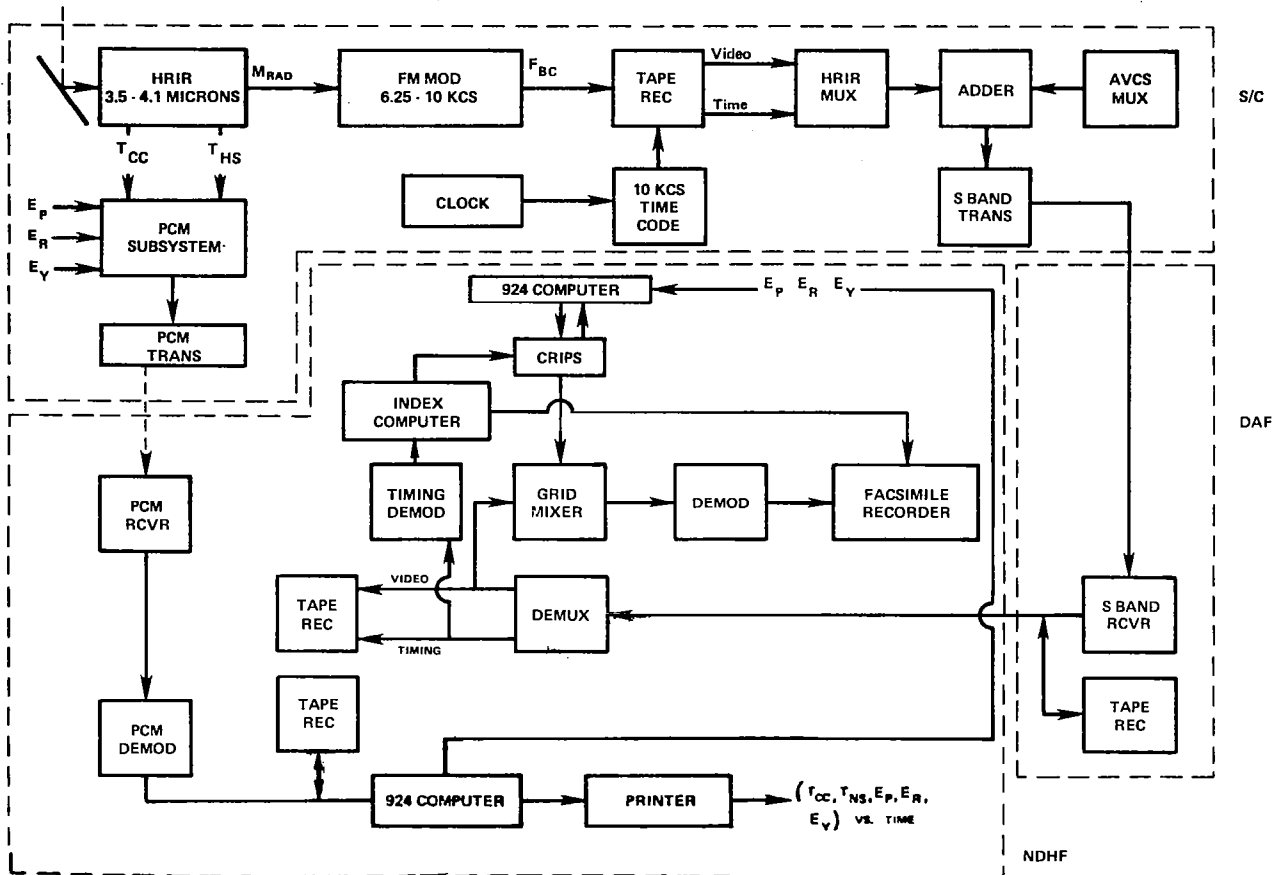
Frequency of Observation: right side of orbit

Data Recovery: delayed telemetry

Precision and Accuracy: noise equiv temp diff of 1 K deg for a 250 deg K background

HIGH-RESOLUTION INFRARED RADIOMETER (HRIR)

FUNCTIONAL DIAGRAM



High Resolution Infrared Radiometer Block Diagram

MEASUREMENTS

Measure thermal radiation in the 3.5 to 4.1 microns window region.

Measurement Range: radiance temperature between 210 and 330K

Spectral Range: 3.5 to 4.1 microns

Field-of-View: 90.0 by 0.5 deg.

POTENTIAL DERIVED PARAMETERS

1. Cloud cover during day and night
2. Storm cycles
3. Cloud top temperature
4. Radiated temperatures of terrain features.

HIGH RESOLUTION INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. B. Schardt
LOCATION: NASA Headquarters

ACRONYM: HRIR
INSTRUMENT TYPE: Radiometer, Dual Channel
SPACECRAFT: NIMBUS-3
CONTRACTOR: ITT
P.I.: G. T. Cherrix, GSFC
L. J. Allison, GSFC

OBJECTIVES

1. To provide both daytime cloud mapping and nighttime radiation measurements on a full time basis.
2. To measure thermal radiation from the Earth.

DESCRIPTION

SUMMARY: The NIMBUS-3 High-Resolution Infrared Radiometer (HRIR) was designed to detect emitted thermal radiation from the Earth-Atmosphere system in the 3.4 to 4.2 micron band, to produce cloudcover pictures, and to measure cloudtop temperatures during the nighttime portion of the orbit. By detecting reflected solar radiation in the 0.7 to 1.3 micron band, the radiometer could also map the Earth's cloud cover during the daytime. Radiant energy from the Earth was collected by a flat scanning mirror inclined at 45° to the optical axis. The mirror rotated at 48 rpm and scanned in a plane normal to the spacecraft velocity. The radiation reflected from the scan mirror was chopped at the focus of a 10.2-cm F/1 modified Cassegrain telescope. The modulated energy was then refocused on a lead selenide detector cell that transformed the received radiation into an electrical output. The output was amplified and recorded on magnetic tape for subsequent playback to a ground acquisition station. Using the direct readout infrared radiometer (DRIR) system, nighttime and daytime data could be transmitted by the real-time transmission system (RTTS) to ground apt stations. A ground resolution of 8.5 km could be obtained at Nadir. The HRIR measured radiance temperatures between 210 and 330° K to a general accuracy of 1° . The experiment was successful. However, after August 1969, noise in the tape recorder system gradually reduced the quality of the data, which caused routine processing of HRIR data to be terminated after January 31, 1970. All experiment operations ceased on January 22, 1972, when the spacecraft was deactivated.

HERITAGE/DERIVATION: Modified version of NIMBUS-1 -2 HRIR.

DATA

DATA PRODUCTS:

Data Set Name

1. HRIR nighttime (3.4 to 4.2 micron) photofacsimile film strips
2. HRIR daytime (0.7 to 1.3 micron) photofacsimile film strips
3. HRIR meteorological radiation tapes
4. NIMBUS- 3 data catalog on microfiche

Film

1. 3235 70 mm photofacsimile film strips, negative or positive
2. 2983 70 mm photofacsimile film strips, negative or positive
3. 55 cards of B/W microfiche arranged in chronological order in a world montage format

HIGH RESOLUTION INFRARED RADIOMETER (HRIR)

Tapes

1. 1815 reels of magnetic tape contain daytime and nighttime radiance values.

DATA ARCHIVES LOCATION: Goddard Space Flight Center

PERIOD OF OPERATION: April 1969 to January 1972.

REFERENCES

1. Goldberg, I. L.: Meteorology Instruments for Satellites, Presented at 13th Annual Technical Symposium of Photo-Optical Engineers, August 23, 1968.
2. NIMBUS-B Press Kit, No. 68-84K, NASA, May 10, 1980
3. NIMBUS-2 User's Guide, GSFC, July 1966.
4. Sabatini, R. R.: NIMBUS-B Data Utilization Plan, Allied Research Assoc., Technical Report No. 4, March 1968.
5. NIMBUS-3 Reference Manual, April 1969.

SYSTEM CHARACTERISTICS

Weight: 18 lbs.

Avg. Power: 9 Watts

Components: radiometer, electronics

Data Recovery: delayed and realtime

Precision and Accuracy: Cloudtop altitude to 1000 ft.; surface temp. to approx. 1 C°

MEASUREMENTS

Measures emitted cloud top and surface radiation during night and day.

Measurement range - radiant temperature between 210 and 330°K.

Channels: 0.7-1.3 microns and 3.4-4.2 microns

Field of view: 90.0 by 0.5 degrees

Pointing accuracy: 1 degree

Ground swath: 1300 nm by 5 nm from 600 nm altitude

POTENTIAL DERIVED PARAMETERS

1. Cloud cover during day and night
2. Storm cycles
3. Cloud top temperatures
4. Radiated temperatures of terrain features.

HIGH RESOLUTION INFRARED RADIATION SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: HIRS
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-6
CONTRACTOR: ITT
P.I.: A. W. McCulloch, GSFC

OBJECTIVES

1. Obtain simultaneous global infrared radiances in the 4.3 micron and 15 micron CO₂ bands.
2. Determine the thermal structure of the atmosphere from the ground to 40 km with the highest atmospheric temperature resolution achievable with IR measurements.

DESCRIPTION

SUMMARY: The High-Resolution Infrared Radiation Sounder (HIRS) supported the GARP data test set by providing vertical temperature profiles twice daily on a global basis, extending up to approximately 40 km, and information on the water vapor distribution in the troposphere. The HIRS measured radiances primarily in five spectral regions -- (1) seven channels near the 15-micrometer CO₂ absorption band, (2) two channels in the IR window, 11.1 and 3.7 micrometers, (3) two channels in the water vapor absorption band, 8.2 and 6.7 micrometers, (4) five channels in the 4.3-micrometer band, and (5) one channel in the visible window 0.69-micrometer region for cloud detection. The sounder consisted of a cassegrain telescope, scanning mirror, dichromatic beam splitter, filter wheel, chopper, and associated electronics. The HIRS scanned the Earth's surface in a plane normal to the spacecraft's orbital path with a maximum scan angle of 30° to either side of the nadir.

DATA

DATA PRODUCTS:

Data Set Name: High Resolution Infrared Radiation Sounder Data on Film

Film: 4 frames seen at vertical or partial scale.

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center,
PERIOD OF OPERATION: June 1975 to May 1976

REFERENCES

1. NIMBUS-6 Users Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

HIGH RESOLUTION INFRARED RADIATION SOUNDER (HIRS)

SYSTEM CHARACTERISTICS

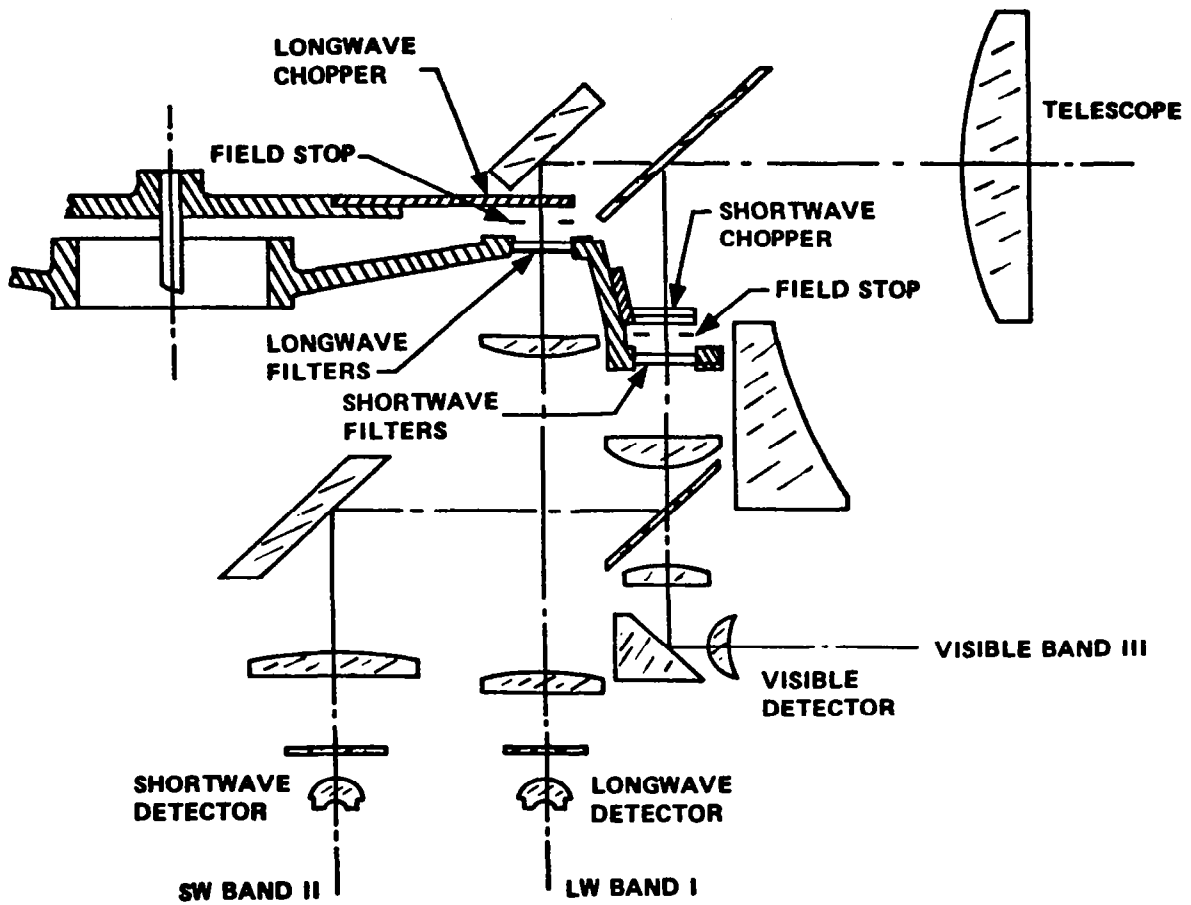
Weight: 45 lbs.

Volume: 1.4 cu. ft.

Avg. Power: 20 Watts

Components: optics, detector, cryostat, electronics

FUNCTIONAL DIAGRAM



High Resolution Infrared Radiation Sounder Schematic Diagram

HIGH RESOLUTION INFRARED RADIATION SOUNDER (HIRS)

MEASUREMENTS

Measurement Range: thermal IR region
Spectral Range: 3.7 to 15 microns
Number of Channels: 17

Channels: 1 - 15 microns
2 - 14.7 microns
3 - 14.4 microns
4 - 14.2 microns
5 - 14.0 microns
6 - 13.6 microns
7 - 13.4 microns
8 - 11.0 microns
9 - 8.2 microns
10 - 6.7 microns
11 - 4.57 microns
12 - 4.52 microns
13 - 4.46 microns
14 - 4.40 microns
15 - 4.24 microns
16 - 3.71 microns
17 - 0.69 microns

Field-of-View: 1.5 by 1.5°

POTENTIAL DERIVED PARAMETERS

1. IR radiances from the Earth
2. Surface temperature
3. Vertical temperature profile from the surface to the 40-km level
4. Vertical water vapor from the surface to the 10-km level
5. Amounts of clouds and cloud heights.

HIGH RESOLUTION INFRARED RADIATION SOUNDER-2

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: HIRS-2
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NOAA-6
CONTRACTOR: ITT
P.I.: A.W. McCulloch, GSFC

OBJECTIVES

1. Obtain simultaneous global infrared radiances in the 4.3 micron and 15 micron CO₂ bands.
2. Determine the thermal structure of the atmosphere from the ground to 40 km with the highest atmospheric temperature resolution achievable with IR measurements.

DESCRIPTION

SUMMARY: The High Resolution Infrared Radiation Sounder-2 (HIRS-2) is a slightly improved version of the Nimbus-6 HIRS. The HIRS measured radiances primarily in five spectral regions -- (1) seven channels near the 15-micrometer CO₂ absorption band, (2) two channels in the IR window, 11.1 and 3.7 micrometers, (3) two channels in the water vapor absorption band, 8.2 and 6.7 micrometers, (4) five channels in the 4.3-micrometer band, and (5) one channel in the visible window 0.69-micrometer region for cloud detection. The sounder consisted of a cassegrain telescope, scanning mirror, dichromatic beam splitter, filter wheel, chopper, and associated electronics. The HIRS scanned the Earth's surface in a plane normal to the spacecraft's orbital path with a maximum scan angle of 30° to either side of the nadir.

HERITAGE/DERIVATION: Nimbus-6 HIRS

DATA

DATA PRODUCTS:

Data Set Name: High Resolution Infrared Radiation Sounder Data on Film
(not commercially available from NOAA)

DATA ARCHIVES LOCATION: National Oceanographic and Atmospheric Administration.

PERIOD OF OPERATION: June 1979 to present.

REFERENCES

1. Nimbus-6 Users Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

HIGH RESOLUTION INFRARED RADIATION SOUNDER-2 (HIRS)

SYSTEM CHARACTERISTICS

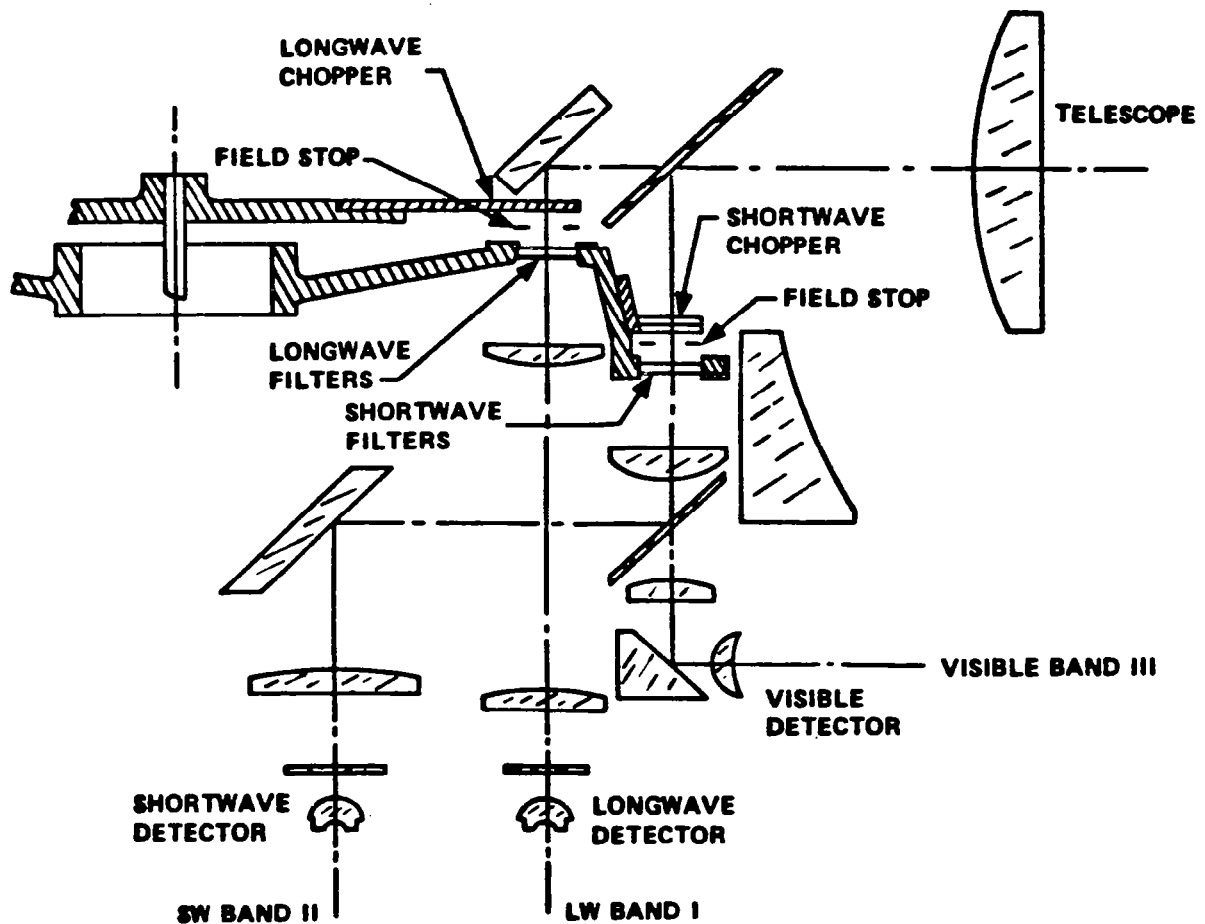
Weight: 45 lbs.

Volume: 1.4 cu. ft.

Avg. Power: 20 Watts

Components: optics, detector, cryostat, electronics

FUNCTIONAL DIAGRAM



High Resolution Infrared Radiation Sounder Schematic Diagram

HIGH RESOLUTION INFRARED RADIATION SOUNDER-2 (HIRS)

MEASUREMENTS

Measurement Range: thermal IR region
Spectral Range: 3.7 to 15 microns
Number of Channels: 17

Channels: 1 - 15 microns
2 - 14.7 microns
3 - 14.4 microns
4 - 14.2 microns
5 - 14.0 microns
6 - 13.6 microns
7 - 13.4 microns
8 - 11.0 microns
9 - 8.2 microns
10 - 6.7 microns
11 - 4.57 microns
12 - 4.52 microns
13 - 4.46 microns
14 - 4.40 microns
15 - 4.24 microns
16 - 3.71 microns
17 - 0.69 microns

Field-of-View: 1.5 by 1.5°

POTENTIAL DERIVED PARAMETERS

1. IR radiances from the Earth
2. Surface temperature
3. Vertical temperature profile from the surface to the 40-km level
4. Vertical water vapor from the surface to the 10-km level
5. Amounts of clouds and cloud heights.

IMAGE DISSECTOR CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. B. Schardt
LOCATION: NASA Headquarters

ACRONYM: IDCS
INSTRUMENT TYPE: Imager
SPACECRAFT: NIMBUS-3 & 4, ATS-3
CONTRACTOR: ITT
P.I.: G. Branchflower, GSFC

OBJECTIVES

1. To acquire high-resolution photographs of the Earth's daytime cloud cover.
2. To evaluate the operational characteristics of the IDC in a space environment, i.e., how electrically scanning as opposed to mechanical scanning, will perform in space.

DESCRIPTION

SUMMARY: The Image Dissector Camera System (IDCS) was designed to take daytime cloud cover photographs. The pictures could be transmitted to APT stations using the real-time transmission system or stored on magnetic tape for subsequent playback to ground acquisition stations. The camera was mounted on the bottom of the satellite sensory ring and pointed vertically down toward the Earth at all times. The image dissector was a shutterless electronic scan and step tube mounted behind a wide-angle (108°) 5.7-mm focal length lens. Scanning and stepping functions occurred continuously while the satellite progressed along its orbital path. The field of view of the optics was 73.6° in the direction of flight and 98.2° in a plane normal to the direction of flight. The image was focused by the optics on a photosensitive surface of the image dissector tube. A line-scanning beam scanned the photosensitive surface at 4 Hz with a frame period of 200 sec. At the nominal spacecraft altitude of 1100 km, each resulting picture was approximately 1400 km on a side with a ground resolution of 3 km at Nadir.

DATA

DATA PRODUCTS:

NIMBUS-3

Data Set: Data Catalogs on microfiche; Film; 51 cards of B/W microfiche of pictorial montages of daily daytime pictures from various orbits.

NIMBUS -4

Data Set Name: NIMBUS-4 Data Catalog on microfiche; Film; 48 B/W cards on microfiche contains pictorial montages from NIMBUS-4 IDCS.

ATS-3

Data Set Name: The ATS Meteorological Data Catalog on microfiche.

Film: 42 cards of B/W microfiche that describe and index the data from the ATS-3 IDCS.

IMAGE DISSECTOR CAMERA SYSTEM (IDCS)

DATA ARCHIVES LOCATION: National Climatic Data Center, Asheville, N.C., National Space Science Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: NIMBUS-3, April 1969 - May 1969
NIMBUS-4, April - 1970
ATS, November 1967 - May 1969

REFERENCES

1. Ostrow, H. and Weinstein, O.: A Review of a Decade of Space Camera Systems Development for Meteorology, Presented at Society of Photo-Optical Instrumentation Engineers, Washington, D. C., August 1968.
2. National Space Science Data Center computer printout 1980.
3. NIMBUS-3 Reference Manual, April 1969.
4. Branchflower, G.; Foote, R.; Figgins, F.; The Applications Technology Satellite Image Dissector Camera Experiment, NASA TN-4186, November 1967.
5. ATS Technical Data Report, Section 8.5, Goddard Space Flight Center, 1968.
6. Meteorological Data Catalog for the ATS, Volume 2, Goddard Space Flight Center, 1968.
7. NIMBUS-4 User's Guide, Greenbelt, MD.

SYSTEM CHARACTERISTICS

Weight: 14 lbs.

Volume: 0.2 cu. ft.

Avg. Power: 12 Watts

Frequency of Observation: 14 pictures/orbit

Data Recovery: delayed and realtime

Precision Accuracy: 800 TV line resolution; S/N = 40 dB at 10,000 foot-lamberts

Components: image dissector, scanning aperture, 12 stage electron multiplier

Standby Power: 1 Watt

IMAGE DISSECTOR CAMERA SYSTEM (IDCS)

FUNCTIONAL DIAGRAM

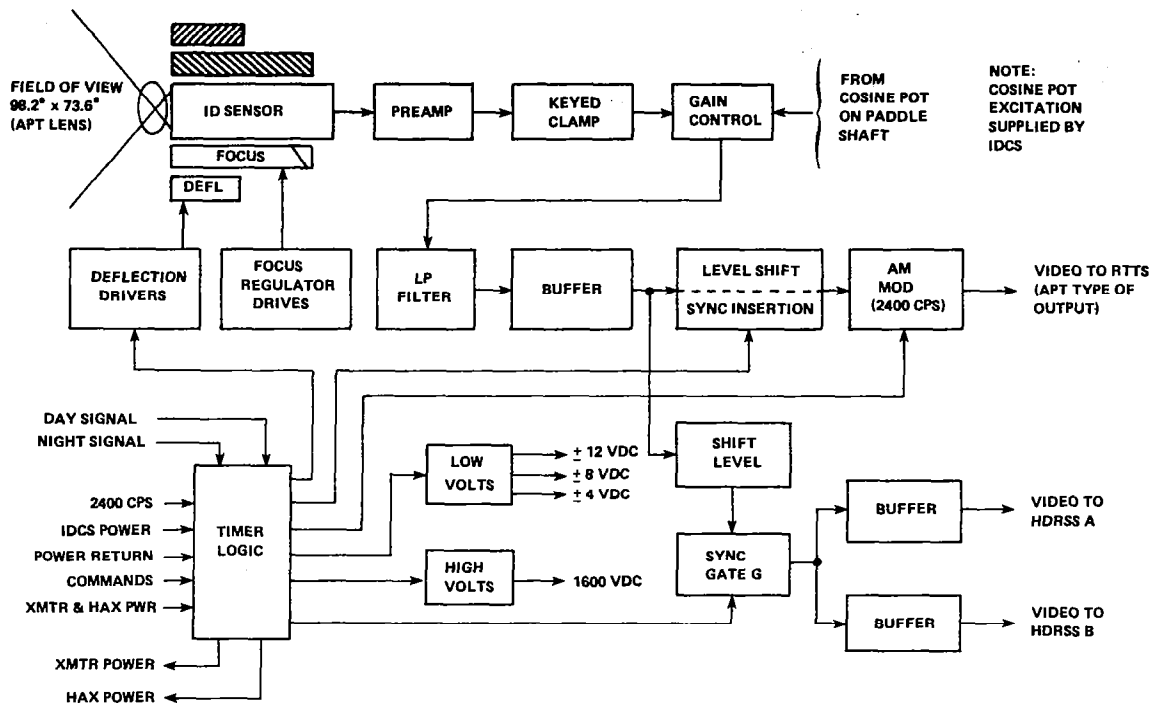


Image Dissector Camera System Block Diagram

MEASUREMENTS

Measure Earth's terrestrial and atmospheric reflection.

Measurement range: 100 to 10,000 ft. lamberts

Field-of-View: 92.0 by 92.0°

POTENTIAL DERIVED PARAMETERS

1. Visible light reflected from Earth and its cloud cover.
2. Daytime cloud cover pictures.

IMAGING SPECTROMETRIC OBSERVATORY

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: G. Eisenwine
LOCATION: NASA Headquarters

ACRONYM: ISO
INSTRUMENT TYPE: Observatory
SPACECRAFT: Spacelab-1
CONTRACTOR: TBD
P.I.: Dr. D. Torz, Univ. of Michigan

OBJECTIVES

Thermospheric studies of:

1. Several metastable species, e.g. $N(2p)$, $N^+(1d)$, $O^+(2d)$, $N(2d)$ and their associated chemistry.
2. The molecular nitrogen system.
3. Metallic trace constituents e.g., Ca, Mg, Fe, K, Li, Na and their ions.
4. The global distribution of He and H.

DESCRIPTION

SUMMARY: The ISO consists of an array of five, pallet-mounted spectrometers and rack-mounted electronics. The instrument is designed to measure the daytime atmospheric emission spectrum at 3-10 angstrom resolution over the wavelength range from 300\AA to $12,000\text{\AA}$. This will provide information on the densities of trace constituents and the excitation processes occurring in the atmosphere. Emission spectra will also be measured of the spacecraft induced atmosphere, artificially induced and natural aurora, and the interplanetary and interstellar medium.

REFERENCES

1. Payloads for Environmental Observations Handout, 1980.
2. STS Payload Planning Data, SP79-MSFC 2327A, Amended November 1979.

SYSTEM CHARACTERISTICS

Weight: 245.3 kg
Dimensions: 1.1 x 0.8 x 1.3 meters
Power: 28 Vdc

IMAGING SPECTROMETRIC OBSERVATORY (ISO)

MEASUREMENTS

Measure trace constituents in the middle atmosphere by High Resolution UV Spectroscopy.

Spectral range: 300-12000Å

Channels: 5 maximum

- Bands:
1. 300-1,000 angstrom
 2. 1,000-3,000 angstrom
 3. 3,000-6,000 angstrom
 4. 6,000-10,000 angstrom
 5. 10,000-12,000 angstrom

POTENTIAL DERIVED PARAMETERS

1. Metastable species and their chemistry.
2. Molecular nitrogen system.
3. Metallic trace constituents, Ca, mg, Fe, K, Li, Na and their ions.

IMPROVED STRATOSPHERIC AND MESOSPHERIC SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: ISAMS
INSTRUMENT TYPE: Radiometer
SPACECRAFT: UARS
CONTRACTOR: Oxford University
P.I.: J.T. Houghton

OBJECTIVES

1. To measure distribution of minor constituents in ozone chemistry.
2. To study the interplay between dynamical, photochemical and radiative processes so that some understanding of stratospheric climate can be achieved.
3. To measure the distribution of important constituents through the altitude region in which they are dissociated so that estimates of rates of production and loss can be made. Such information regarding H₂O and CH₄ have a bearing on the rate of loss of hydrogen from the planet and the evolution of atmospheric composition.

DESCRIPTION

SUMMARY: The ISAMS instrument is designed to view the limb of the atmosphere on either side of the spacecraft normal to the direction of flight. The fore-optics consists of a double-sided scanning mirror and two folded telescopes. Each telescope has an aperture of 180 cm² and consists of a paraboloid, an ellipsoid and a composite field stop with three reflecting facets which define adjacent elements of field-of-view each 0.08° high and 0.8° wide. The plane surfaces of the scanning mirror are mounted at an angle to one another such that if the assembly is positioned with one telescope viewing a particular level in the atmospheric limb the other always has a clear space view so that it can be used as the chopping reference, and vice versa. The positioning of the lines of sight is under the control of a ground-programmable step-scan generator which allows any desired data gathering sequence to be implemented. The chopper is of the reflective rotating type and is positioned where the beams of the telescopes intersect at their first focal points. It interchanges the two composite field stops between the two sets of fore-optics at a frequency of 300 Hz. The facets of the field stop mirrors distribute the beams to various trains of secondary optics containing pressure modulator cells, filters, beam splitters, relay components and detectors.

HERITAGE/DERIVATION: SCR, Nimbus-4 & -5; PMR, Nimbus-6; SAMS, Nimbus-7.

DATA

DATA PRODUCTS: Gridded magnetic tapes, contour maps.

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

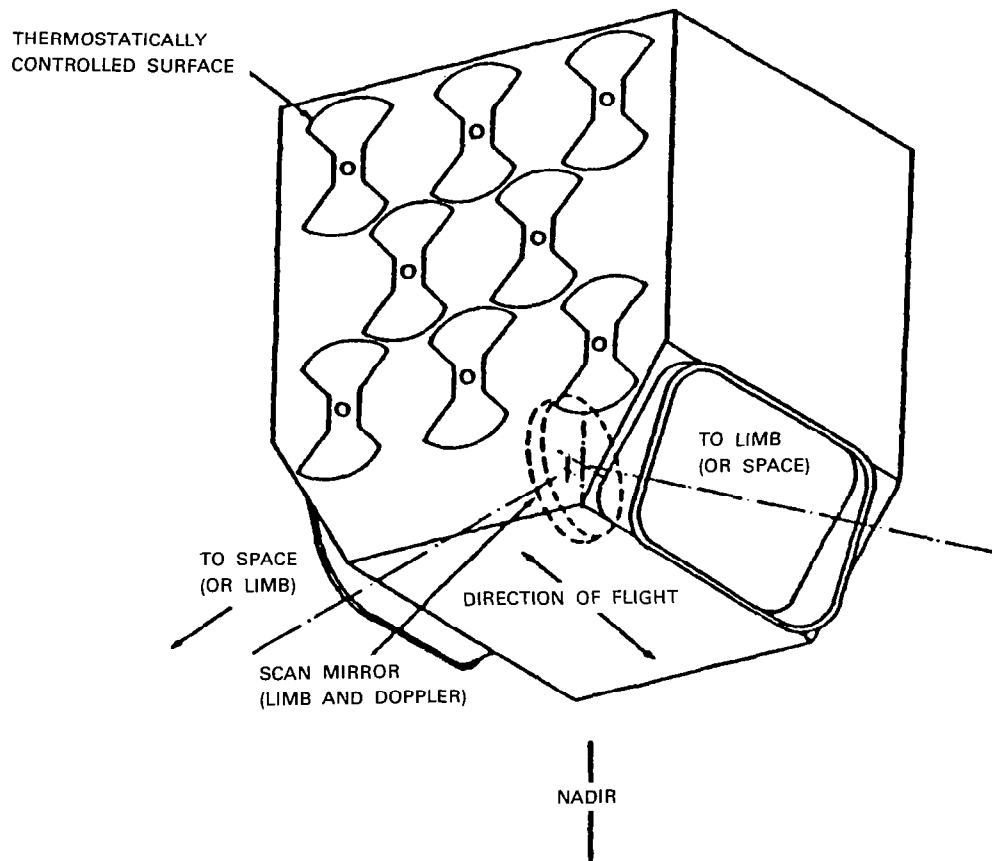
1. UARS Proposal, An Improved Stratospheric and Mesospheric Sounder, Oxford University, Oxford, England, December 1978.

IMPROVED STRATOSPHERIC AND MESOSPHERIC SOUNDER (ISAMS)

SYSTEM CHARACTERISTICS

Weight: 73 kg
Size: .76m x .64m x .9m
Power: 85 W
Data rate: 500 b/s

FUNCTIONAL DIAGRAM



Improved Stratosphere and Mesosphere Sounder Optical Diagram

IMPROVED STRATOSPHERIC AND MESOSPHERIC SOUNDER (ISAMS)

MEASUREMENTS

Observes thermal emissions and resonance fluorescence of solar radiation from atmospheric limb by gas correlation spectroscopy.

Vertical resolution: 4 km

Horizontal resolution: 400 km

Frequency: 25-50 Hz

Chopping rate: 300 Hz

IFOV: $0.8^\circ \times 0.24^\circ$

Limb scan range: 10°

Telemetry: 500 bits/sec

Sampling rate: every 2 seconds

Channels: 1. 15 microns (CO_2)
2. 25-100 microns (H_2O)
3. 7.7 microns (N_2O , CH_4)
4. 4-5.5 microns (CO_2 , NO , $\text{CO}_2 \nu_3$)
5. 2.7 microns (H_2O)

POTENTIAL DERIVED PARAMETERS

Global measurements of the following constituents:

CO_2 , NO , N_2O , H_2O , CO , CH_4

INFRARED INTERFEROMETER/SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: IRIS
INSTRUMENT TYPE:
Interferometer/Spectrometer
CONTRACTOR: Texas Instruments
SPACECRAFT: NIMBUS-3
P.I.: R. A. Hanel, GSFC

OBJECTIVES

1. To determine the vertical profile of temperature.
2. To determine the vertical distributions of ozone and water vapor.
3. To determine the temperature of the Earth's surface or cloud tops.
4. Identify some of the gases present in the atmosphere.
5. Collection of spectra for research studies in meteorology, in radiative transfer, and for non-meteorological purposes.

DESCRIPTION

SUMMARY: The NIMBUS-3 Infrared Interferometer Spectrometer (IRIS) experiment was designed to provide information on the vertical structure of the atmosphere and the emissive properties of the Earth's surface by measuring the surface and atmospheric radiation in the 5.0- to 20-micrometer band using a modified Michelson interferometer. Incoming radiation was reflected into the instrument from a plane mirror. The radiation was split into two beams that recombined and interfered after reflection on a fixed mirror and a moving Michelson mirror. The recombined beam was then focused on a bolometer detector. Interference effects resulted from the optical path difference between the two beams as the mirror moved. The moving mirror traveled about 2 mm in 11 sec to give an interferogram, which was recorded on magnetic tape. The interferograms were transmitted to an acquisition station, where a Fourier transform was performed to produce a thermal emission spectrum of the Earth. From these spectra, vertical profiles of temperature, water vapor, and ozone, as well as other parameters of meteorological interest, could be derived. The instrument had a field-of-view equivalent to a 144-km-diameter circle on the surface of the Earth at a planned orbital height of 1100 km.

DATA

DATA PRODUCTS: 102 reels of magnetic tape of thermal emission spectra of Earth's atmosphere system.

DATA ARCHIVES LOCATION: National Space Sciences Data Center, GSFC.
PERIOD OF OPERATION: April 1969 - July 1969.

INFRARED INTERFEROMETER/SPECTROMETER (IRIS)

REFERENCES

1. Hanel, R. A. and Chaney, L.: The Infrared Interferometer Spectrometer Experiment (IRIS), Vol. 2 - Meteorological Mission, NASA/GSFC Document X-650-65-75.
2. Hanel, R. A. and Chaney, L.: The Merits and Shortcomings of an IRIS to Obtain Meteorological Data, GSFC Report X-620-66-476, October 1966.
3. NIMBUS-3 Reference Manual, April 1969.
4. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 28 lbs.

Avg. Power: 12 Watts

Peak Power: 24 Watts

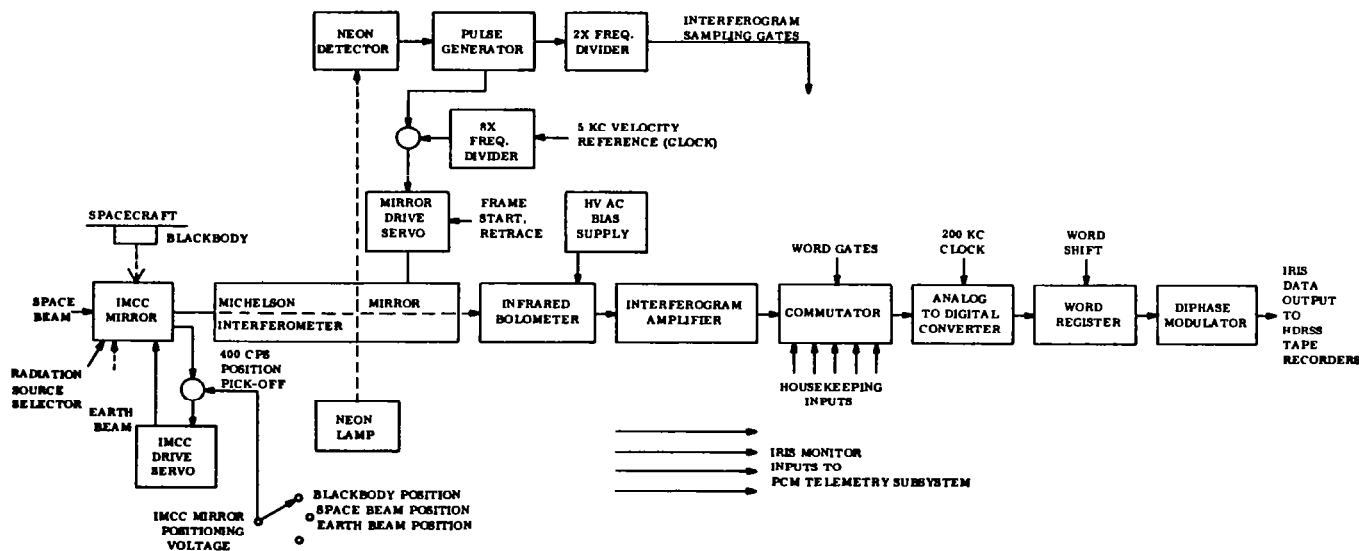
Components: Michelson interferometer spectrometer, rotating meter, bolometer

Frequency of Observation: every 16 seconds

Data Recovery: delayed telemetry

Precision and Accuracy: for temp., 2° C; for water vapor and scale height, 10 percent

FUNCTIONAL DIAGRAM



Infrared Interferometer/Spectrometer Block Diagram

INFRARED INTERFEROMETER/SPECTROMETER (IRIS)

MEASUREMENTS

Measure reflected radiation from atmosphere and Earth's surface.

Measurement Range: near zero to 300°K

Spectral Resolution: 0.1 micron

Spectral Range: 5.0 to 20.0 microns

Field-of-View: 8.0 degrees at 600 nm

POTENTIAL DERIVED PARAMETERS

1. Emission from the Earth from 5 to 20 microns
2. Temperature profiles
3. Atmospheric gases
4. Vertical distribution of ozones.

INFRARED INTERFEROMETER/SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Mission
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: IRIS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-4
CONTRACTOR: Texas Instruments
P.I.: R. A. Hanel, GSFC
Dr. B. Conrath, GSFC

OBJECTIVES

1. Determine the vertical temperature profile.
2. Vertical ozone distribution.
3. Vertical water vapor distribution.
4. Temperature of the Earth's surface or cloud tops.

DESCRIPTION

SUMMARY: This is a Twyman-Green modification of a Michelson interferometer spectrometer operating in the 6.5 to 40 micron wavelength region. Radiation from a cylinder of atmosphere, whose base on the surface of the Earth is a circle of 53 nm in diameter, is reflected into the instrument from a plane mirror which rotates to provide image motion compensation. The radiation is split into 2 beams, one of which is reflected from a moving mirror, recombined and focused onto a bolometer detector. Interference effects result from the path length differences in the two beams as the mirror moves. It travels about 2 mm in 13 seconds to give an interferogram which is recorded on tape. Observations are begun 16 seconds apart in which time the spacecraft travels about 65 nm, thus there is no overlap in successive observations. After recording 14 interferograms, two calibration observations are made, one for a reference blackbody at 300°K and one for outer space. A fourier transformation, performed by digital computer must be made on each telemetered interferogram to produce a spectrum. Then, to relate this to atmospheric conditions appropriate spectral absorption regions must be chosen and employed in an inversion of the radiative transfer equations.

HERITAGE/DERIVATION: Michelson Interferometer, NIMBUS-3 IRIS.

DATA

DATA PRODUCTS:

NIMBUS-4 IRIS Data

1. Data Set Name: IRIS Radiance Tapes

Data Tapes

1. 466 reels of magnetic radiance tape - 9 track, 1600 BPI.

DATA ARCHIVES LOCATION: National Space Sciences Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: April 1970 to January 1972

INFRARED INTERFEROMETER/SPECTROMETER (IRIS)

REFERENCES

1. The NIMBUS-4 User's Guide, GSFC, Greenbelt, MD
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 38 lbs.

Volume: 0.3 cu. ft.

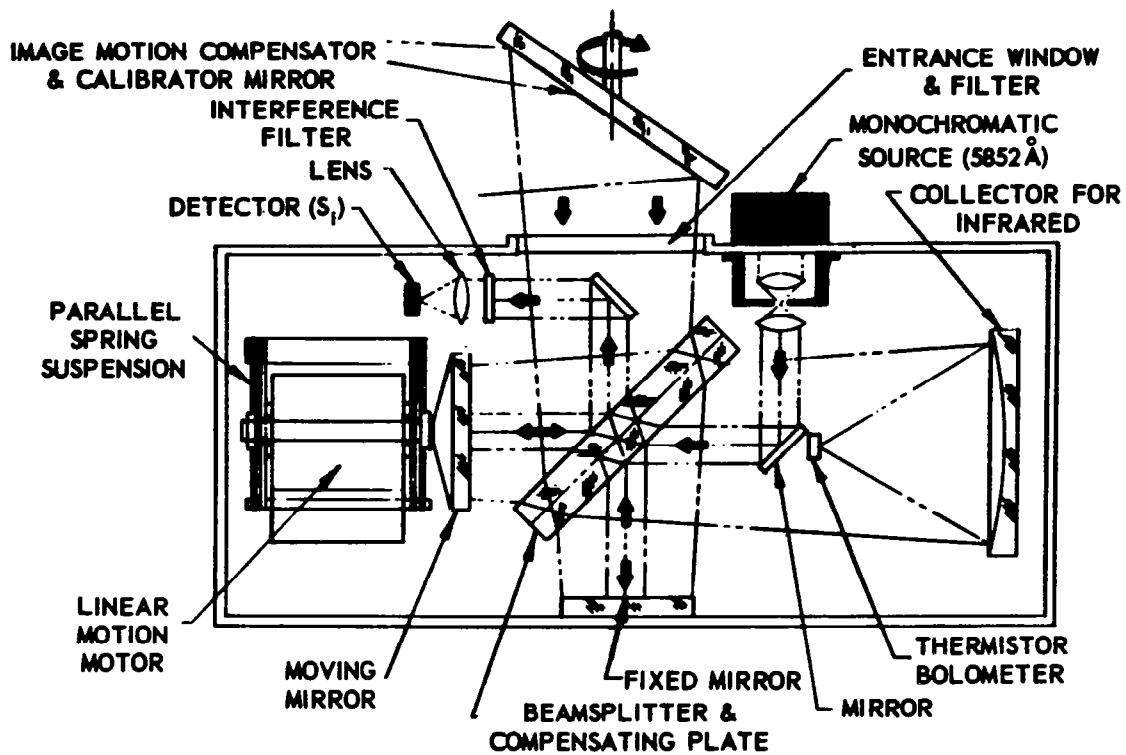
Avg. Power: 12 Watts

Peak Power: 24 Watts

Precision and Accuracy: Temp to 2°K; total water vapor and scale height 5%

Components: interferometer spectrometer, electronics

FUNCTIONAL DIAGRAM



Schematic Diagram of Michelson Interferometer

MEASUREMENTS

Measure surface and atmospheric radiation.

Measurement Range: thermal IR energy

Spectral Resolution: 0.32 microns

Spectral Range: 6.5 to 40.0 microns

Field of View: 5.0 degrees

INFRARED INTERFEROMETER/SPECTROMETER (IRIS)

POTENTIAL DERIVED PARAMETERS

1. Ozone and water vapor distribution.
2. Atmospheric vertical temperature profile.
3. Temperature of earth's surface and cloud tops.

INFRARED SPECTROMETER: EARTH RESOURCES EXPERIMENT

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: T. L. Fischetti
LOCATION: NASA Headquarters

ACRONYM: IRS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: Skylab-1
CONTRACTOR: Block Engineering Co.
P.I.: T. L. Barnett, MSC

OBJECTIVES

1. To make an evaluation of the applicability and usefulness of sensing Earth resources from orbital altitudes in the visible through near-infrared and in the far infrared spectral regions.
2. To assess the value of real-time identification of ground sites by an astronaut.
3. Perform controlled experiments in which applicability of .4 to 2.4 microns and 6.2 to 15.5 microns region of spectrum is quantitatively evaluated from space.

DESCRIPTION

SUMMARY: The Infrared Spectrometer was a dual spectral band system, with its short-wavelength band at 0.4 to 2.4 micrometers, and its long wavelength spectral band at 6.2 to 15.5 micrometers. The field-of-view of the system was one millirad, with a spectral resolution of 1 to 5%. The experiment included a viewfinder tracking system which a crewman used in acquiring and tracking desired sites for S191 use, providing the ability to look at relatively small ground targets about 0.44 km (1/4 nm) in size. A 16 mm camera was used to photograph these sites.

DATA

DATA PRODUCTS: The primary data were recorded on magnetic tape along with data from other sensors in the EREP. The magnetic tape and the film from the viewfinder camera were returned with each crew rotation.

1. Magnetic Tape
2. Film Products

REFERENCES

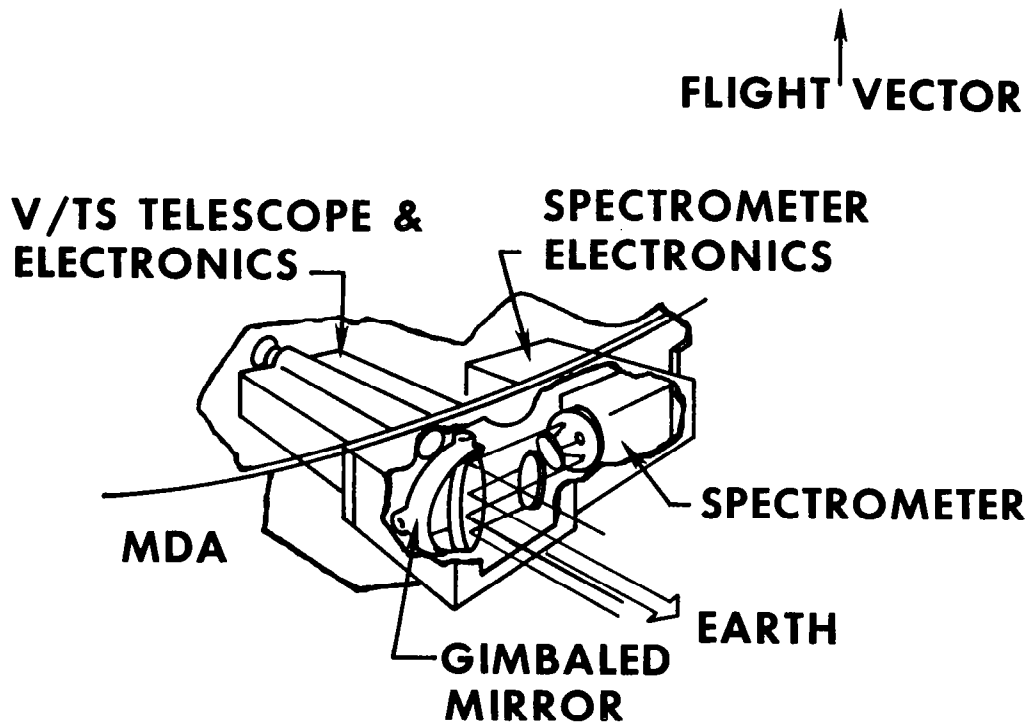
1. National Space Science Data Center computer printout, 1980.
2. Skylab Experiments, August 1972, NASA.
3. Skylab A, EREP Users Handbook, March 1971.

INFRARED SPECTROMETER: EARTH RESOURCES EXPERIMENT (IRS)

SYSTEM CHARACTERISTICS

Precision and Accuracy: 8% absolute in 0.4-2.4 micron region, 72% beyond
Components: collecting optics, filterwheel, detectors, film and magnetic tape
Weight: 300 lbs.
Volume: 11.2 cu. ft.
Avg. Power: 200 Watts
Data Recovery: from film and tape

FUNCTIONAL DIAGRAM



Infrared Spectrometer Schematic Diagram

INFRARED SPECTROMETER: EARTH RESOURCES EXPERIMENT (IRS)

MEASUREMENTS

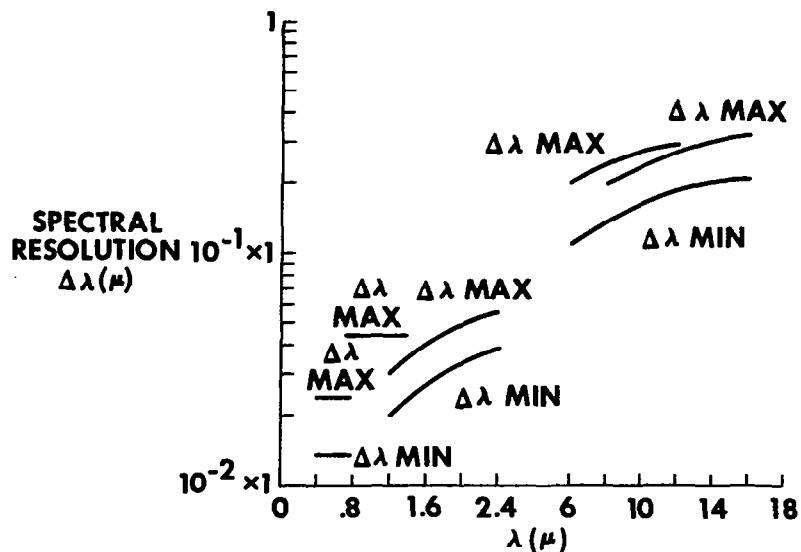
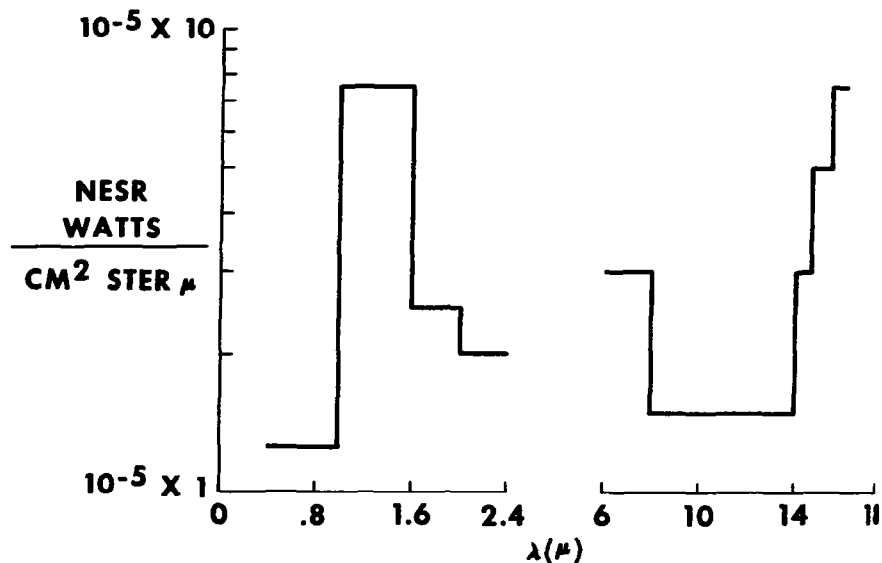
Measurement Range: visible, near IR, and thermal wavelengths

Spectral Range: 0.4 to 15.5 microns

Bands: VIS/IR: 0.4 - 2.4 microns

Far IR: 6.2 - 15.5 microns

Field-of-View: 0.05°



POTENTIAL DERIVED PARAMETERS

1. Surface vegetation extent and health.
2. Geological information.
3. Sea surface temperatures.

INFRARED TEMPERATURE PROFILE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: ITPR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-5
CONTRACTOR: Gulton Industries
P.I.: W. L. Smith, NOAA
D. Q. Wark, NOAA

OBJECTIVES

1. Test an IR radiometer which is designed to meet the engineering and scientific demands of an operational remote temperature sounder.
2. Develop a technique for deriving three-dimensional temperature of the atmosphere.

DESCRIPTION

SUMMARY: The NIMBUS-5 Infrared Temperature Profile Radiometer (ITPR) experiment was designed to test the feasibility and operational applications of a remote sounding technique using simultaneous medium-resolution (32 km) measurements in nine spectral intervals. The radiometer sensed six intervals in the water vapor rotational band near 20 micrometers and two spectral intervals in the atmospheric window regions near 3.8 and 11 micrometers. The ITPR viewed the Earth successively at various angles distributed symmetrically about nadir in a plane normal to the orbital track. Forty-two geographically independent scanspots were taken along a single strip. As the satellite progressed along its orbital path, the radiometer observed 10 such '42-spot' strips to form a matrix of independent scan spots. Each matrix was produced in 222 seconds with the whole scanning sequence repeated every 240 seconds. The matrix data were recorded on magnetic tape for subsequent playback to a ground acquisition station. Matrix measurements taken in the CO₂ and water vapor absorption bands were used to calculate temperature profiles and total water vapor content in the troposphere and lower stratosphere. The two window measurements helped to detect and eliminate cloud contamination of the radiances, thus permitting actual determination of profiles down to the Earth's surface in all but completely overcast areas.

HERITAGE/DERIVATION: Similar to NIMBUS-2 MRIR

DATA

DATA PRODUCTS:

Data Set Name: Infrared Temperature Profile Radiance Observations on magnetic tape.

Tape: 14 reels of 7-track, binary 556 BPI magnetic tapes containing radiance values.

DATA ARCHIVES LOCATION: National Space Sciences Data Center, Goddard Space Flight Center, Greenbelt, Maryland; National Oceanographic and Atmospheric Administration/NESS.

PERIOD OF OPERATION: February 1975 to September 1976

REFERENCES

1. NIMBUS-5 Users Guide, Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

INFRARED TEMPERATURE PROFILE RADIOMETER (ITPR)

SYSTEM CHARACTERISTICS

Weight: 35 lbs.

Volume: 0.84 cu. ft.

Avg. Power: 25 Watts

Components: radiometer, with associated optics, plus electronic package

Precision and Accuracy: better than 0.25 ERG/SEC/SQ-CM/STERADIAN/CM-1

MEASUREMENTS

Measures upwelling radiant flux.

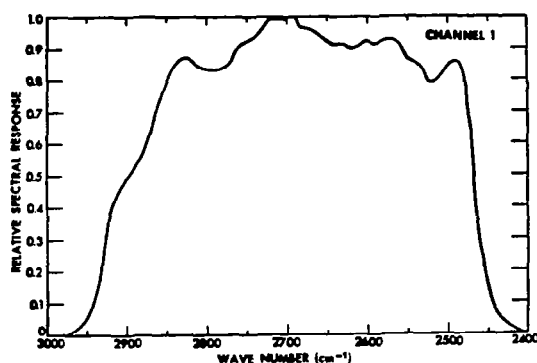
Spectral Range: 3.8 to 20 microns

Field-of-View: 1.5 by 1.5°

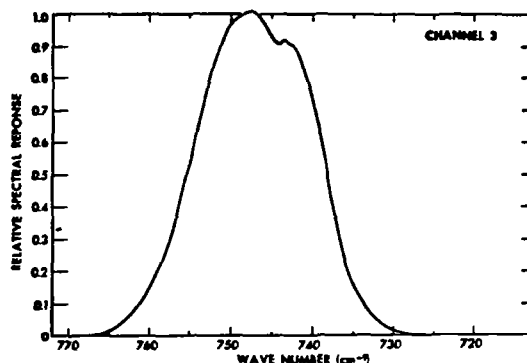
Channels: 2 at 3.8 and 11 microns (atmospheric windows)

4 - near 15 microns (carbon dioxide absorption band)

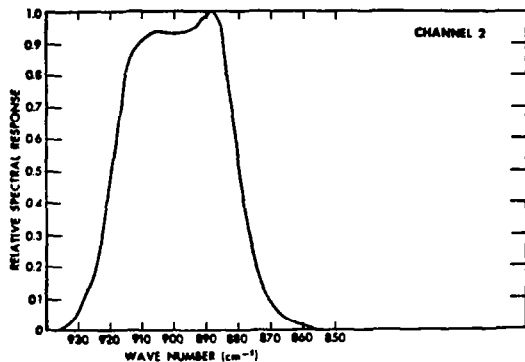
1 - near 20 microns (rotational water vapor absorption band)



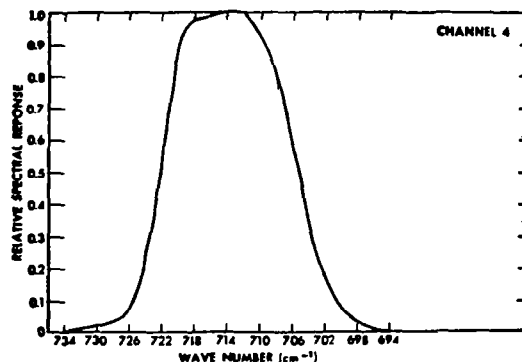
ITPR Channel 1 Spectral Response Function



ITPR Channel 3 Spectral Response Function



ITPR Channel 2 Spectral Response Function

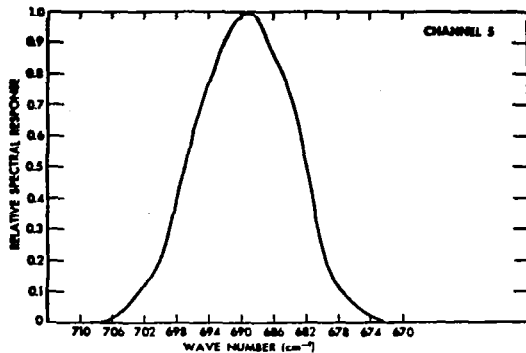


ITPR Channel 4 Spectral Response Function

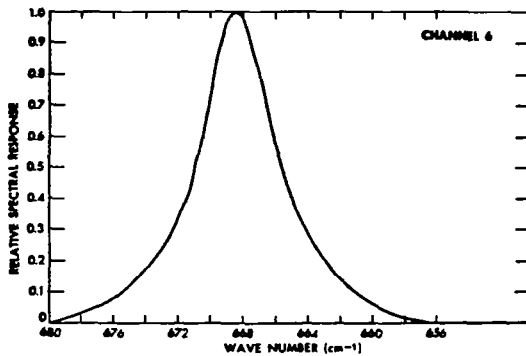
Spectral Response Functions for the ITPR Channels 1 Through 4

INFRARED TEMPERATURE PROFILE RADIOMETER (ITPR)

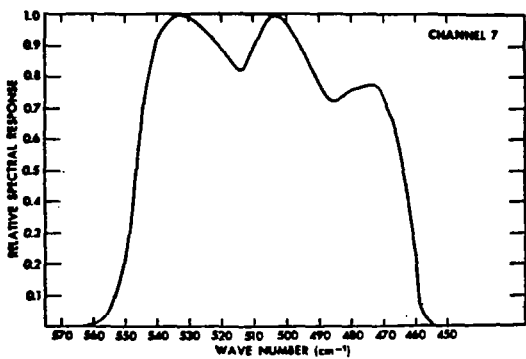
MEASUREMENTS (cont'd)



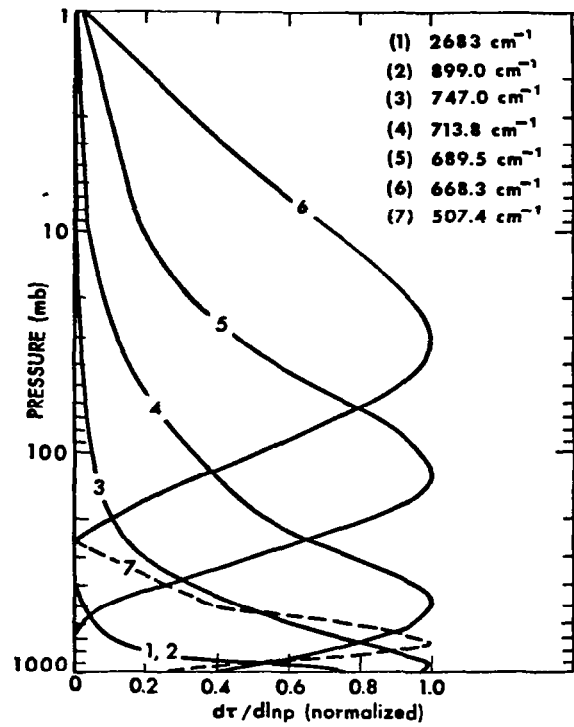
ITPR Channel 5 Spectral Response Function



ITPR Channel 6 Spectral Response Function



ITPR Channel 7 Spectral Response Function



Atmospheric Weighting Functions for ITPR Spectral Channels

Spectral Response Functions for the ITPR Channels 5 Through 7

INFRARED TEMPERATURE PROFILE RADIOMETER (ITPR)

POTENTIAL DERIVED PARAMETERS

1. IR energy emitted from the surface and the Earth.
2. Temperature profiles and water vapor in the lower stratosphere and troposphere.
3. Cloud contamination.

ION CONVECTION ELECTRODYNAMICS

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: ICE
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS
CONTRACTOR: University of Texas
P.I.: R.A. Heelis

OBJECTIVES

1. Measure the bulk ion velocity vector.
2. Derive the ion convection electric field from these data.
3. Use the derived electric field, together with other measurements from UARS (e.g., neutral winds and precipitating particles), as inputs to various modeling programs that deal with the dynamics and chemistry of the mesosphere and thermosphere, and with the electrical coupling between the lower and the upper atmosphere.

DESCRIPTION

SUMMARY: The ICE instrument consists of a planar retarding potential analyzer (RPA) sensor and an ion drift meter (IDM) sensor packaged in a single mount and an electronics box containing the bulk of the instrument electronics circuitry. The RPA instrument gathers and stores data during a one-second instrument cycle period. The stored data is formatted into digital words and telemetered continuously via the allotted digital words. Data from the ion drift meter are in both analog and digital form, and will be presented to the telemeter in real time.

The instrument as proposed requires $1.5 \text{ k bits sec}^{-1}$, but this can be reduced to about $1.1 \text{ k bit sec}^{-1}$ with some sacrifice in the RPA spatial resolution. The analog data requirement consists of 4 outputs sampled 16 times per second. The rest of the data is digital or is A to D converted within the instrument. The resulting digital data, about $900 \text{ bits sec}^{-1}$, will be formatted into telemetry words as required by the spacecraft TM system.

DATA

DATA PRODUCTS: Analog Form
Digital Form

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

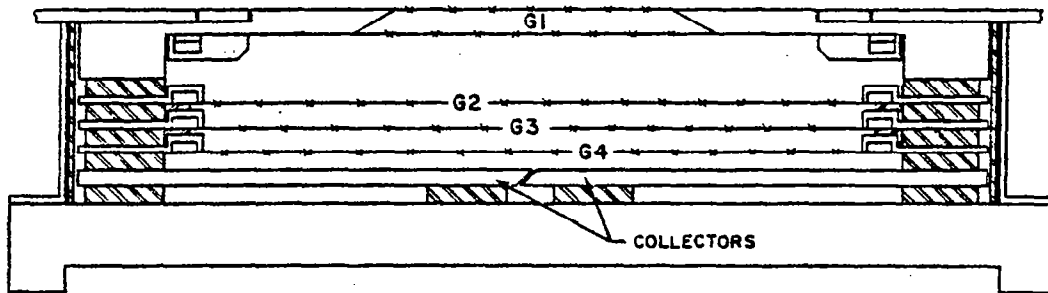
1. UARS Proposal - Ion Convection Electrodynamics for the Upper Atmosphere Research Program, University of Texas at Dallas December, 1978.

ION CONVECTION ELECTRODYNAMICS (ICE)

SYSTEM CHARACTERISTICS

Weight: ~5 kg
Power: ~6 W
Standby power: ~0.01W
Data rate: ~1400 b/s
Volume: ~7900 cm³
Pointing requirements: ~0.05 deg (3 axis)
Conducting ground plane: ~30x40 cm

FUNCTIONAL DIAGRAM

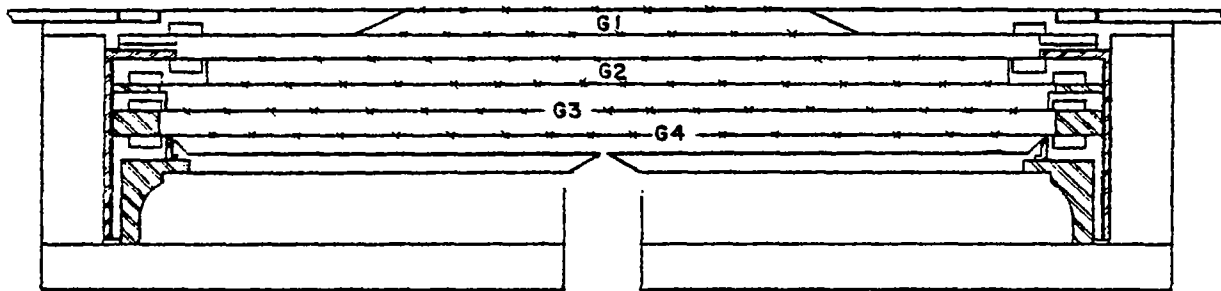


Ice Sensor Schematic

- INSULATOR

GRID DESIGNATORS

- G1 - INPUT (DUAL)
- G2 - SHIELD
- G3 - REPELLER
- G4 - SUPPRESSOR



- INSULATOR

GRID DESIGNATORS

- G1 - INPUT (DUAL)
- G2 - RETARDING (DUAL)
- G3 - SHIELD
- G4 - SUPPRESSOR

IDM Sensor

ION CONVECTION ELECTRODYNAMICS (ICE)

MEASUREMENTS

Measure bulk ion velocity vector to derive the ionospheric convective electric field from the data.

Field-of-View: 2°

Measured Parameter	Range	Sensitivity*	Accuracy	Sampling ⁺ Distance
Bulk Ion Velocity	RAM Component	± 3 km sec	10 m/sec	±15 m/s or 5% < 8 km
	Horizontal	± 3 km sec	2/msec	±15 m/x or 5% ~250 m
	Vertical	± 3 km sec	2 m/s	±15 m/s or 5% ~500 m
Ion Temperature	200-20,000°K		±3%	< 8 km
Ion Concentration	10-10 ⁶ cm ⁻³		±3%	~500 m
Electron Temperature	300-20,000°K		±10%	< 60 km

*10 m/s \approx 0.5 mv/m at high latitude
 \approx 0.25 mv/m at low latitude

⁺Sampling distances are mode sensitive.

POTENTIAL DERIVED PARAMETERS

1. Energetic particles and x-ray imaging (>50° inv. latitude) to obtain atmospheric conductivity and particle heating.

Energy range - 50 ev to 200 mev
 Pitch angle - 0 to 90°
 Spatial resolution 10 km
 Nadir x-ray imaging along orbit path.

2. Winds (global coverage in altitude range 85-200 km). Two horizontal components ±25 to 50 m/s, 100 km spatial resolution.

3. 3 axis magnetic field measurements ±5 γ (>50° inv. latitude), to determine ionospheric current patterns. 1 km spatial resolution.

4. Global coverage of the O₃ and NO concentration profiles (±10%) in the altitude range 40 to 150 km. 100 km spatial resolution.

5. Neutral temperature profile from 40 to 150 km.

6. Measurement of CO₂ IR irradiance from O₂ (Δ) emission at high latitudes to look for 'hot spots' from magnetosphere heat source. 20 km spatial resolution.

LARGE ANTENNA MULTIFREQUENCY MICROWAVE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: D. Broome
LOCATION: NASA Headquarters

ACRONYM: LAMMR
INSTRUMENT TYPE: Microwave Radiometer
SPACECRAFT: TBD
CONTRACTOR: NASA/GSFC
P.I.: E. C. Mundy, Jr.

OBJECTIVES

1. To provide high-resolution radiometric brightness temperature maps of the Earth's surface and atmosphere at multiple frequencies in vertical and horizontal polarization.

DESCRIPTION

SUMMARY: The LAMMR is a multichannel, dual linear polarization microwave radiometer system which operates in five frequency bands from 4.3 to 37 GHz. From a 700 km orbit, the swath width is 1350 km, and the ground resolution varies from 36 km at 4.5 GHz to 7 km at 37 GHz, using a 4 m diameter aperture antenna which rotates 360° continuously at approximately 1 revolution per second. The passive system is operated during 120° (forward direction) of the 360° of rotation to collect the primary passive channel data. An offset parabolic reflector was chosen for the antenna because of its ability to operate over wide frequency ranges with high beam efficiency and low system RF losses. The Cassegrain feed approach for 4.3 to 37 GHz, and the prime-focus approach for 1.4 GHz has tentatively been selected over a total prime-focus approach because of its more compact mechanical configuration which will tend to minimize the anticipated problems in dynamically and statically balancing this sensor at the 1 rps scan rate.

The radiometer electronics subsystem design proposes to use total power radiometers, which are calibrated once a second using ambient loads and cold sky horns on all channels.

HERITAGE/DERIVATION: SEASAT, NIMBUS-7 SMMR

REFERENCES

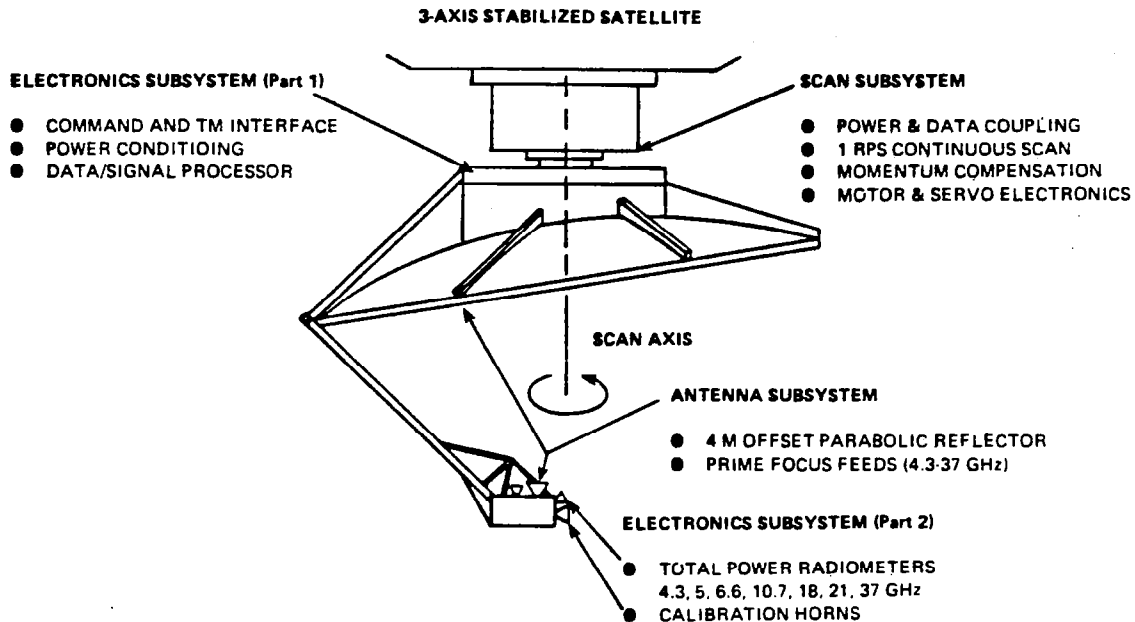
1. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Physical Size: 4 meter diameter antenna
Power Requirement: 235 Watts
Mass: 220 kg
Data Rate: 50 kbps

LARGE ANTENNA MULTIFREQUENCY MICROWAVE RADIOMETER (LAMMR)

FUNCTIONAL DIAGRAM



Large Antenna Multifrequency Microwave Radiometer Schematic Diagram

MEASUREMENTS

Measures microwave emissions over the 4.3 to 36.5 GHz range.

	4.3	10.65	18.7	21.0	36.5
Frequency GHz	4.3	10.65	18.7	21.0	36.5
Surface Resolution, km	21x32	9x13	5.5x7.5	4.5x7	4.5x7
Sensitivity, deg. K	0.167	0.86	1.3	1.43	0.94

POTENTIAL DERIVED PARAMETERS

<u>Parameter</u>	<u>Range</u>	<u>Accuracy</u>	<u>Resolution</u>
Sea-Surface Temp.	-2 to 35°C	1.5°C	25 km
Sea-Surface Temp.	-2 to 35°C	2.5°C	16 km
Oceanic Wind Speed	0 to 50 m/s	2 m/s	20 km
Sea-Ice Coverage	0 to 100%	15%	9 km
	New to Multiyear	New, 1 yr. Multiyear	
Water Vapor-Integrated Atmosphere Water Vapor Content	0 to 6 gms/cm ²	0.2 gm/cm ²	9 km
Liquid Water	0 to 100 mg/cm ²	4 mg/cm ²	9 km

L-BAND RADIOMETER: EARTH RESOURCES EXPERIMENT PACKAGE (EREP)

IDENTIFICATION

DISCIPLINE: Resource Observations

STATUS: Flight Missions

NASA TECH. OFFICER: T. L. Fischetti

LOCATION: NASA Headquarters

ACRONYM: LBR

INSTRUMENT TYPE: Radiometer

SPACECRAFT: Skylab-1

CONTRACTOR: Airborne Inst. Labs

P.I.: D. Evans, JSC

OBJECTIVES

1. To measure brightness temperature of the terrestrial surface in order to compile a comprehensive surface brightness temperature map.
2. To determine the dielectric constant and the ratio of electrical-to-thermal effective depth along the Earth's surface by comparing radiometer data with simultaneous measurements made at various ground locations.

DESCRIPTION

SUMMARY: This Skylab experiment was to supplement experiment S193 (73-027A-20) in measuring brightness temperature of the Earth's surface along the spacecraft track, which would provide ocean surface features, meteorology winds and earth surface features. The S194 experiment was a passive microwave sensor utilizing a fixed planar array antenna. S194 recorded the brightness temperature of the Earth in the L-band range with a digital output giving an absolute antenna temperature to an accuracy of one degree K. The system utilized a built-in calibration scheme that sampled known sources. The spatial characteristics were a half power beam width of 15 degrees, first null beam width of 37 degrees (97 percent of power) and having a circular footprint of approximately 111 km (60 nautical miles) diameter (half power) at the expected 435 km (235 nautical miles) altitude. All data were recorded on magnetic tapes. The data output was at 200 bps.

DATA

DATA PRODUCTS: Output is 18 10-bit words, PCM - signal recorded on magnetic tape - 200 bits/sec.

Data Set Name: Earth Resources Data Catalog on Microfiche

DATA ARCHIVES LOCATION: EROS Data Center, Sioux Falls, South Dakota.

REFERENCES

1. Experiment Implementation Plan for Manned Spaceflight Experiment Title: L-Band Microwave Radiometer - Skylab-A, EREP User's Handbook, NASA/MSC, February 1971.
2. National Space Science Data Center computer printout, 1980.
3. Skylab Experiments, August 1972, NASA.

L-BAND RADIOMETER: EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (LBR)

SYSTEM CHARACTERISTICS

Weight: 38 lbs.

Volume: 10.3 cu. ft.

Avg. Power: 10 Watts

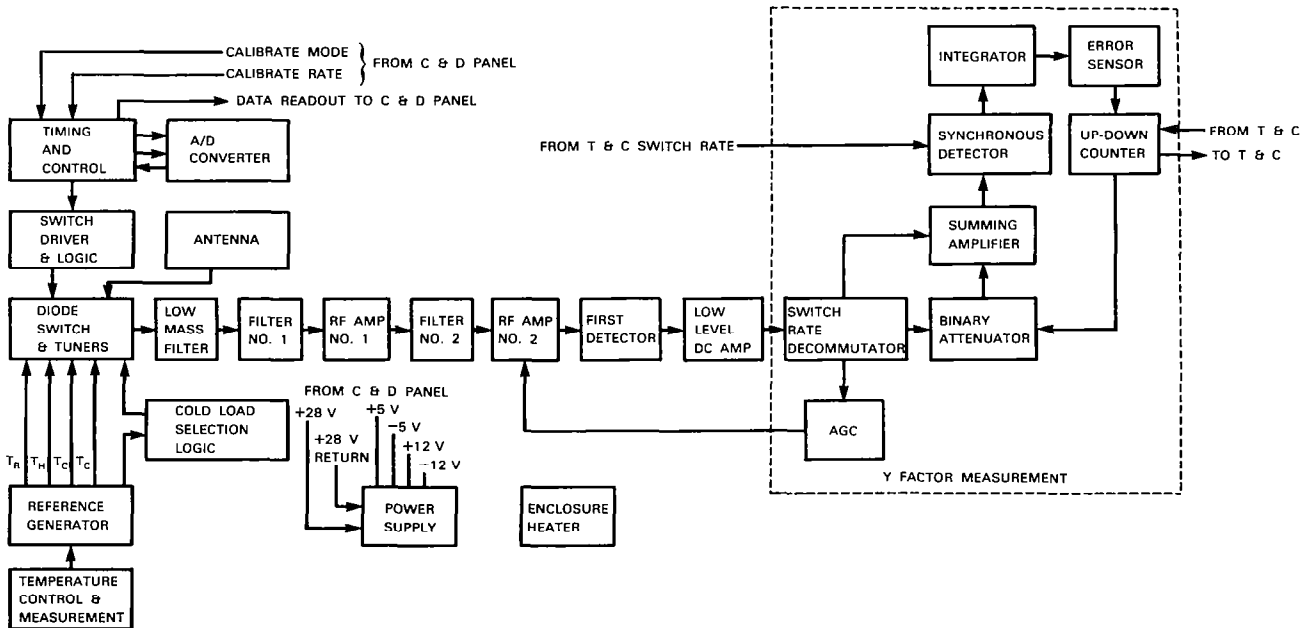
Peak Power: 15 Watts

Components: antenna, receiver, reference loads, recorder, electronics

Data Recovery: from returned tapes

Precision & Accuracy: better than 1°K

FUNCTIONAL DIAGRAM



L-Band Radiometer Block Diagram

L-BAND RADIOMETER: EARTH RESOURCES EXPERIMENT PACKAGE (ERP) (LBR)

MEASUREMENTS

Measures brightness temperature of the surface.

Measurement Range - L-band.

Resolution: 111 km at 235 nautical miles

Operating Frequency: 1.42 GHz

FOV: 15 deg.

Data Output: 200 bps

POTENTIAL DERIVED PARAMETERS

1. Ocean surface features.
2. Wind and Earth surface feature.

LIDAR SYSTEM FOR OH AND O₃

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: R. McNeal
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: LIDAR
SPACECRAFT: A/C
CONTRACTOR: NASA/Goddard Space Flight Center
P.I.: W. Heaps, GSFC

OBJECTIVES

1. To measure concentration of hydroxyl radical in the upper troposphere.
2. To map 3D the intrusion of ozone rich stratospheric air into troposphere.

DESCRIPTION

SUMMARY: This instrument is essentially identical to a balloon-borne laser radar (lidar) being assembled at GSFC for measuring hydroxyl radical (OH) and ozone (O₃). This instrument is proposed for flight on a NASA WB-57 aircraft. This system is designed to obtain ozone profiles and hydroxyl concentrations in the 12-22 km altitude range along with seasonal variations. Aerosol concentrations can be obtained from the ozone lidar backscatter.

HERITAGE/DERIVATION: Balloon-borne lidar

REFERENCES

1. Proposal for "An Aircraft Borne Lidar System for Simultaneous Hydroxyl and Ozone Measurements", June 23, 1978.

DATA

DATA PRODUCTS: TBD

DATA ARCHIVES LOCATION: TBD

PERIOD OF OPERATION:

SYSTEM CHARACTERISTICS

Weight: 2500 lbs.
Size: 3° x 4° x 12° long (lab model)
Power: 1500 Watts
Data Rate: <50 kbs

LIDAR SYSTEM FOR OH AND O₃

MEASUREMENTS

1. OH is measured by remote laser induced fluorescence in which the laser transmits a wavelength which excites the measured species and the strength of the resulting fluorescence is measured.
2. O₃ is measured by the differential absorption technique in which several wavelengths are simultaneously transmitted and the relative intensity of the backscattered return is related to the abundance of the measured species.

Horizontal spatial resolution: 50 meters

Vertical resolution: 150 meters

Wavelengths: 282 nm; 355 nm

Detection channels: 3

282 nm

355 nm

305-315 nm

POTENTIAL DERIVED PARAMETERS

1. Ozone (O₃) profiles
2. Aerosol concentrations
3. Hydroxyl (OH) concentrations
4. Other species such as H₂O, NO and NO₂.

LIMB INFRARED MONITOR OF THE STRATOSPHERE

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. Theon
LOCATION: NASA Headquarters

ACRONYM: LIMS
INSTRUMENT TYPE: VIS/IR Spectroradiometer
SPACECRAFT: NIMBUS-7
CONTRACTOR: Honeywell
P.I.: J. Gille, NCAR
J.M. Russell, LaRC

OBJECTIVES

1. To map the vertical profiles of temperature and the concentration of ozone, water vapor, nitrogen dioxide, and nitric acid in the lower to middle stratosphere range, with extension to the stratopause for water vapor and into the lower mesosphere for temperature and ozone.

DESCRIPTION

SUMMARY: The Limb Infrared Monitor of the Stratosphere (LIMS) experiment has a six-channel infrared (IR) radiometer that incorporated Hg-Cd-Te detectors cooled by a two-stage solid cryogen cooler. The radiometer mapped vertical profiles of thermal IR emission coming from the horizon in six bands (6.2, 9.5, 11.3, 14.9, and 15.2 micrometers) of the atmospheric constituents of interest. Two of the channels were used to determine radiance profiles of emission by CO₂. These profiles were mathematically inverted to obtain temperature versus pressure. The inferred temperature profile, together with radiance profiles in the other spectral bands, were then used to infer the vertical distribution of trace constituents. The temperature was determined to an accuracy of about 1.5°K. Constituent concentrations were determined with an accuracy of about 20 percent, with the exception of NO₂ which was determined to within about 50 percent. Instantaneous vertical field-of-view at the horizon was 2 km for the temperature, ozone, and nitric acid channels and 4 km for the NO₂ and water vapor channels.

HERITAGE/DERIVATION: NIMBUS-6 Limb Radiance Inversion Radiometer (LRIR)

DATA

DATA PRODUCTS:

COMPUTER COMPATIBLE TAPES

RAT (Radiance Archival Tape)
IPAT (Inverted Profile Archival Tape)
MAT (Map Archival Tape)
SMAT (Stacked Map Archival Tape)
CAT (Cross-section Archival Tape)
SCAT (Summary Cross-section Archival Tape)
MATRIX-M (Map Data Matrix Tape)
MATIC-C (Cross-section Data Matrix Tape)
PROFILE-R (Radiance Profile Tape)
PROFILE-I (Inverted Profiles and Radiance Tape)

DISPLAY PRODUCTS

Map Sets
Cross Section Sets
Profile Sets
Plots
Microfilm

DATA ARCHIVES LOCATION: National Space Sciences Data Center/Goddard Space Flight Center.

PERIOD OF OPERATION: October 1978 to present.

LIMB INFRARED MONITOR OF THE STRATOSPHERE (LIMS)

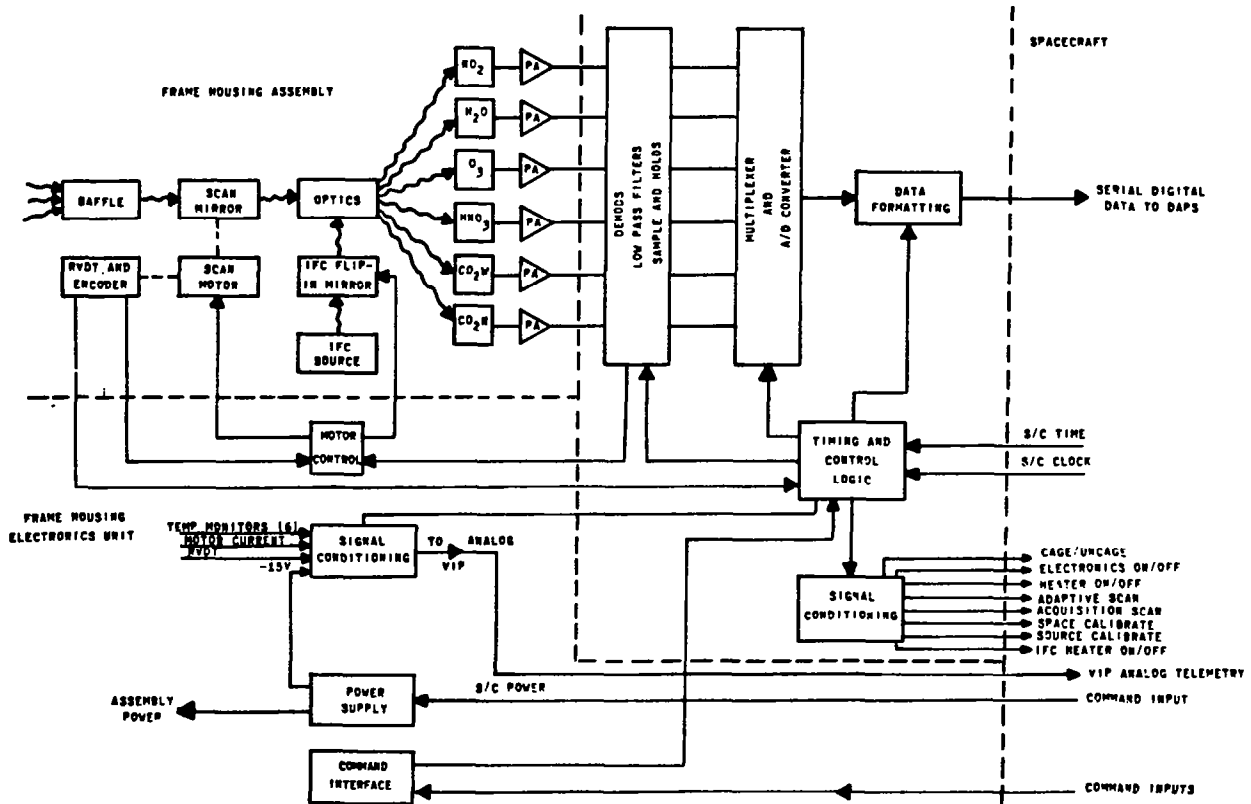
REFERENCES

1. The NIMBUS-7 User's Guide, NASA/GSFC, August 1978.
2. National Space Science Data Center computer printout, 1980.

SYSTEM DESCRIPTION

Number of channels: 6
 Resolution: 0.5 mrad
 FOV: 2 degrees

FUNCTIONAL DIAGRAM



Limb Infrared Monitor of the Stratosphere System Block Diagram

LIMB INFRARED MONITOR OF THE STRATOSPHERE (LIMS)

MEASUREMENTS

Measures infrared radiation emitted by the atmosphere.

Characteristics of LIMS Channels

No.	Gas	Band Pass 5% Relative Response Points	Band Pass 50% Relative Response Points	Field of View		Noise Equivalent Radiance NEN (Watt/m ² -n)
				Vertical	Horizontal	
1	NO ₂	1560 – 1630 cm ⁻¹ (6.4 – 6.1 μm)	1580 – 1613 cm ⁻¹ (6.3 – 6.2 μm)	3.6 km	28 km	0.0006
2	H ₂ O	1370 – 1560 cm ⁻¹ (7.3 – 6.4 μm)	1396 – 1527 cm ⁻¹ (7.2 – 6.5 μm)	3.6 km	28 km	0.0021
3	O ₃	926 – 1141 cm ⁻¹ (10.8 – 8.8 μm)	947 – 1103 cm ⁻¹ (10.6 – 9.1 μm)	1.8 km	18 km	0.0035
4	HNO ₃	844 – 917 cm ⁻¹ (11.8 – 10.9 μm)	859 – 900 cm ⁻¹ (11.6 – 11.1 μm)	1.8 km	18 km	0.0015
5	CO ₂ W	579 – 755 cm ⁻¹ (17.3 – 13.2 μm)	595 – 739 cm ⁻¹ (16.8 – 13.5 μm)	1.8 km	18 km	0.005
6	CO ₂ N	637 – 673 cm ⁻¹ (15.7 – 14.9 μm)	645 – 673 cm ⁻¹ (15.5 – 14.9 μm)	1.8 km	18 km	0.0013

POTENTIAL DERIVED PARAMETERS

1. Chemistry and transport of stratospheric NO_x including sources and sinks, and possible feedbacks upon the dynamics.
2. Initial analyses of a variety of stratospheric dynamic phenomena, including planetary waves, equatorial waves, and high frequency waves, plus global modes.
3. Relationship between temperature and O₃ mixing ratio and its dependence on height, latitude, and season in the photochemically controlled altitude regions.
4. Response of LIMS measured fields to perturbations within the Earth's geophysical environment due to solar and cosmic ray variability, etc., and how these changes might correlate with temperature.
5. Temporal and spatial distributions of transports of chemical constituents, heat, momentum, energy, and potential vorticity by geostrophic and possibly ageostrophic motions.
6. Climatology of the northern and southern hemispheres, with statistical information on the temporal and spatial variability of the stratospheric variables.
7. Day-night difference in trace gas concentrations (especially NO₂ and O₃) and temperature.
8. Improved constituent profiles in radiative energy budget calculations of the middle atmosphere.
9. Stratospheric-troposphere exchange, with particular emphasis on O₃ injections and tropopause folding.

LIMB RADIANCE INVERSION RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: LRIR
INSTRUMENT TYPE: IR Radiometer
SPACECRAFT: NIMBUS-6
CONTRACTOR: National Center for
 Atmospheric Research
P.I.: J. C. Gille, Florida State University
 F. B. House, Drinel University

OBJECTIVES

1. Acquire and present global measurements of temperature, ozone and water vapor in the stratosphere and lower mesosphere for one year.
2. Obtain the geostrophic component of the wind up to a level of 1 mb (~48 km) through integration of the temperature profile in the thermal wind equation.

DESCRIPTION

SUMMARY: The NIMBUS-6 Limb Radiance Inversion Radiometer (LRIR) provided calibrated radiance versus altitude profiles by intercepting radiation emanating from an atmospheric path which is tangential to a particular geocentric height. The LRIR sensed radiation in four spectral intervals -- (1) the 14.6- to 15.9-micrometer CO₂, (2) the 14.20 to 17.3-micrometer CO₂ band, (3) the 8.8- to 10.1-micrometer ozone band, and (4) the 20- to 25-micrometer water vapor rotational band. Measurements taken in the two CO₂ channels and the water vapor channel were used to calculate global temperature and water vapor profiles in the stratosphere and lower mesosphere. In addition, values of the geostrophic wind up to 1 mb (approximately 48 km) were derived analytically from the deduced temperature profiles. The radiometer included an optical system, a scanning mirror, choppers, and associated electronics and employed an ammonia-methane cooler system for three of the four detector channels. While the deduced temperature profiles had an rms accuracy of ±3° at heights above 15 km, the values for ozone were accurate to within ±20% at 1 mb. Water vapor values at the same height were within 50 percent.

DATA

DATA PRODUCTS:

Form	Volume (reels)	Format	Characteristics
Radiance Archival Tape	470	7 track, 800 BPI Packed Binary	All useable limb radiance observations, as well as decalibration parameters, spacecraft status, ephemeris data, and tangent point annotators.
Inverted Profile Archival Tape	23	7 track, 800 BPI Packed BCD	Inverted profiles of temperature, ozone concentration, and water vapor concentration, and water vapor concentration at pressure points spaced 1.5 km vertically (relative altitude). Parameters are interpolated for, and thicknesses computed between, the pressure levels of 100, 70, 50, 30, 10, 5, 2, 1, 0.4, and 0.1 mb.
Map Archival Tape	23	7 track, 800 BPI Packed BCD	"Synoptic" maps of temperature, ozone concentration, water vapor concentration, and geostrophic winds (where possible) at the standard pressure levels of 100, 70, 50, 30, 10, 5, 2, 1, 0.4, and 0.1 mb.

Volume and Characteristics of LRIR Archival Data

LIMB RADIANCE INVERSION RADIOMETER (LRIR)

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center.

REFERENCES

1. NIMBUS-6 Users Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 89 lbs.

Volume: 3.2 cu. ft.

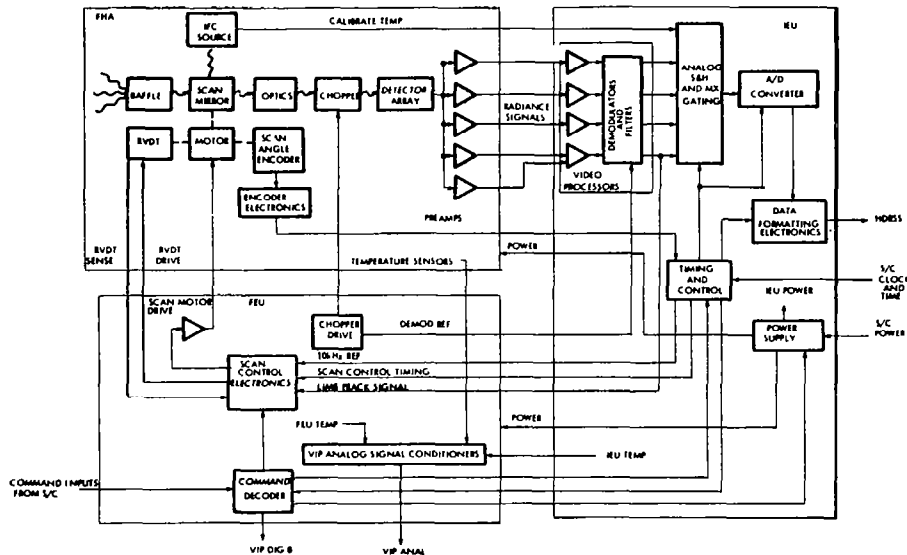
Avg. Power: 37 Watts

Components: radiometer, cooler, electronics

Data Recovery: telemetry

Precision and Accuracy: Temperature $\pm 3^{\circ}\text{K}$, wind ± 7 m/sec, ozone $\pm 18\%$, water vapor $\pm 53\%$

FUNCTIONAL DIAGRAM



Limb Radiance Inversion Radiometer Block Diagram

MEASUREMENTS

Horizon's emitted radiances in four IR spectral regions.

Measurement Range: 8.8 - 10.1, 14.6 - 15.9, 14.2 - 17.1, 20 - 25 microns

Spectral Range: 8.8 to 25 microns

Field-of-View: 0.3 deg

POTENTIAL DERIVED PARAMETERS

1. Measure the stratosphere temperature structure.
2. Ozone density and water vapor distribution.
3. Geostrophic winds.

LOW-RESOLUTION NON-SCANNING RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. L. Garbacz
LOCATION: NASA Headquarters

ACRONYM: LRNR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: TIROS-2, 3, 4
CONTRACTOR: Barnes Engineering
P.I.: Dr. R. Hanel

OBJECTIVES

1. To measure the thermal and reflected solar radiation from the Earth.
2. To permit the determination of the apparent blackbody temperatures and albedo of the Earth.

DESCRIPTION

SUMMARY: This Low-Resolution Non-Scanning Radiometer consists of two detectors. One of these is a black thermistor bolometer detector and the other a white one, each of which is mounted in the apex of a highly reflective cone. The black detector is equally sensitive to reflected sunlight and to long wave terrestrial radiation (0.2 to 50 microns). The white detector is coated to be reflective in the visible and near infrared, thus, it measures only long wavelength thermal radiation (5 to 50 microns). These detectors present the instrumentation package with resistances which vary with radiation. From the detected values the heat balance of an area can be computed. The field when viewing directly below is parallel to the spin axis and is a circle of 470 nm diameter (50° field-of-view). This view observes an area which is within the field of the wide angle television camera. The output of each detector is amplified, and the resulting signal is used to modulate separate audio-frequency oscillators. This modulated output is processed through the time-sharing switching circuit with the output of the scanning radiometer.

DATA

DATA PRODUCTS: Magnetic tapes (poor quality; not analyzed or reduced).

DATA ARCHIVES LOCATION: World Data Center, Asheville, North Carolina.

PERIOD OF OPERATION: TIROS-2: November 1960-February 1961
TIROS-3: July 1961-October 1961
TIROS-4: February 1962-June 1962

REFERENCES

1. IR and Reflected Solar Radiation Measurements from TIROS 2 Meteorological Satellite, NASA TN D-1096, November 1961.
2. Bandeen, W. R.: Experimental Approaches to Remote Atmospheric Probing in the IR from Satellites, NASA TM X-63188, May 1968.
3. Bartko, F., et. al.: TIROS Low Resolution Radiometer, NASA TN D-614, September 1964.
4. National Space Science Data Center computer printout, 1980.

LOW-RESOLUTION NON-SCANNING RADIOMETER (LRNR)

SYSTEM CHARACTERISTICS

Weight: 2 lbs
Avg. Power: 5 Watts
Peak Power: 30 Watts
Components: 2 thermistors, reference resistors, electronics
Data Recovery: delayed telemetry
Precision and Accuracy: S/N better than 30 dB

MEASUREMENTS

Measures thermal and reflected solar radiation from Earth atmosphere system.
Measure radiation heat balance of Earth-atmosphere system

Spectral Range: 0.2 to 50 microns
Field-of-View: 50 degrees
Spatial Resolution: 470 nm at center from 475 nm alt

POTENTIAL DERIVED PARAMETERS

1. Thermal and reflected solar radiation from Earth
2. Heat balance of Earth atmosphere system
3. Blackbody temperatures
4. Albedo of the Earth.

LOW-RESOLUTION OMNIDIRECTIONAL RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. L. Garbacz
LOCATION: NASA Headquarters

ACRONYM: LROR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: TIROS-3, 4, 7
CONTRACTOR: University of Wisconsin
P.I.: Dr. V. E. Suomi
University of Wisconsin

OBJECTIVES

1. To measure the gross heat budget of the Earth.
2. To determine how much solar energy is absorbed, reflected, and emitted by the Earth and its atmosphere.

DESCRIPTION

SUMMARY: This experiment was flown in an identical configuration on TIROS-3, 4, and 7, two wide angle (55° field-of-view) low-resolution IR detection devices, each composed of a black-and-white bolometer and a reflecting mirror, are mounted 180° apart on telescoping supports which project from the side of the spacecraft. The mirrors shield each sensor from direct radiation emitted by the satellite's body. Both bolometers have a high absorptivity to the IR radiation from the Earth. The black bolometer also has a high absorptivity for solar radiation. Thus reflected and emitted radiation can be separated. Thermistors, fastened inside of the hemispheric shells, measure sensor temperatures. Because of the limited telemetry capability, matched pairs of thermistors are connected in series with similar sensors on opposite sides of the spacecraft. Therefore, the measured sensor temperature received from the satellite is an average of two temperatures from matched thermistors. The information telemetered to Earth includes temperatures of the mirrors and sensors and a fixed resistance value which allows one to compensate for drift of the electronics in the satellite.

HERITAGE/DERIVATION: Similar to Explorer 7.

DATA

DATA PRODUCTS:

TIROS-2

Data Set: Low Resolution Omnidirectional Radiometer Temperature Tapes.

Tape: 5 reels magnetic tape of temperature data.

TIROS-4

Data Set: Low Resolution Omnidirectional Radiometer Temperature Tapes.
Omnidirectional Radiometer Radiance Value Tapes.

Tape: 10 reels magnetic tape of black and white sensor temperature values.
2 reels magnetic tape of longwave radiation values.

LOW-RESOLUTION OMNIDIRECTIONAL RADIOMETER (LROR)

DATA PRODUCTS (cont'd)

TIROS-7

Data Set: Low-Resolution Omnidirectional Radiometer Temperature Tapes.

Tape: 9 reels magnetic tape.

DATA ARCHIVES LOCATION: National Space Science Data Center, NASA/Goddard Space Flight Center.

PERIOD OF OPERATION: June 1961 to October 1961 (TIROS-3)
February 1962 to June 1962 (TIROS-4)
June 1963 to September 1963 (TIROS-7)

REFERENCES

1. Radiation Balance of the Earth from a Satellite. House, F. B., PhD Thesis, University of Wisconsin 1965.
2. Satellite and Rocket Expts, National Space Sciences Data Center, NASA/Goddard Space Flight Center, January 1968.
3. Mission Plan TIROS-7, GSF Report No. X-650-63-99, May 1963.
4. Juno 2 Summary Project Report Volume 1, Explorer 7, NASA TN-D-608, July 1961.

SYSTEM CHARACTERISTICS

Weight: 3 lbs.

Avg. Power: 1 Watt

Components: 2 detector devices, electronics

Data Recovery: delayed telemetry

Precision and Accuracy: S/N better than 30 DB

MEASUREMENTS

Measure irradiance from the Sun and Earth.

Spatial Resolution: 480 nm at center from 450 nm alt

Spectral Range: 0.3 to 60.0 micron

Field-of-View: 55.0 degrees

POTENTIAL DERIVED PARAMETERS

1. Absorbed irradiance from Sun and Earth; energy emitted from Earth.
2. Gross heat budget data.

MAGNETOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: MAG
INSTRUMENT TYPE: Magnetometer
SPACECRAFT: UARS
CONTRACTOR: Johns Hopkins
P.I.: T.A. Potemra

OBJECTIVES

1. To monitor and investigate large-scale, field-aligned currents that comprise an important element in the coupling processes of the solar wind-magnetosphere-ionosphere-atmosphere system.

DESCRIPTION

SUMMARY: This experiment is designed to observe continuously the characteristics of the field-aligned currents by virtue of the magnetic perturbations that they produce using triaxial, fluxgate magnetometer sensor A/D converters and a magnetometer boom assembly. The triaxial fluxgate magnetometer has a total range of $\pm 60,000$ nT, it measures the vector magnetic field at the rate of 16 times per second and has a resolution of 7.3 nT. The boom is required to reduce the Spacecraft and Payload magnetic noise to less than 2 nT at the magnetometer sensor. The recommended boom length is 3 to 4 meters (10 to 13 feet).

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

1. UARS Proposal, A Proposal for a Magnetometer Experiment for the Upper Atmosphere Research Satellite Program, The Johns Hopkins University, December 1978.

SYSTEM CHARACTERISTICS

Data Rate: 672 bits/sec (approximately 1% of the total spacecraft instrument data rate)

Sensor Alignment: Orthogonal within $\pm 0.25^\circ$; alignment with respect to a mechanical reference on the spacecraft to be determined within $\pm 0.01^\circ$ (equal to the coarse attitude orientation of the spacecraft)

Temperature Range: Tolerate -30°C to $+80^\circ\text{C}$ without permanent damage. To operate at $20^\circ\text{C} \pm 10^\circ\text{C}$ with active temperature control

Weight: 2.3 kg (5 lbs.) (less than 0.1% of the total spacecraft instrument mass)

Power: 10 watts, including thermal control of sensor

MAGNETOMETER

SYSTEM CHARACTERISTICS (continued)

Size: 4,100 cm³ (250 in³) including sensor, electronics, and TM interface

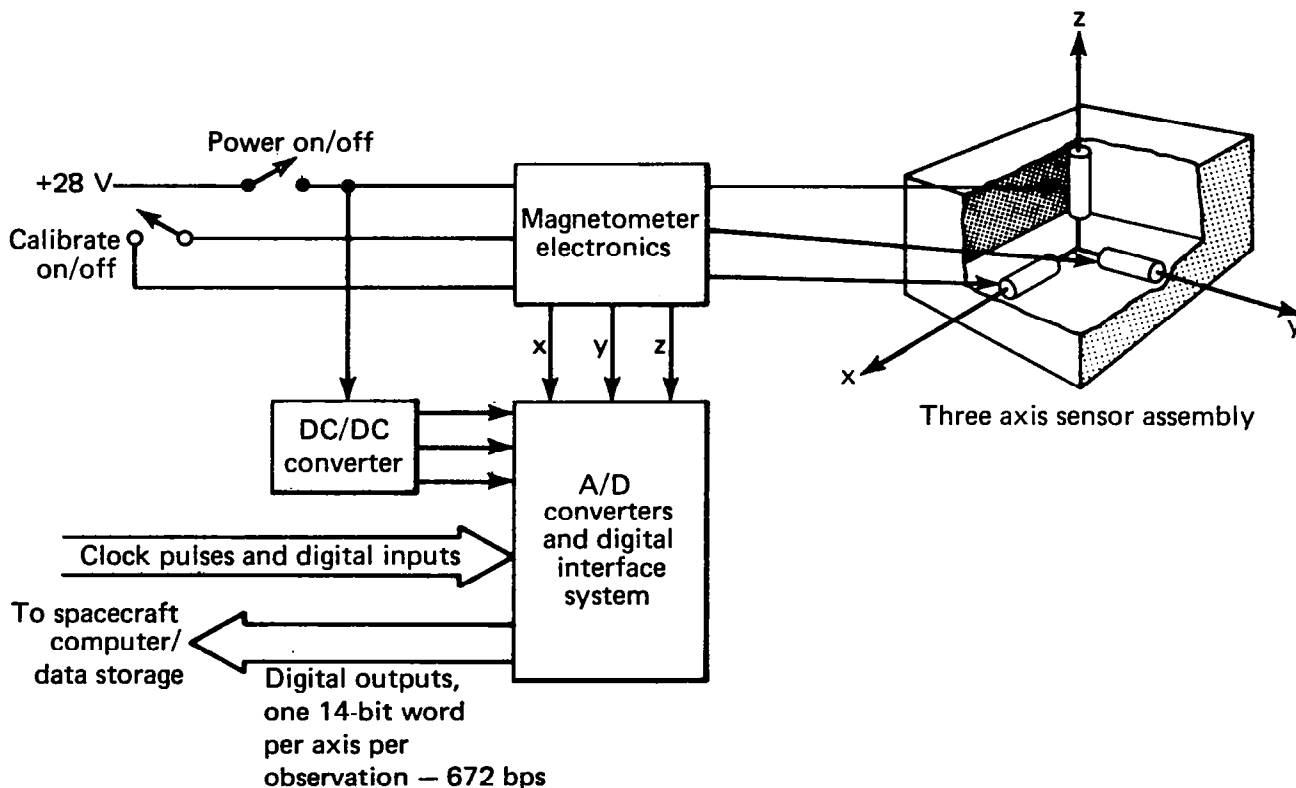
Magnetometer Boom Length: Sufficiently long to reduce Spacecraft and Payload magnetic noise to less than 2 nT at magnetometer sensor. Recommended length 3 to 4 meters (10 to 13 feet)

Stability of Boom Extension Orientation: 0.1° (6 arc minutes) over range of spacecraft operating conditions (including thermal and vibration effects)

Boom Deployment Repeatability: 0.1° (6 arc minutes)

Overall Alignment Tolerance of Magnetometer Sensors with Respect to Spacecraft Attitude Reference: ±0.25° (15 arc minutes).

FUNCTIONAL DIAGRAM



Magnetometer System Block Diagram

MAGNETOMETER

MEASUREMENTS

Measures magnetic perturbations produced by field-aligned currents.

Range: $\pm 60,000$ nT (1 nT = 1 γ)

Resolution: 7.3 nT (least significant bit determined by 13-bit plus sign A/D converter)

Absolute Sensitivity: to be determined by spacecraft definition (absolute sensitivity to be sacrificed in favor of making disturbance magnetic field measurements)

Sampling rate: 16 magnetic field samples/axis/sec (anti-aliasing filter required with 8 Hz corner frequency).

POTENTIAL DERIVED PARAMETERS

1. The interplanetary and magnetospheric mechanisms that control upper atmosphere structure and variability
2. The response of the upper atmosphere to solar and interplanetary perturbation
3. The role of the upper atmosphere and magnetosphere in climate and its possible relationship to the Sun
4. Monitor the field-aligned currents (and general level of geomagnetic activity) by measuring the geomagnetic field continuously with a triaxial fluxgate magnetometer on the high inclination UARS spacecraft.

MEASUREMENT OF AIR POLLUTION FROM SHUTTLE

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: G. Eisenweier
LOCATION: NASA Headquarters

ACRONYM: MAPS
INSTRUMENT TYPE:
PAYLOAD: OSTA 1
CONTRACTOR: Langley Research Center
P.I.: R.T. Sherrill

OBJECTIVES

1. Measure CO concentration in the mid and upper troposphere to:
 - a) Observe and define the extent of interhemisphere air mass transport at mid troposphere level and define the spatial variations of CO concentration, and
 - b) Investigate and evaluate the orbital performance of MAPS and the influence of orbital conditions on data reduction and analysis.

DESCRIPTION

SUMMARY: The MAPS is a non-dispersive gas filter correlation instrument. All MAPS equipment will be attached to the single base plate and mounted in the Shuttle cargo bay. The Pallet Interface on MAPS will be coupled to a cold plate on the pallet since the instrument's performance is dependent on its internal temperature. The pallet will also supply 28 VDC power at the MDM interface.

The Electro-Optical Head contains the high and low pressure CO gas cells, their corresponding detectors, the direct radiation detector, and the internal balancing system (a chopper). The chopper is a reflective disk with two sets of holes lying at different radii along the perimeter. Incident radiation passes through the instrument's objective lens onto the wheel and is chopped against a reference blackbody by the outer set of holes. The wheel simultaneously chops the radiation from the two balance blackbodies into the optical path of the instrument with the inner set of holes. The balance signal from the hot and cold blackbodies is chopped at a different frequency than the signal from the incident radiation and reference source and so can be distinguished by the instrument's electronics. The balance signal is fed to an automatic gain control (AGC) loop which continually adjusts the gain of the gas cell detector to compensate for variations in the properties of the optical elements and the electronics situated in the internal balance path in order to maintain instrument balance.

An external balance/calibration subassembly located in front of the objective lens provides for the rebalancing of the instrument every 12 hours. It compensates for long term variations in the properties of the optical elements in front of the internal balance path. This subassembly contains a hot balance blackbody, a cold balance blackbody, and a calibration source consisting of a gas cell with known absorption features in front of a blackbody. The viewing port and these sources are located 90° apart such that a pointer mirror can be rotated to permit the instrument to view any one of the three sources or take data through the viewing port.

REFERENCES

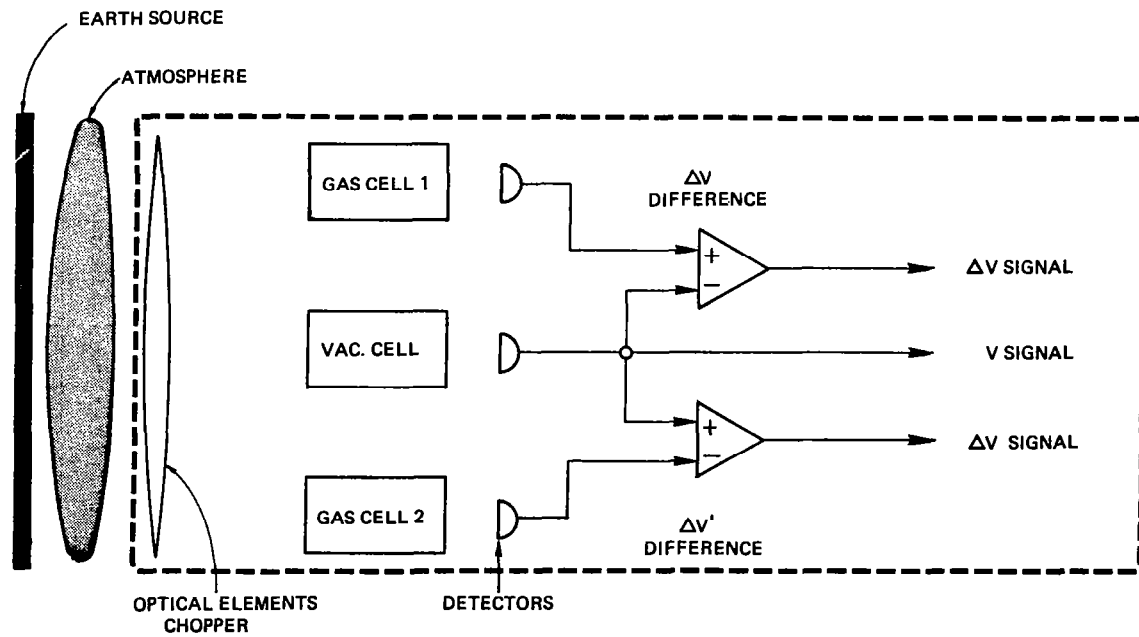
1. Office of Space and Terrestrial Applications-1, Handout, 1980.

MEASUREMENT OF AIR POLLUTION FROM SHUTTLE (MAPS)

SYSTEM CHARACTERISTICS

Weight: 80 kg
Volume: 0.40 cu m
Power: 75 W

FUNCTIONAL DIAGRAM



MAPS Instrument Concept

MEASUREMENTS

Measures terrestrial radiation.

Spectral Range: 4.6 microns
FOV Half Angle: 2.2 degrees
Viewing: nadir

POTENTIAL DERIVED PARAMETERS

1. CO concentrations.

MEDIUM ENERGY PARTICLE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R. J. McNeal
LOCATION: NASA Headquarters

ACRONYM: MEPS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS
CONTRACTOR: University of Texas
P.I.: Dr. J. David Winningham

OBJECTIVES

1. Determine the global input of charged-particle energy into the earth's stratosphere, mesosphere and thermosphere and the predicted atmospheric responses.

DESCRIPTION

SUMMARY: The MEPS is one of three sensors which make up the Particle Environment Monitor (PEM). The other two sensors are the High Energy Particle Spectrometer (HEPS) and the Atmospheric X-ray Imaging Spectrometer (AXIS). In addition to this system there will be a Central Command and Data Handling Package (CDHP) for handling the interface of the PEM with the UARS spacecraft.

The MEPS will use parabolic plate electrostatic analyzers to measure electrons at 5 angles in the energy range 100 eV to 50 keV.

HERITAGE/DERIVATION: The present analyzer is a generic derivation from those used on the ISIS-1 and -2 satellites, DE A & B satellites, and sounding rockets.

MEP's will be identical to the HAPI (High Altitude Plasma Instrument) on the Dynamics Explorer-A mission built by UTD and SwRI except for the channel electron multipliers (CEM), CEM power supply, amplifiers, and scalars normally used for ion measurements.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

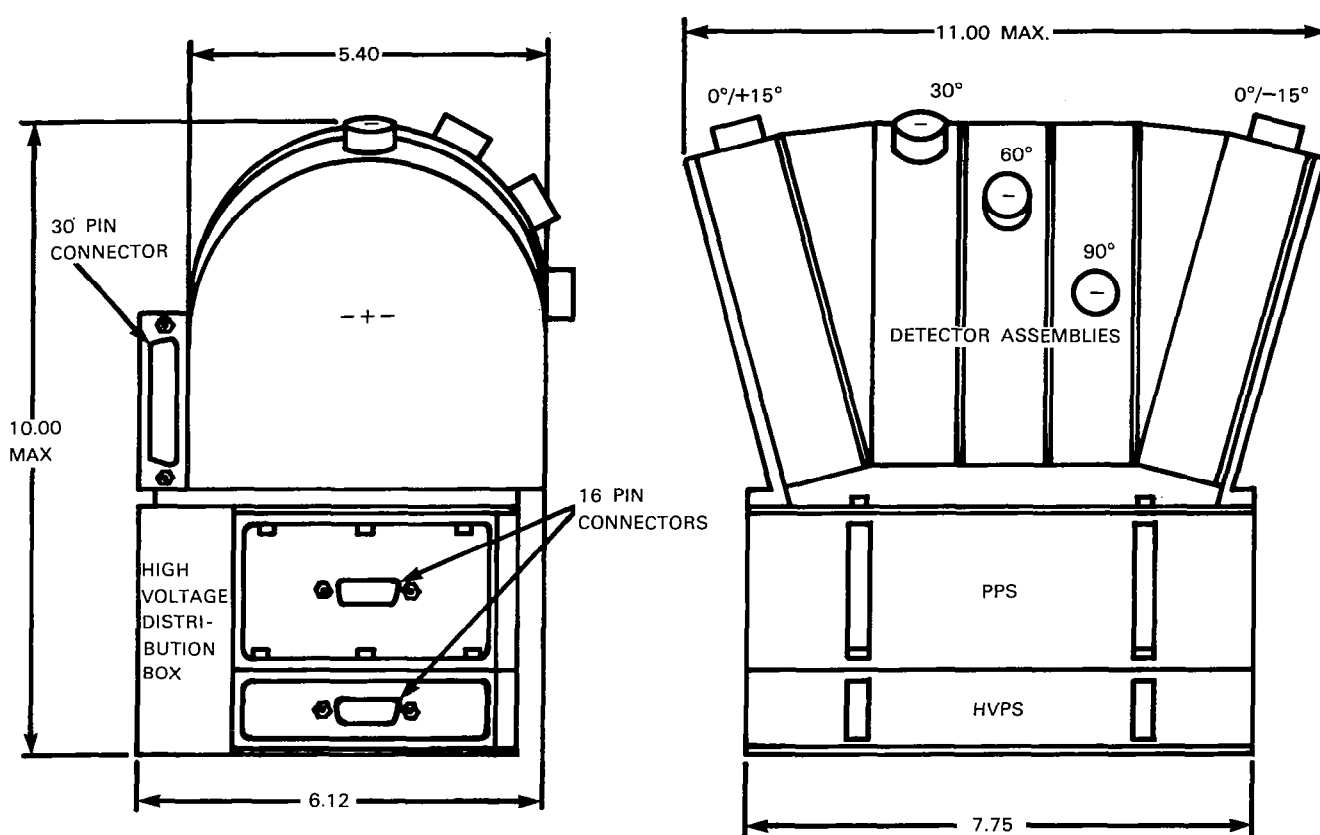
1. UARS Proposal, Particle Environment Monitor, University of Texas, December 1978.

SYSTEM CHARACTERISTICS

Mass: 7 kg
Power: 9 W
Data Rate: 510 bps
Energy Steps: 16 or 32
Temporal Coverage: 16 Steps/Sec
Data Telemetry: 16 8 bit Word/Sec

MEDIUM ENERGY PARTICLE SPECTROMETER (MEPS)

FUNCTIONAL DIAGRAM



Medium Energy Particle Spectrometer Schematic Diagram

MEASUREMENTS

Measures proton and electron particles at five angles over the energy range.

FOV: 5 degrees x 30 degrees

Temporal Resolution: 16 Energy Steps per Second

Range: Protons: 100 eV to 50 KeV

Electrons: 100 eV to 50 KeV

Pointing Accuracy: ~1 degree

POTENTIAL DERIVED PARAMETERS

1. Atmospheric ionization profiles.
2. Chemical and dynamic responses of the atmosphere to the precipitating particle fluxes.

MEDIUM RESOLUTION INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. B. Schardt
LOCATION: NASA Headquarters

ACRONYM: MRIR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-2 &-3
CONTRACTOR: Santa Barbara Research Center
P.I.: A. McCulloch, GSFC

OBJECTIVES

1. To measure electromagnetic radiation emitted and reflected from the Earth and its atmosphere.
2. The atmospheric water vapor absorption.
3. The surface or near-surface temperature.
4. The cloud cover data.
5. The radiation from stratosphere (CO₂) band.
6. The heat budget of the Earth.
7. The intensity of reflected solar energy.

DESCRIPTION

SUMMARY: The Medium-Resolution Infrared Radiometer (MRIR) electromagnetic radiation emitted by and reflected from the Earth and its atmosphere in five selected wavelength intervals from 0.2 to 30 microns. Data for heat balance of the Earth-atmosphere system were obtained, as well as measurements of water vapor distribution, surface or near-surface temperatures, and seasonal changes of stratospheric temperature distribution. The five wavelength regions were (1) The 6.4- to 6.9-micron channel, which covered the 6.7-micron water vapor absorption band, (2) The 10- to 11-micron band, which operated in the 'Atmospheric Window,' (3) The 14- to 16-micron band, which covered the 15-micron carbon dioxide absorption band, (4) The 5- to 30-micron band, which measured the emitted long-wavelength infrared energy for heat budget purposes, and (5) The 0.2- to 4.0-micron channel, which yielded information on the intensity of reflected solar energy (albedo). Radiant energy from the Earth was collected by a flat scanning mirror included at 45° to the optical axis. The mirror rotated at 8 rpm scanned in a plane perpendicular to the direction of motion of the satellite. Each of the five channels contained a 4.33-cm-diameter folded telescope with a 2.8° field-of-view and a thermistor-bolometer. The collected energy was modulated by a mechanical chopper to produce an AC signal. The signal was then amplified and recorded on magnetic tape for subsequent playback to a ground acquisition station. At a satellite altitude of 1100 km, a horizontal resolution of 55 km could be obtained.

HERITAGE/DERIVATION: TIROS MRR

DATA

DATA PRODUCTS:

NIMBUS-2 Data (MRIR)
Data Set Name

1. MRIR meteorological radiation data on tape
2. MRIR photo display
3. MRIR pictorial data
4. Catalog on microfiche

MEDIUM RESOLUTION INFRARED RADIOMETER (MRIR)

Tape

98 reels of magnetic tape - data from all five channels

Film

979 films of daylight portion of an orbit

10 cards of B/W microfiche showing photos available from experiment

NIMBUS-3 Data (MRIR)

Data Set Name

1. MRIR photofacsimile films
2. MRIR meteorological radiation tapes
3. NIMBUS-3 data catalog on microfiche

DATA ARCHIVES LOCATION: National Space Science Data Center, NASA/GSFC.

PERIOD OF OPERATION NIMBUS-2, May 1966 - July 1966
NIMBUS-3, April 1969 - January 1972

REFERENCES

1. NIMBUS-2 User's Guide, GSFC, July 1966
2. Data Catalog of Satellite and Rocket Experiments, NASA/GSFC, National Space Science Data Center, Report No. NSSDC 68-01, January 1968.
3. Significant Achievements in Space Applications, NASA SP-156, 1967.
4. Goldberg, I.L.: Met IR Instruments for Satellites, NASA/GSFC, August 1968.
5. NIMBUS-3 Reference Manual
6. National Space Science Data Center computer printout 1980.

SYSTEM CHARACTERISTICS

Weight: 14 lbs.

Avg. Power: 8 Watts

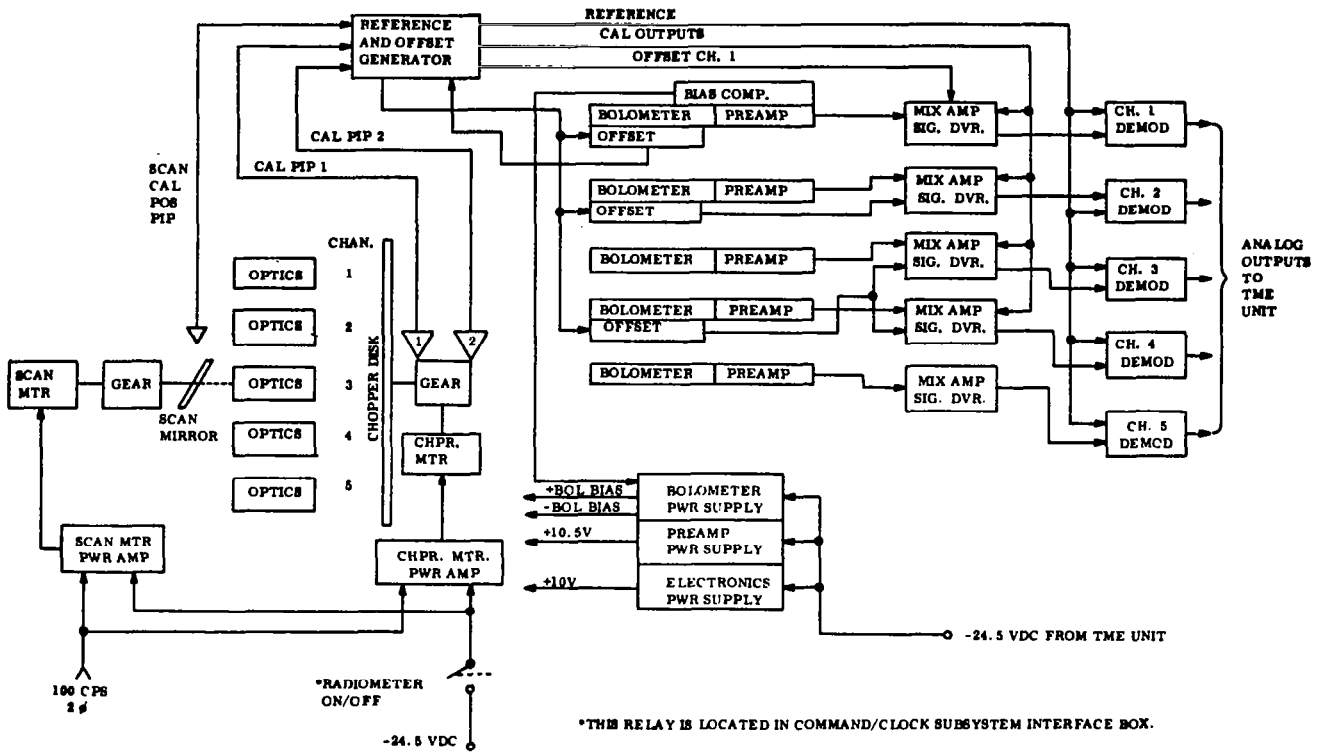
Components: radiometer, electronics

Data Recovery: delayed telemetry

Precision and Accuracy: A S/N ratio of better than 30 DB; absolute accuracy of ± 3 DEG C

MEDIUM RESOLUTION INFRARED RADIOMETER (MRIR)

FUNCTIONAL DIAGRAM



Medium Resolution Infrared Radiometer Block Diagram

MEASUREMENTS

Measure emitted and reflected radiation from Earth and atmosphere.

Measurement Range: 185-300°K for 10 micron channel, 185-270° K of 6.15 micron channels

Spectral Range: 0.2 to 30.0 microns

Bands: 2-4 microns

6.4-6.9 microns

10-11 microns

14-16 microns

5-30 microns

Field-of-View: 360.0 by 2.8°

POTENTIAL DERIVED PARAMETERS

1. Albedo of the Earth
2. Atmospheric structure and water vapor
3. Surface, cloud and lower atmosphere radiation
4. Surface and near surface temperature
5. Cloud cover.

MICROWAVE LIMB SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions & Development
NASA TECH. OFFICER: R. J. McNeal
LOCATION: NASA Headquarters

ACRONYM: MLS
INSTRUMENT TYPE: Limb Sounder
SPACECRAFT: UARS, Shuttle
CONTRACTOR:
P.I.: Dr. J. W. Waters

OBJECTIVES

1. To perform microwave measurements to improve our understanding of Earth's stratosphere, mesosphere and lower thermosphere.
2. Measure altitude profiles of ozone, molecular oxygen, both horizontal components of wind, temperature, and reference pressure levels by observing thermal emission from the atmospheric limb.

DESCRIPTION

SUMMARY: The Microwave Limb Sounder (MLS) consists of an antenna system which receives thermal radiation within a narrow field of view from the atmospheric limb, heterodyne radiometers which measure this radiation at frequencies of certain molecular spectral lines, electronic filter banks which perform spectral analysis, a data system which interfaces the data to a telemetry system for transmission to the ground, a system which implements commands from the ground, and a ground support system which formats the received data, calibrates it, displays those portions required for making real-time decisions and stores the data for further analysis. The MLS contains a system for scanning the antenna field of view through the atmospheric limb and also the necessary power and thermal control systems. Its total weight is 200 kgm and power consumption is 150 watts.

HERITAGE/DERIVATION: NIMBUS, SEASAT, TIROS

DATA

DATA PRODUCTS: Daily global maps of upper atmosphere parameters.

DATA ARCHIVES LOCATION: National Space Science Data Center

REFERENCES

1. UARS Proposal - A proposal for the Upper Atmosphere Research Satellite Program, Microwave Limb Sounder, Jet Propulsion Laboratory. December 1978.
2. Payloads for Environmental Observations Handout, 1980.

MICROWAVE LIMB SOUNDER (MLS)

SYSTEM CHARACTERISTICS

Vertical resolution for profile measurements is 3-6 km; horizontal resolution is 30 km across and 300 km along the observation direction. Complete profiles are obtained in less than 50 seconds.

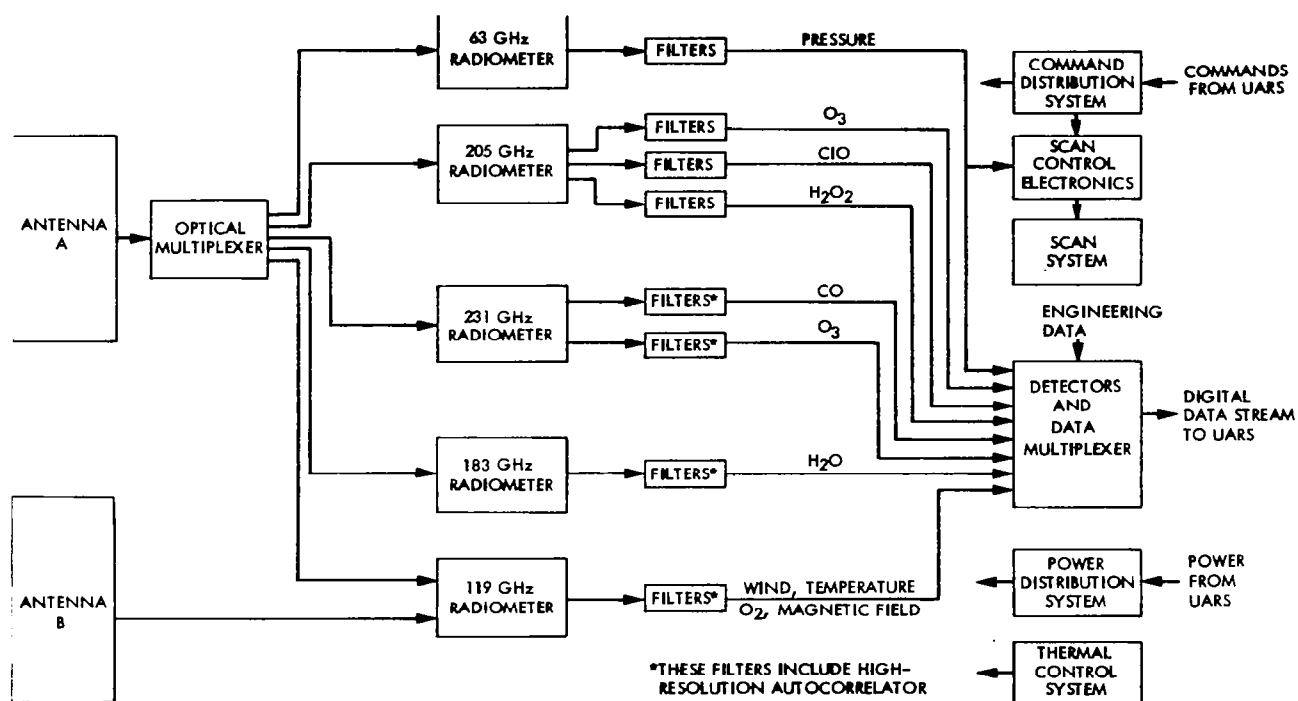
Dimensions: 2.2 x 1.3 x 1.9 meters

MLS mass: 200°K

Data rates: 4 kbs

Cooling requirements: none

FUNCTIONAL DIAGRAM



Microwave Limb Sounder Block Diagram

MEASUREMENTS

Observes millimeter-wavelength thermal emissions from the atmospheric limb in five spectral regions.

FOV: set by diffraction - is inversely proportional to the size of the antenna

Spectral regions: 63 GHz; 119 GHz; 183 GHz; 205 GHz; 231 GHz.

MICROWAVE LIMB SOUNDER (MLS)

POTENTIAL DERIVED PARAMETERS

1. Measured wind, temperature, and tracer (CO) fields the transports of momentum, heat and mass in the mesopause region.
2. Measurements of O₃, O₂, H₂O and kinetic temperature will also be used to estimate the radiative heating of the upper atmosphere.
3. Measurements of infrared CO₂ emission, expected to be available, should provide valuable complementary data on radiative cooling necessary for understanding the overall energy balance.
4. Geostrophic winds will be calculated from the observed temperature field and compared with the measured wind field to determine the non-geostrophic components. Daily and monthly averages of the wind and temperature fields, which smooth out variations with local time, will be used to separate tidal and gravity wave components. Monthly averages of the global distributions of O₃, ClO, H₂O₂, H₂O, CO, and lower thermospheric O₂ will be prepared.

MICROWAVE PRESSURE SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations	ACRONYM: MPS
STATUS: Development	INSTRUMENT TYPE: Sounder
NASA TECH. OFFICER: J. Theon	SPACECRAFT: Shuttle
LOCATION: NASA Headquarters	CONTRACTOR: Jet Propulsion Laboratory
	P.I.: Dr. Dennis Flower, JPL

OBJECTIVES

1. Measure atmospheric pressures at the surface of the Earth.

DESCRIPTION

SUMMARY: The Microwave Pressure Sounder (MPS) design is based on using active millimeter wave techniques. By using the MPS, the surface pressure can be deduced from measurements of the ratios of atmospheric transmissivity at pairs of frequencies. The primary pair of frequencies lie in the lower wing of the 60 GHz oxygen absorption band. The instrument will have six channels operating at 29.2, 36.5, 44.8, 52.8, 67.5 and 73.0 GHz. Three radiometers are used which have similar design but different operating frequencies. As presently envisaged the package will have a single multifrequency dual antenna system. Each has an area of about 0.2 m^2 , a RF subsystem, and an electronics subsystem with a total volume of 0.1 m^3 .

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory

REFERENCES

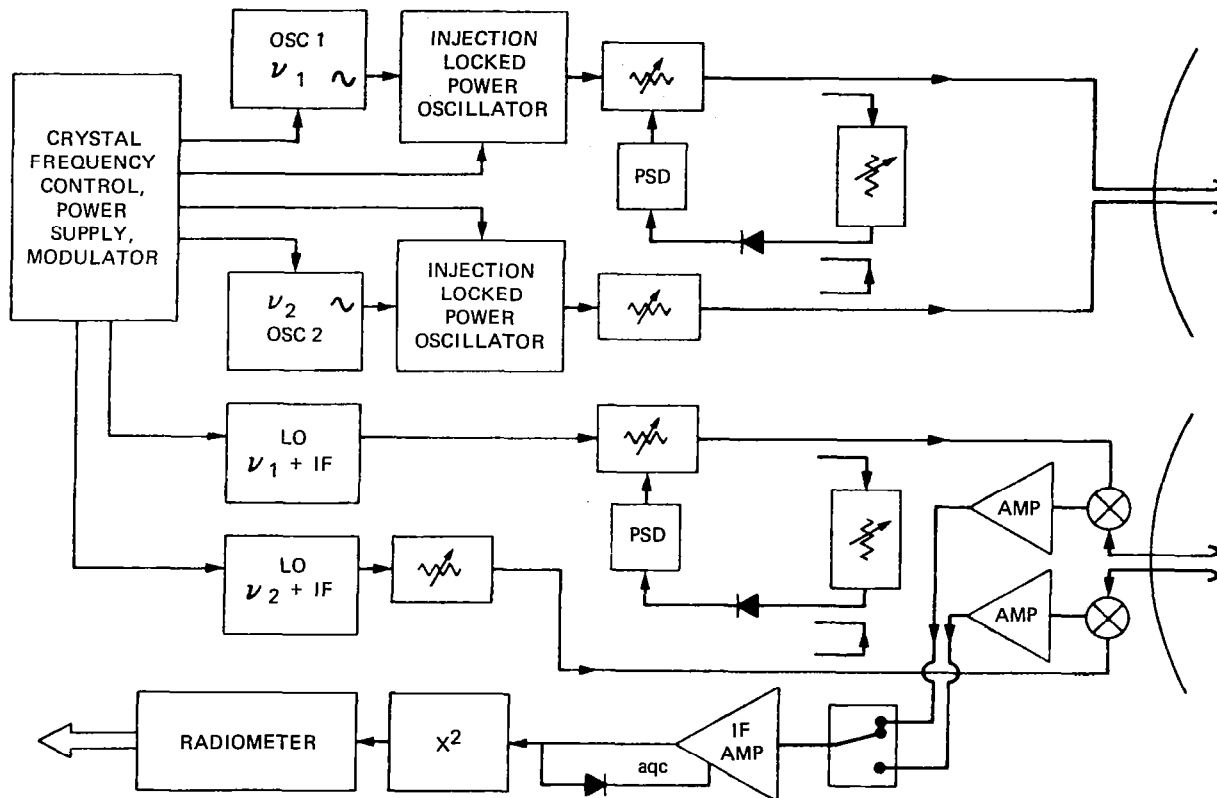
1. A Microwave Pressure Sounder, D.A. Flower, G.E. Peckham, JPL 78-68, 1 August 1978; STS Payload Planning Data, Volume II, OSTA Payload Planning Data, Teledyne Brown Engineering P179-MSFC-2327.

SYSTEM CHARACTERISTICS

Physical Size (m): 0.5 m^3
Power Requirement (We): 100
Mass (kg): 50
Data Rate (kbps): 1(max)
Overall Size: $1.5 \times 0.6 \times 0.5 \text{ m}$
Weight: 100 kg
Field of View: $5^\circ \times 0.5^\circ$
Power: 100 W
Data Rate: 1 kbps
Pointing Accuracy: $\pm 0.2^\circ$

MICROWAVE PRESSURE SOUNDER (MPS)

FUNCTIONAL DIAGRAM



Microwave Pressure Sounder - Two Frequency Radiometer Schematic Diagram

MEASUREMENTS

Measures radar backscatter or reflections from the earth.

Channels: 6

- Bands:
1. 29.2555 GHz
 2. 36.555 GHz
 3. 44.80 GHz
 4. 52.80 GHz
 5. 67.51 GHz
 6. 73.01 GHz

Effective surface resolution: 10 x 100 km

POTENTIAL DERIVED PARAMETERS

1. Sea surface pressure
2. Sea state and foam.

**MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER
EARTH RESOURCES EXPERIMENT PACKAGE (EREP)**

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: T. L. Fischetti
LOCATION: NASA Headquarters

ACRONYM: MRSA
INSTRUMENT TYPE: Microwave Radiometer/
Scatterometer and Altimeter
SPACECRAFT: Skylab-1
CONTRACTOR: General Electric Company
P.I.: D. Evans

OBJECTIVES

1. To provide simultaneous evaluations of radar backscattering cross-section and passive microwave emissivity of land and sea.
2. To obtain initial value data for the atmosphere above the boundary layer to aid in numerical weather prediction.

DESCRIPTION

SUMMARY: The active/passive microwave system is a combination radar scatterometer and passive microwave radiometer operating at 13.9 GHz. The altimeter operates independently. The experiment is based on simultaneous measurements of radar differential backscattering cross section and passive microwave emissivity of land and sea surfaces. The antenna is a four foot mechanically scanning parabolic reflector with a 1.4 degree half-power conical pencil beam. On the non-contiguous "along track" and "cross track" scanning modes the antenna moves in discrete steps (0, 15, 30, 40, and 48 degree) from one cell to another dwelling on each cell a predetermined period of time. During contiguous scan modes the antenna moves continuously either along track (0 to 48 degrees) or cross-track (+-12.5 degree centered on roll angles of +-30, +-15 and 0 degree at pitch angles of 0, 15, 30, 40, and 48 degrees). The altimeter, a narrow pulse radar, transmits a 100 or 10 nano-second pulse at a PRR of 360/second and a peak power of two kilowatts. The received signal is down-converted and square-law detected. The altimeter also performs in-phase and quadrature detection.

DATA

DATA PRODUCTS: All data were recorded on magnetic tape on one digitized channel. The radiometer/scatterometer data were recorded at 5.33 kbs. The altimeter data at 10 kbs.

REFERENCES

1. Experiment Implementation Plan for Manned Spaceflight experiments, Title: Microwave Radiometer Scatterometer - 11/21/69.
2. Earth Resources Remote Sensing Systems, MSC P6-0406, November 1970.
3. Opportunities for Participation in Space Flight Investigation, Memo Change 33, Dec. 22, 1970.
4. Skylab-A, EREP User's Handbook, NASA MSC, Feb. 1971.
5. National Space Science Data Center computer printout, 1980.
6. Skylab Experiment, Aug. 1972, NASA.

MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (MRSA)

SYSTEM CHARACTERISTICS

Weight: 210 lbs.

Volume: 24.2 cu. ft.

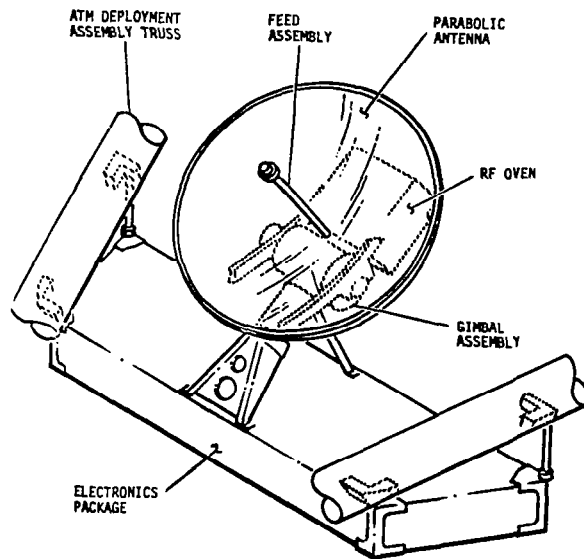
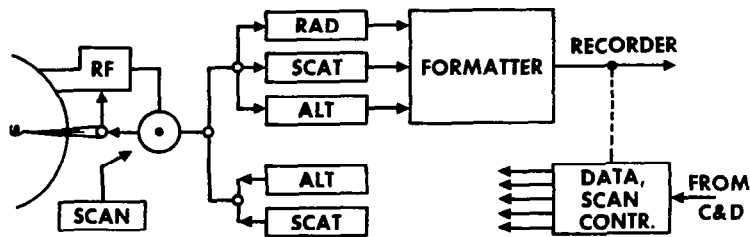
Avg. Power: 153 Watts

Components: radiometer, scatterometer, altimeter, antenna, electronics

Data Recovery: from tape/10 kilobit

Precision & Accuracy: Tracker has noise level 1-meter RMS at S/N ratios = OR 20dB

FUNCTIONAL DIAGRAM



Microwave Radiometer/Scatterometer and Altimeter Basic Design

**MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER
EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (MRSA)**

MEASUREMENTS

Measures backscatter coefficients and altitude.

Spectral Range: 13.9 GHz

POTENTIAL DERIVED PARAMETERS

1. Radar differential backscattering, passive microwave emissivity.
2. Sea state/wind velocity.
3. Weather prediction.
4. Clouds and rain.
5. Snow, ice cover.
6. Flooding, rainfall.
7. Agriculture, geology.

MONITOR OF ULTRAVIOLET SOLAR ENERGY

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: MUSE
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-3, NIMBUS-4
CONTRACTOR: ADCOLE Corp.
P.I.: Dr. D. F. Heath, GSFC

OBJECTIVES

1. Detect variation of relative intensity of solar flux in five spectral bands.
2. Determine the distribution of ozone in the atmosphere.
3. Make absolute measurements of the flux.
4. Measure the rate of decrease of flux as the satellite enters the Earth shadow near the poles.
5. Measure ozone and molecular oxygen high in the atmosphere.

DESCRIPTION

SUMMARY: The MUSE ultraviolet sensors consist of five photodiodes whose short wavelength response is determined by suitable optical filters, while the long wavelength cutoff is determined by varying degrees of 'solar blindness' of different photocathode materials. The five channels have responses to radiation in the following ranges: 1300-1600Å, 1750-1850Å, 2750-3150Å, 2050Å, and 2760-3860Å. A solar aspect sensor gives the angle at which the Sun's rays strike the diodes with seven-bit accuracy. Usable data is obtained over a 90 degree FOV. The radiation intensity is read as the current from the photodiodes by either of two parallel electrometers with four decade ranges. There is an automatic zero setting device for the electrometers. They are calibrated using five constant currents supplied by a radioactive source (AM 241). Each sensor is monitored for five seconds per cycle. The absolute accuracy of the measurements will be 20 percent.

HERITAGE/DERIVATION: Similar to NIMBUS-2.

DATA

DATA PRODUCTS:

NIMBUS-3, NIMBUS-4 MUSE

Very little data. The VIP data were stored on magnetic tape and transmitted on playback to the Data Acquisition Facility.

DATA ARCHIVES LOCATION: National Space Science Data Center/Goddard Space Flight Center

PERIOD OF OPERATION: April 1969 to September 1970 (Nimbus-3)
April 1970 to April 1971 (Nimbus-4)

REFERENCES

1. The NIMBUS-3 User's Guide GSFC, Greenbelt, MD.
2. The NIMBUS-4 User's Guide GSFC, Greenbelt, MD.

MONITOR OF ULTRAVIOLET SOLAR ENERGY (MUSE)

SYSTEM CHARACTERISTICS

Weight: 9 lbs.

Frequency of Observation: 25 min/orbit

Data Recovery: delayed telemetry

Components: photodiode detectors, electronics

Precision and accuracy: absolute accuracy of flux measurement within 20%

Spatial Resolution: 7 nm from 600 nm altitude

MEASUREMENTS

Measures solar radiation in the atmosphere.

Measurement range: Signal current from 0.1 nanoamp to 100 nanoamps.

Spectral Resolution: 100Å

Spectral Range: 1300 to 3150

Field-of-View: 90.0°

Channels: Three

1. 2750-3150Å
2. 1750-1850Å
3. 1350-1600Å

POTENTIAL DERIVED PARAMETERS

1. Ultraviolet solar radiation flux
2. Solar influence on stratosphere.

MULTISPECTRAL CLOUD RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: S. Tilford
LOCATION: NASA Headquarters

ACRONYM: MCR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: A/C
CONTRACTOR:
P.I.: Robert Curran, GSFC

OBJECTIVES

1. To remotely detect cloud optical properties.
2. To obtain cloud optical thickness, thermodynamic phase and temperature, and cloud top altitude.

DESCRIPTION

SUMMARY: The MCR is a seven channel scanning radiometer with six channels in the near IR and one channel in the thermal IR.

REFERENCES

1. RTOP 146-10-03-15 GSFC, 1981.

MULTISPECTRAL LINEAR ARRAY

IDENTIFICATION

DISCIPLINE: Resource Observations

STATUS: Development

NASA TECH. OFFICER: K. Ando

LOCATION: NASA Headquarters

ACRONYM: MLA

INSTRUMENT TYPE: MSS

SPACECRAFT: TBD

CONTRACTOR: TBD

P.I.: H. Richard, GSFC

OBJECTIVES

1. To develop an operational sensor for future resource observations using solid-state linear array technology.
2. To provide improved resolution data in agriculture, forestry, geology, hydrology, and other areas.

SUMMARY: The MLA is currently in the study phase. The MLA uses solid-state linear arrays operating in the pushbroom scan mode. Study efforts have been directed toward developing a system which operates in the spectral bands between 0.45 microns and 2.5 microns for operational land observations. The MLA will have a longer lifetime than current systems, improved resolution, improved sensitivity and six channels. Detailed designs and the final configuration are still under study. The basic approach uses a linear array of thousands of detectors which simultaneously view a line of picture elements on the earth's surface and makes use of the motion of the spacecraft to build an image. The MLA will provide a nominal 15 FOV across track and have the capability for stereo mode of operation and a missed scene mode.

HERITAGE/DERIVATION: Landsat 1,2,&3 Multispectral Scanner

REFERENCES

1. MLA Instrument Definition Study Statement of Work, May 11, 1981, NASA/Goddard Space Flight Center.

SYSTEM CHARACTERISTICS

Weight: To be determined

Volume: To be determined

Power: 28 Vdc

Data link: Two wideband lines nominally at 150 Mbs

Pointing requirements: LOS pointing accuracy (resolution) - ± 0.01 degrees
LOS pointing precision - ± 0.001 degrees

MULTISPECTRAL LINEAR ARRAY (MLA)

MEASUREMENTS

Measures reflected solar and thermal radiation from the Earth.

Channels: 6

Spectral Range: 0.45 to 2.4 microns

- Spectral Bands:
1. Visible - 0.45 to 0.52 microns
 2. Visible - 0.52 to 0.60 microns
 3. Visible - 0.63 to 0.69 microns
 4. Near infrared - 0.76 to 0.90 microns
 5. Short wave infrared - 1.55 to 1.75 microns
 6. Short wave infrared - 2.08 to 2.35 microns

IFOV: 15 to 30 meters (705 km altitude, nadir view)

POTENTIAL DERIVED PARAMETERS

1. Agriculture/crop mapping
2. Range resources mapping
3. Vegetation mapping
4. Geologic/terrain mapping.

**MULTISPECTRAL PHOTOGRAPHIC FACILITY:
EARTH RESOURCES EXPERIMENT PACKAGE (EREP)**

IDENTIFICATION

DISCIPLINE: Resource Observation
STATUS: Flight Missions
NASA TECH. OFFICER: T. L. Fischetti
LOCATION: NASA Headquarters

ACRONYM: MPF
INSTRUMENT TYPE: Camera
SPACECRAFT: Skylab-1
CONTRACTOR: ITEK Corp.
P.I.: J. E. Dornbach, JSC

OBJECTIVES

1. To obtain precision multispectral photography which will provide the basis for a wide range of Earth resources photographs.
2. To provide photographic facility to allow studies of the value of multispectral photography using various film/filter combinations for the identification and assessment of Earth, ocean, and cloud features.
3. To provide high-quality multispectral photography.
4. To determine extent multispectral photography can be applied to detailed analysis in Earth resources.

DESCRIPTION

SUMMARY: This facility consists of six high precision 70 mm cameras with matched distortion and focal length. The lenses have a six-inch focal length (21.2 degree field-of-view across flats) providing approximately 88 nm square surface coverage from the expected 235 nm orbit. The system has the following wavelength/film combination: .5-.6 micron-pan x b&w, .6-.7 micron-pan x b&w, .7-8 micron-IR b&w, .8-9 micron-IR b&w, .5-.88 micron-IR color, .4-.7 micron-HI-res color. The spectral regions designated were selected to separate the visible and photographic infrared spectrum into the bands that are most useful for multispectral analysis. The two color films provide a preregistered cross-check of the black and white imagery in two proven color combinations.

DATA

DATA PRODUCTS: Film - black and white, infrared sensitive black and white, high resolution color, and infrared sensitive color, 30,000 frames.

Data Film
5 in high resolution
color film

Paper
173 pages of tabulated indexing and
6 maps which identify photograph
available from this experiment.

PERIOD OF OPERATION: May 1973 to November 1974.

**MULTISPECTRAL PHOTOGRAPHIC FACILITY:
EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (MPF)**

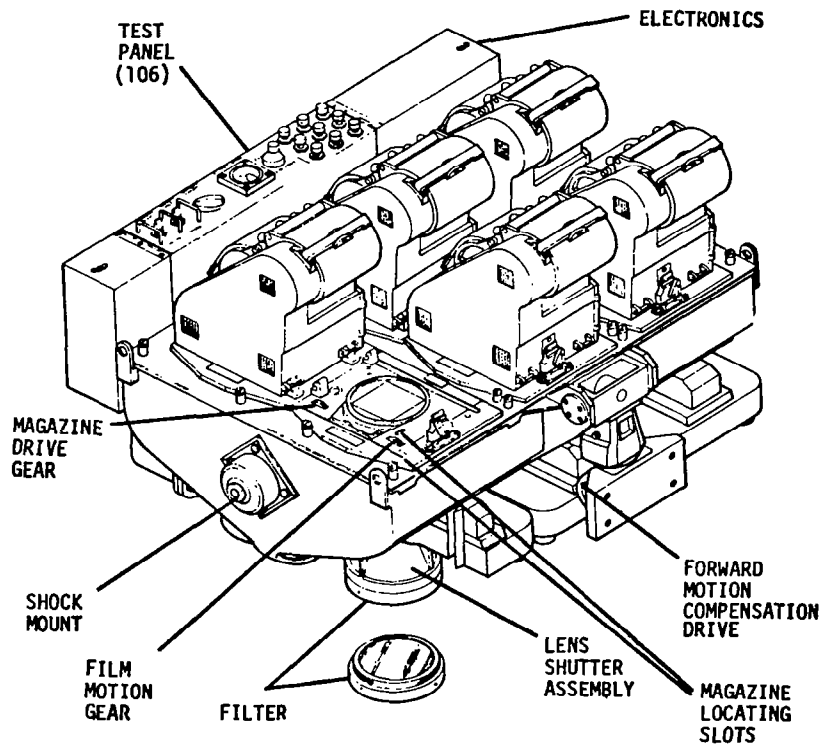
REFERENCES

1. Experiment Implementation Plan for Manned Space Flight Experiment, 11/24/69; Title: Multispectral Photographic Facility (Earth Applications).
2. Earth Resources Remote Sensing System, MSC-P6-0406.
3. National Space Science Data Center computer printout, 1980.
4. Skylab Experiments, August 1972, NASA.
5. Skylab A, EREP User's Handbook, March 1971.

SYSTEM CHARACTERISTICS

Weight: 328 lbs.
Volume: 18.9 cu. ft.
Peak Power: 616 Watts
Data Recovery: film
Precision & accuracy: filter calibrations, Pre & Post flight
Components: 6 cameras

FUNCTIONAL DIAGRAM



Multispectral Photographic Facility Schematic Diagram

**MULTISPECTRAL PHOTOGRAPHIC FACILITY:
EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (MPF)**

MEASUREMENTS

Measures energy in the visible and IR regions emitted or reflected from Earth features.

Spectral Range: wavelengths 0.4 to 0.9 micron

Number of Channels: 6 - 4 black and white; 2 color

- Bands:
1. 0.5-0.6 micron
 2. 0.6-0.7 micron
 3. 0.7-0.8 micron
 4. 0.8-0.9 micron
 5. 0.5-0.88 micron
 6. 0.4-0.7 micron

Spectral Resolution: 0.1 micron

FOV: 21.1 deg.

POTENTIAL DERIVED PARAMETERS

1. Earth, ocean, and cloud features.

MULTISPECTRAL SCANNER

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. Calibrese
LOCATION: NASA Headquarters

ACRONYM: MSS
INSTRUMENT TYPE: Scanner
SPACECRAFT: Landsat 1,2,3 & D
CONTRACTOR: NASA/GSFC
P.I.: G. F. Banks

OBJECTIVES

1. To provide an alternate data source to the Thematic Mapper (TM).
2. To provide data in areas such as agriculture, forestry, geology, and hydrology.
3. Provides repetitive day/night acquisition of high-resolution multispectral data of the Earth's surface on a global basis.

DESCRIPTION

SUMMARY: The Landsat Multispectral Scanner (MSS) was designed to provide repetitive daytime acquisition of high-resolution, multispectral data of the Earth's surface on a global basis and to demonstrate that remote sensing from space is a feasible and practical approach to efficient management of the Earth's resources. In addition to obtaining data for use in Earth resource type studies, the MSS system was used to conduct oceanographic and meteorological studies, i.e., to map sea-ice fields, locate and track major ocean currents, monitor both air and water pollution, determine snow cover, investigate severe storm environments, etc. The MSS consisted of a double reflector-type telescope, scanning mirror, filters, detectors, and associated electronics. The scanner operated in the following spectral intervals -- band 1, 0.5 to 0.6 micrometer; band 2, 0.6 to 0.7 micrometer; band 3, 0.7 to 0.8 micrometer; and band 4, 0.8 to 1.1 micrometers. A fifth band in the near (thermal) infrared from 10.4 to 12.6 micrometers was included on Landsat 2 and 3. Landsat D MSS is similar to Landsat 3 MSS except for changes necessary to accommodate the lower orbital altitude. The swath width of 185 km will remain the same by increasing the FOV of the sensors from 11.56 to 14.92°. The ground resolution will be 82.6 m for bands 1 through 4 and 248 m for band 5. The primary image produced at the image plane is relayed by use of fiber-optic bundles to detectors where conversion to an electronic signal is accomplished. Optical filters produce spectral separation. Six detectors are employed in each of the first four spectral bands and two in the fifth band -- bands 1 through 3 use photomultiplier tubes as detectors, band 4 uses silicon photodiodes, and band 5 uses mercury-cadmium-telluride detectors.

DATA

DATA PRODUCTS: Catalogs of data from Landsat are available from EROS Data Center. Images stored on magnetic tape for subsequent playback. Computer compatible. 70 mm film, prints.

DATA ARCHIVES LOCATION: Earth Resources Data Center, Department of the Interior, Sioux Falls South Dakota.

PERIOD OF OPERATION: Landsat 1 - July 23, 1972 - January 6, 1978
Landsat 2 - January 22, 1975 - August 6, 1980
Landsat 3 - March 5, 1978 - July 7, 1980

REFERENCES

1. National Space Science Data Center computer printout, 1980.
2. Landsat D project plan, April 1978, Goddard Space Flight Center.

MULTISPECTRAL SCANNER (MSS)

SYSTEM CHARACTERISTICS

Components: double reflection-type telescope, scanning mirror, filters, detectors, and associated electronics

Weight: 75 kg

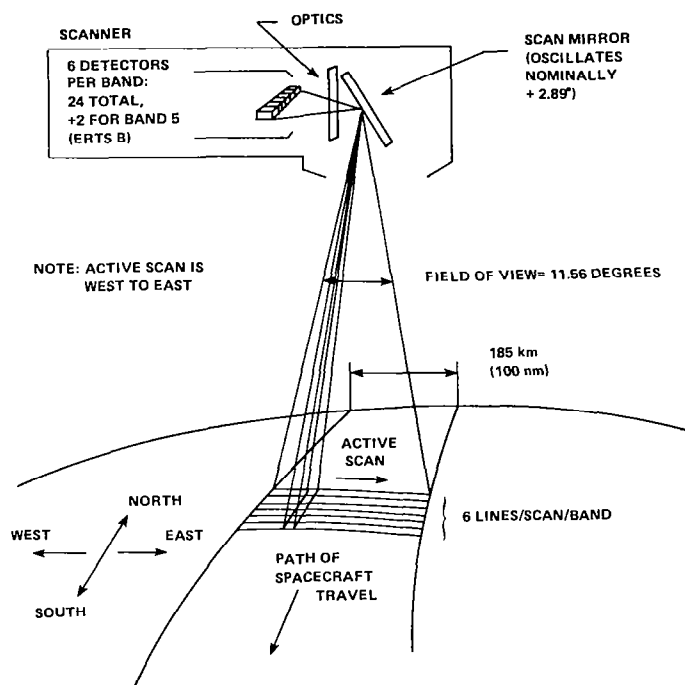
Data Rate: 15 mbs

Scenes/day: 200

Average power: 55 Watts

Volume: 6.1 cu. ft.

FUNCTIONAL DIAGRAM



Multispectral Scanner Schematic Diagram

MEASUREMENTS

Measures reflected solar and thermal radiation from the Earth.

Field-of-View: 14.92°

Ground Resolution: 82.6M

Spectral Bands:

1. 0.5-0.6 micron
2. 0.6-0.7 micron
3. 0.7-0.8 micron
4. 0.8-1.1 micron
5. 10.4-12.6 microns Landsat 3

MULTISPECTRAL SCANNER (MSS)

POTENTIAL DERIVED PARAMETERS

Oceanographic and meteorological purposes:

1. Map sea-ice fields
2. Locate and track major ocean currents
3. Monitor both air and water pollution
4. Determine snow cover
5. Investigate severe storm environments.

NIGHTTIME/DAYTIME OPTICAL SURVEY OF LIGHTNING

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. Dodge
LOCATION: NASA Headquarters

ACRONYM: NOSL
INSTRUMENT TYPE: Camera
PAYLOAD: OSTA
CONTRACTOR:
P.I.:

OBJECTIVES

1. To obtain films of ordinary and severe thunderstorms, which will provide information on storm dynamics and electrical phenomena.
2. Film records of the appearance of the cloud systems and the lightning.

DESCRIPTION

SUMMARY: The NOSL instrument consists of the camera, the attached photocell sensor, and the stereo cassette tape recorder. The camera will be mounted so that it can photograph out the overhead window in the crew cabin. The tape recorder will be attached by velcro to the side of the aft bulkhead. The motion picture camera to be used by NOSL is a 16 mm Data Acquisition Camera (DAC), a model which has been flight tested on Apollo and Skylab missions. The camera will run on 28 VDC power supplied by the Orbiter. It interfaces with the Orbiter power supply via a DAC power cable. The photocell sensor is mounted on top of the DAC and its field-of-view is aligned with the camera's. It contains its own battery power supply. A battery powered Sony TC 124 stereo cassette recorder, equipped with a plug-in earphone, interfaces with the camera and photocell via connecting wires. Three 60-minute tape cassettes, twenty 140' film magazines, and spare recorder batteries will be kept in a storage apron velcro mounted in the crew compartment.

REFERENCES

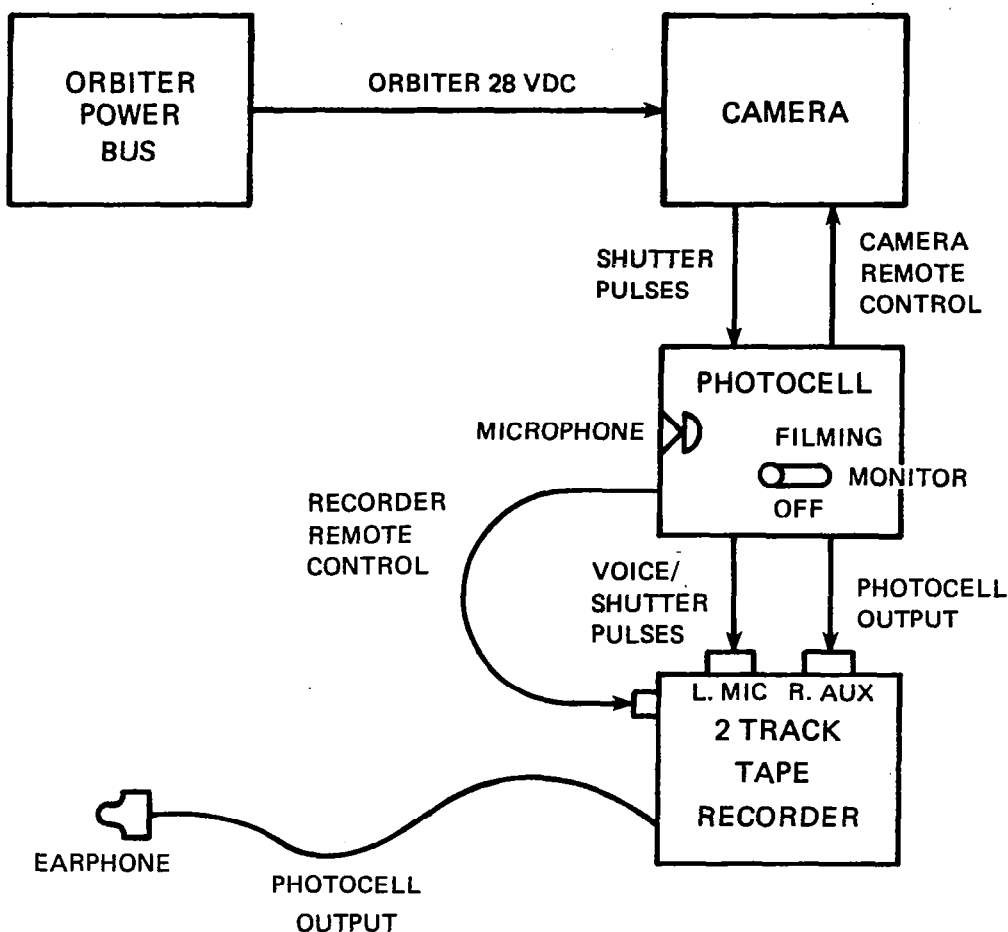
1. Nighttime/Daytime Optical Survey of Lightning and Convective Phenomena Experiment (NOSL), February 1980.
2. Office of Space and Terrestrial Applications-1, Handout, 1980.

SYSTEM CHARACTERISTICS

Size: 0.28 m³
Mass: 15.75 kg
Maximum power: 25 We

NIGHTTIME/DAYTIME OPTICAL SURVEY OF LIGHTNING (NOSL)

FUNCTIONAL DIAGRAM



Nighttime/Daytime Optical Survey of Lightning Functional Diagram

POTENTIAL DERIVED PARAMETERS

1. Thunderstorm activity of interest
2. Long lightning discharges
3. Unusual lightning in tornado-producing storms
4. Electrical discharges in the clear air above thunderstorms
5. Changes in the reflection of sunlight from upper part of thundercloud as a result of electrical reorientation
6. Cloud circulation
7. Maritime thunderstorms
8. Warm cloud electrification
9. Electrical activity in hurricanes and typhoons
10. Lightning in volcanic eruptions
11. Relationships between cloud types and lightning
12. Spectroscopic observations lightning.

NIMBUS E MICROWAVE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Mission
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: NEMS
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-5
CONTRACTOR: Jet Propulsion Laboratory
P.I.: Dr. D. H. Staelin, MIT
F. T. Barath, JPL

OBJECTIVES

1. Demonstrate the capabilities and limitations of microwave sensors for measuring tropospheric temperature profiles, water vapor abundance, and cloud water content.
2. Supplement IR sensors in gathering data for weather prediction purposes, especially over cloud-covered regions of the Earth.

DESCRIPTION

SUMMARY: The NEMS continuously monitored emitted radiation at wavelengths of 11.1, 9.55, 5.58, 5.46, and 5.10 mm. The three channels near the 5-mm oxygen absorption band were used primarily to determine the atmospheric temperature profile. NEMS provided measurements for use in deriving temperature profiles even in cloud cover conditions that normally restrict the usefulness of conventional IR data in such situations. The two water vapor channels near 10 mm permitted the water vapor and cloud liquid water content over oceans to be estimated and also yielded an estimated temperature once the surface emissivity had been calibrated by comparison with direct measurements. The three oxygen channels shared a common signal and reference antenna. Both water vapor channels had their own signal and reference antennas. From an average satellite height of 1100 km, the NEMS viewed a 180-km diameter circle on the Earth's surface. NEMS data were recorded on magnetic tape for subsequent playback to a ground acquisition station.

DATA

DATA PRODUCTS:

Data Set Name: Microwave Spectrometer Outputs Tapes
NEMS Output Tapes on Microfiche
NEMS Brightness Temperature Data on Microfiche

Tapes: 31 reels of 9-track, 1600 BPI magnetic tapes containing data for a NEMS calibration cycle.

Film: 168 B/W cards containing listings of the NEMS output tapes on microfiche.
93 cards of B/W microfiche containing NEMS brightness temperatures on microfiche.

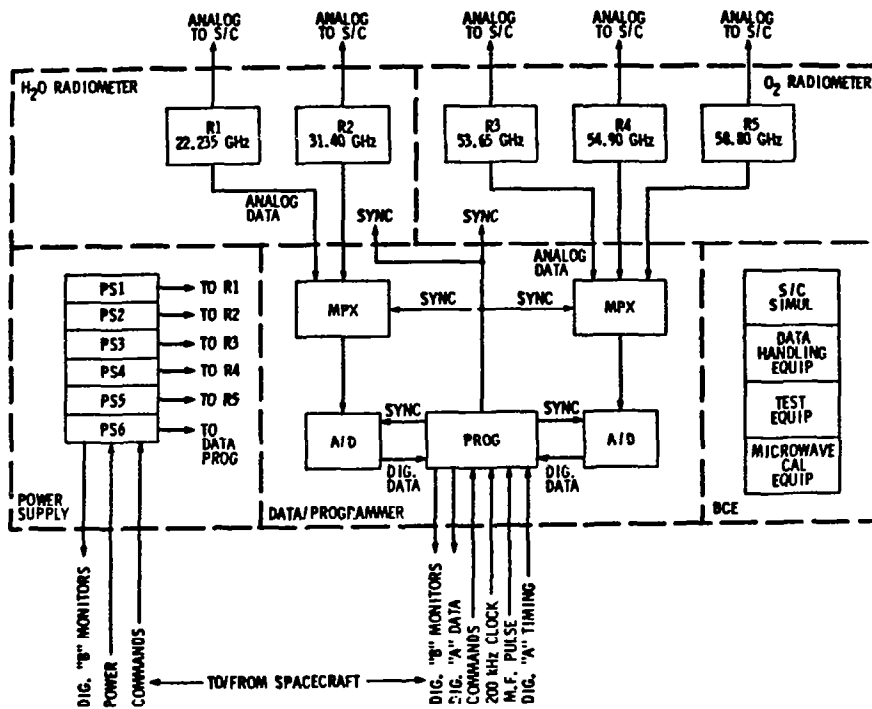
DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center.
PERIOD OF OPERATION: August 1972 - December 1973

NIMBUS E MICROWAVE SPECTROMETER (NEMS)

SYSTEM CHARACTERISTICS

Weight: 50 lbs.
 Volume: 1.33 cu. ft.
 Avg. Power: 35 Watts
 Peak Power: 40 Watts
 Components: radiometers (5), antennas (3 sets), associated electronics
 Data Recovery: telemetry
 Precision and Accuracy: Temperature -2°K; water-vapor-0.1GM/SQCM; clouds - 0.04GM/SQCM

FUNCTIONAL DIAGRAM



NIMBUS E Microwave Spectrometer System Block Diagram

NIMBUS E MICROWAVE SPECTROMETER (NEMS)

MEASUREMENTS

Measures microwave radiation at five spectral wavelengths.

Measurement Range: radiant temperature from 175 to 400°K

Field-of-View: 9.0°

Resolution: 100 nautical miles

Wavelengths:

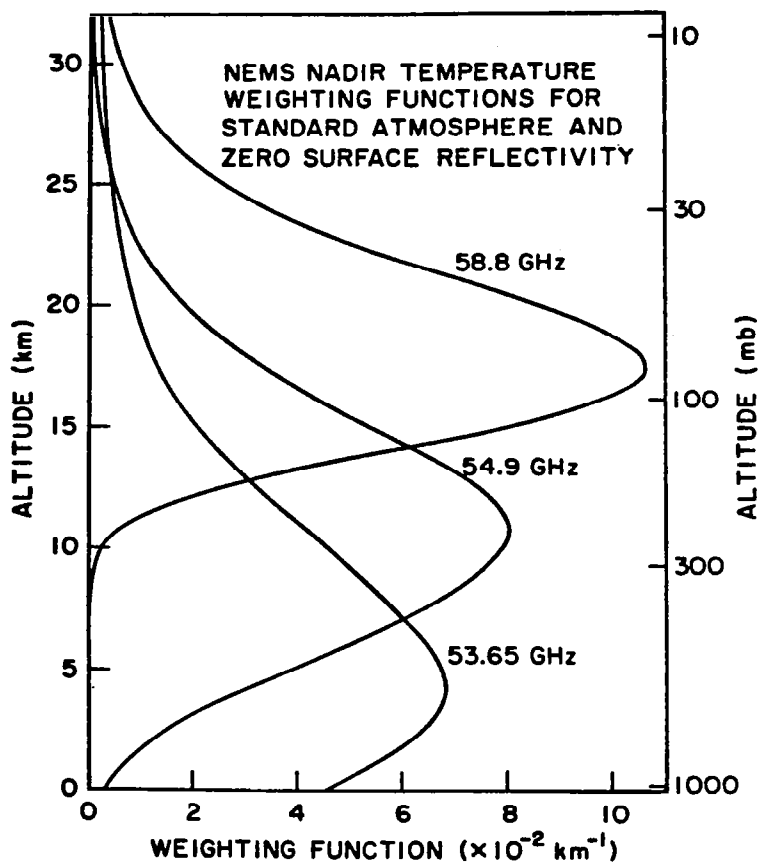
22.2 GHz

31.4 GHz

53.6 GHz

54.9 GHz

58.8 GHz



NEMS Nadir Temperature Weighting Functions

POTENTIAL DERIVED PARAMETERS

1. Atmospheric and surface radiation in the 0.5 to 1.35 cm bands.
2. Snow cover.
3. Ice type.
4. Soil moisture.

OCEAN COLOR EXPERIMENT

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: OCE
INSTRUMENT TYPE: Scanner
SPACECRAFT: OSTA-1 Shuttle
CONTRACTOR:
P.I.: H.H. Kim, GSFC

OBJECTIVES

1. To verify the validity of a technique to gather ocean color information and to distinguish it from the obscuring radiation scattered from the atmosphere.
2. To map the distribution of marine algae.
3. By mapping the combination of chlorophyll concentrations with temperatures, the approximate location of fish schools can be determined.
4. Mapping the abundance and distribution of the algae is necessary to monitor the marine ecosystem and to see that its balance is not upset by pollutants and chemical wastes.

DESCRIPTION

SUMMARY: A rotating mirror on the OCE instrument scans $\pm 45^\circ$ from nadir across the direction of flight and reflects radiation into a Dall Kirkham telescope. The telescope images the scene into a 1 x 2 mm field stop and onto a diffraction grating. The diffracted light is directed onto a bundle of 24-glass fibers, and a different spectral band is channeled through each glass fiber. Eight of the fibers are coupled to eight silicon photodiode detectors while the others are routed to a storage rack.

The signal containing useful information will be extracted from the measured radiance in the following way: the signal from the 700-800 nanometer channel is essentially independent of subsurface scattering because of water absorption of radiance in this spectral range. It is mostly caused by surface reflection and scattering off of air molecules. The signal can therefore be used to calculate the contribution of these factors to the radiance received by the other spectral channels. The useful signal is contained in the difference between the total radiation registered in each channel and the radiation computed using the signal from the 700-800 nanometer channel.

The signals from each channel will be examined to determine the spectral bands which were absorbed by the water. Chlorophyll absorbs blue light, and the water appears greenish in the presence of chlorophyll.

HERITAGE/DERIVATION: Differential Radiometer, CZCS - NIMBUS

REFERENCES

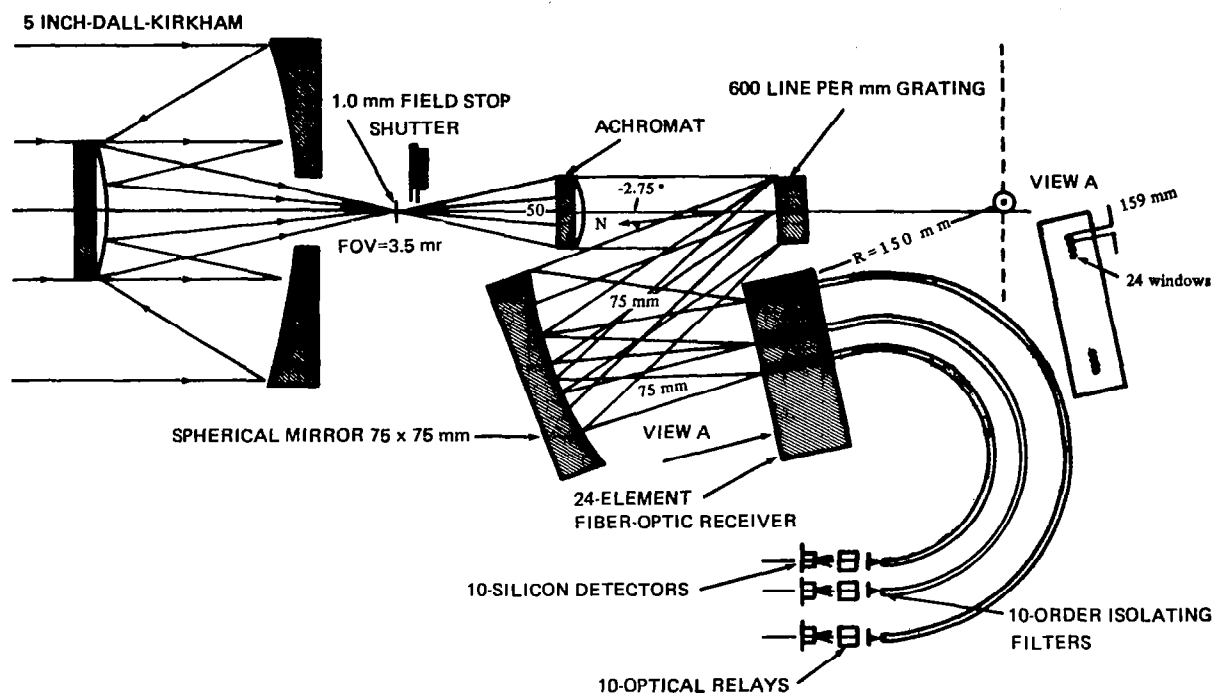
1. Office of Space and Terrestrial Applications-1, Handout, 1980.

OCEAN COLOR EXPERIMENT (OCE)

SYSTEM CHARACTERISTICS

	<u>Wt (Kg)</u>	<u>Dim (cm)</u>
Scanner	34	23 x 27 x 75
Main Electronics Assembly	60	29 x 71 x 91

FUNCTIONAL DIAGRAM



Ocean Color Experiment Schematic Diagram

MEASUREMENTS

Makes spectroscopic observations of open ocean.

Channels: 8

Spectral Range: 0.44-0.75 microns

Bandwidth: 0.02-0.05 microns

POTENTIAL DERIVED PARAMETERS

1. Cloudless ocean
2. Atmospheric aerosols
3. Sea state
4. Water clarity
5. Water depth
6. Nutrient rich water upwelling zones.

1.27 MICRON AIRGLOW SENSOR

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: S. Tilford
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: Solar Mesosphere Explorer
CONTRACTOR: Jet Propulsion Laboratory
P.I.:

OBJECTIVES

1. To measure products of ozone photo-dissociation.
2. To measure emissions between 7000Å and 2.4 microns caused by O₂, OH, and O₂.

DESCRIPTION

SUMMARY: The 1.27 micron Airglow Sensor is one of five instruments to be carried on the SME spacecraft. It will measure the ozone density and altitude distribution, monitor the incoming solar radiation, and measure other atmospheric constituents which affect ozone.

HERITAGE/DERIVATION: Dual channel Ebert-Fastie spectrometer, NASA OSS, Jet Propulsion Laboratory.

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory, National Center for Atmospheric Research, LASP.

REFERENCES

1. Project Plan for Solar Mesosphere Explorer 1981 Mission, Jet Propulsion Laboratory 629-1, September 1978.

SYSTEM CHARACTERISTICS

Physical Size (m): 0.35 x 0.13 x 0.10
Mass (kg): 2.72
Power Requirement (We): 5
Data Rate: 42.7

MEASUREMENTS

Measures the emission from excited molecular oxygen.

1. Number of channels: 2
2. Spectral range: 0.7 to 1.4 micron and 1.2 to 2.4 microns

POTENTIAL DERIVED PARAMETERS

1. Atmospheric ozone distribution
2. Ozone photochemistry.

PRESSURE MODULATOR RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: PMR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-6
CONTRACTOR: Clarendon Laboratory
P.I.: J. T. Houghton, Oxford University

OBJECTIVES

1. Measure the atmosphere's temperature distribution in the upper stratosphere and mesosphere (between 40 km and 85 km altitude) with as near-global coverage as is possible from each day of satellite operations.
2. Monitor the atmosphere's mean structure, and the changes which occur with latitude and season at the 40 km to 85 km altitude range.
3. Investigate the propagation of large-scale atmospheric waves (especially stratospheric warmings) at this altitude, and to determine to what extent these disturbances are generated in the mesosphere itself.
4. Investigate links between ionospheric phenomena and the circulation.

DESCRIPTION

SUMMARY: The NIMBUS-6 Pressure Modulated Radiometer (PMR) experiment took radiometric measurements in the 15-micrometer CO₂ band at altitudes between 45 and 70 km on a global scale. By appropriate mathematical retrieval methods, the temperature structures of the upper stratosphere and lower mesosphere were then deduced. The pressure modulation technique permitted the extension of selective chopping techniques to higher altitudes where the pressure-broadened emission lines in the 15-micrometer CO₂ band became so narrow that conventional spectrometers and interferometers had insufficient spectral resolution. In addition to pressure scanning (in discrete steps), the radiometer also employed doppler scanning along the direction of flight. The PMR comprised two similar radiometer channels, each consisting of a plane scanning mirror, reference blackbody, pressure modulator cell, and detector assembly. The plane mirror was gold-coated and mounted at 45° on a 90° stepping motor so that the field-of-view of the channel could be directed to space or to the internal reference blackbody for inflight range and zero calibration. The motor was mounted on a pair of flexible pivots so that the mirror can be rotated through $\pm 7\text{-}1/2^\circ$ from its rest position to give the required doppler scan. Major components in the pressure modulator cell were a movable piston, a diaphragm, and a magnetic drive coil. The detector assembly consisted of a field lens, a condensing light pipe, and a pyroelectric flake bolometer. Each radiometer had a field-of-view that was 20° whole angle across the spacecraft's line of flight and 40° whole angle parallel to the line of flight.

DATA

DATA PRODUCTS: Magnetic tapes of temperature data.

PRESSURE MODULATOR RADIOMETER (PMR)

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center.
PERIOD OF OPERATION: October 1973 to December 1977

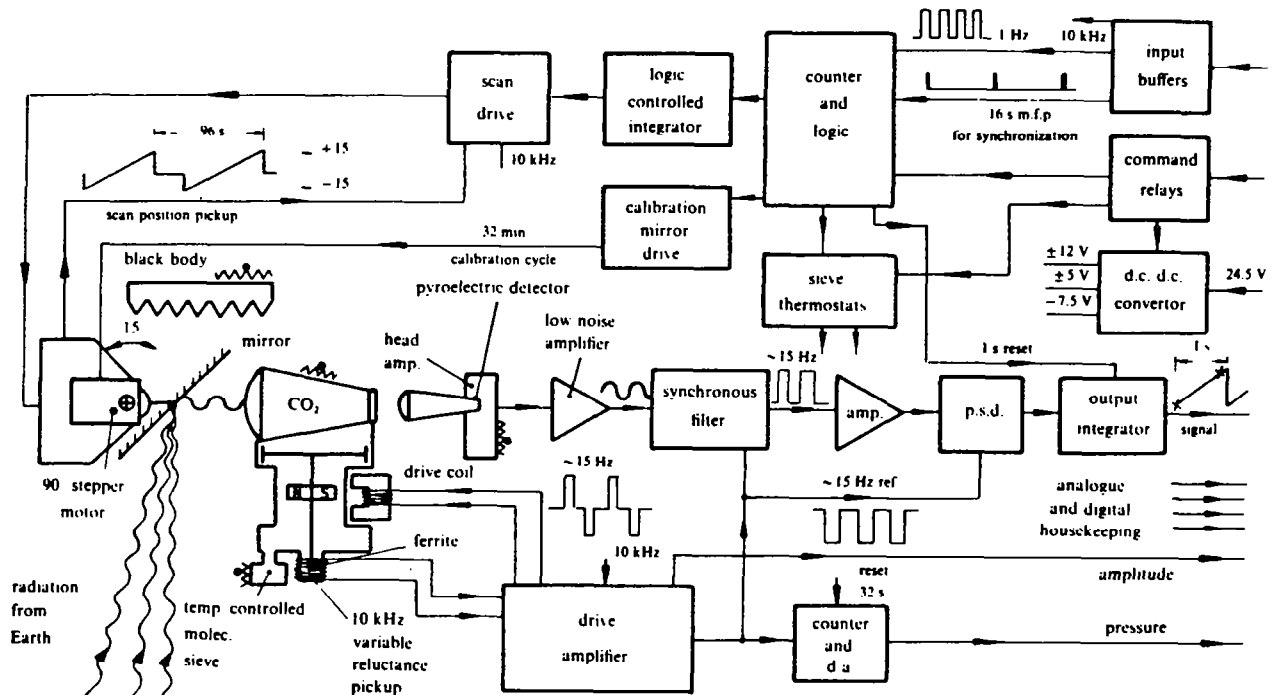
REFERENCES

1. NIMBUS-6 Users Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 5 lbs.
 Volume: 0.25 cu. ft.
 Avg. Power: 3 Watts
 Data Recovery: telemetry

FUNCTIONAL DIAGRAM



Pressure Modulator Radiometer Electronics Block Diagram

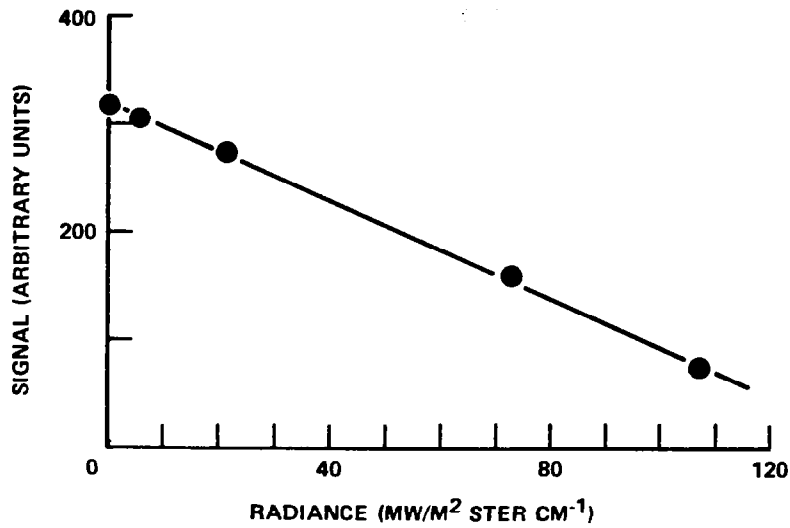
PRESSURE MODULATOR RADIOMETER (PMR)

MEASUREMENTS

Measures the Earth's emitted radiance.

Measurement Range: 15 micron CO₂ band

Field-of-View: 20 degrees whole angle



Signal Versus Radiance for One of the Channels of the PMR

POTENTIAL DERIVED PARAMETERS

1. Temperature distribution in the stratosphere and mesosphere.
2. Stratospheric warmings.

RADAR ALTIMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. T. McGoogan
LOCATION: NASA/Wallops Flight Center

ACRONYM: ALT
INSTRUMENT TYPE: Altimeter
SPACECRAFT: SEASAT-A
CONTRACTOR: APL
P.I.: Dr. Sam Smith, NWL

OBJECTIVES

1. To measure significant wave heights and mean sea level.
2. To detect tides, currents and storm surges in support of global forecasting.
3. A precise orbital measurement and refinement of the geoid model.

DESCRIPTION

SUMMARY: The SEASAT-A satellite bearing the altimeter was launched to obtain a mean circular orbit with a 108° inclination, mean altitude of 790 km and approximate ground speed of 6.6 km/sec. An orbital period of 104 minutes results in 14 orbits/day. Seven orbits are required for complete (mission) ocean coverage. The altimeter employs a nadir viewing parabolic dish antenna to illuminate and receive energy from a circular area on the sea surface with an effective radius of 1.6 to 12 km dependent on sea state. All altimeter data will be recorded. Playback data becomes the source of data records for the low rate telemetry link as the satellite passes over selected tracking stations (STDN). Correlative data from the other four SEASAT-A sensors in addition to sea truth data and precise orbital information from laser tracking sites are necessary to reduce the ALT data to accurate geophysical units (i.e., waveheight, altitude).

HERITAGE/DERIVATION: Skylab-S193; GEOS-3

DATA

DATA PRODUCTS: Tape products, 9 track, 1600 BPI. Latitude, longitude, and time located geophysical data every 18 km along spacecraft track of the displacement of the spacecraft from the ocean surface, significant wave heights, atmospheric pressure effect, ionospheric correction, wet and dry tropospheric correction, and surface pressure.

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory
PERIOD OF OPERATION: July 7 through October 10, 1978

REFERENCES

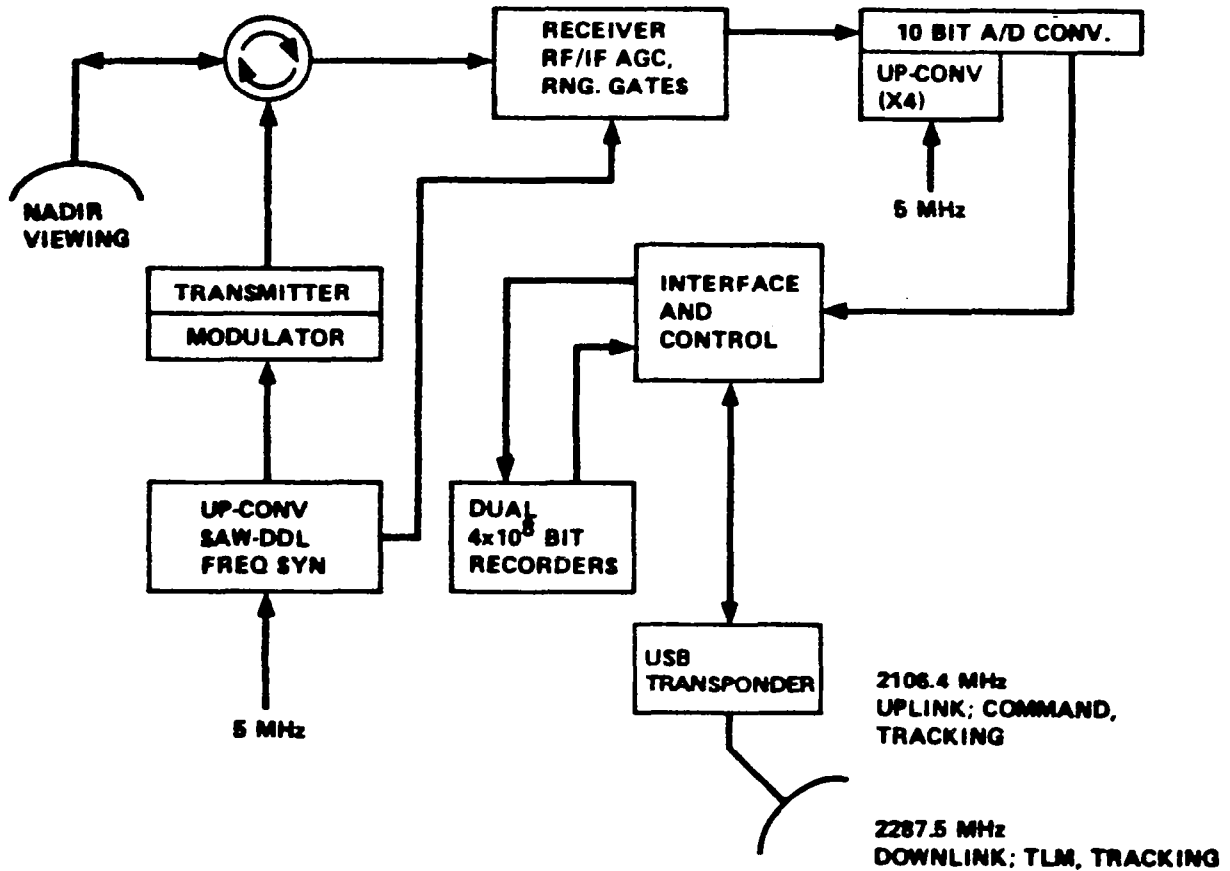
1. Satellite Data Users Bulletin, Volume 1, No. 1, January 1979.

SYSTEM CHARACTERISTICS

Receiver Bandwidth: ± 160 mHz
Orbital Period: 104 minutes
Orbits/day: 14
Weight: 70 kg
Data Rate: 8.15 kbps
Power: 8.25 W

RADAR ALTIMETER (ALT)

FUNCTIONAL DIAGRAM



Radar Altimeter Block Diagram

MEASUREMENTS

Frequency: 13.499 GHz
Receiver Dynamic Range: 63 dB
Bandwidth: 320 MHz
Backscatter Measurement Accuracy: within 1.0 dB
Pulse Width: 3.2 microseconds
Swath Width/FOV: 1.6 km at nadir
Measurement Accuracy: ± 1 meter (wave); ± 10 cm (marine geoid)

POTENTIAL DERIVED PARAMETERS

1. Wave height (sea state)
2. Sea surface topography
3. Geoid

RADAR ALTIMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: W. Townsend
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Radar Altimeter
SPACECRAFT: TOPEX
CONTRACTOR: Wallops Flight Center
P.I.: J. McGoogan, WFC

OBJECTIVES

1. To measure altitude above sea surface to a precision of ± 1.5 cm.
2. To measure significant waveheights to an accuracy consistent with overall measurement and at least ± 0.5 meter or 10 percent.
3. To measure scattering cross section to an accuracy consistent with overall measurement and at least ± 1 dB.
4. To measure the free electron path correction to an accuracy of ± 0.5 cm.

DESCRIPTION

SUMMARY: The altimeter planned to the TOPEX mission is a derivative of the SEASAT-1 altimeter. This instrument will be a dual channel sensor which will operate in the Ku band and C-band. It will be used to measure the instantaneous round trip light time from the satellite to the nadir point on the ocean surface. The telemetered data for each frequency will include height, $H^{1/3}$, receiver AGC, and the return signal power versus time waveform. The ionospheric propagation path will be calculated from the dual frequency ranging data. The altimeter will use a 2 meter parabolic antenna with a dual focal point feed system. The sensor will operate at 13.7 GHz and nominally at 5.1 GHz.

HERITAGES/DERIVATION: SEASAT-1 Altimeter.

REFERENCES

1. "Satellite Altimetric Measurements of the Ocean", Report of the TOPEX Science Working Group, March 1, 1981. NASA and JPL.

SYSTEM CHARACTERISTICS

Mass: 99 kg (94 electronics, 5 antenna)
Volume: 0.067 cubic meter
Power: 199 Watts
Data rate: 7.9 kbps (prime) or 12.7 kbps (engineering assessment)
Reliability: 0.84 (5 yr.)
Antenna size: 2 meter

RADAR ALTIMETER

MEASUREMENTS

Measures reflected and backscatter radiation.

Channels: 2

Frequency: 1. 13.7 GHz
2. 5.1 GHz

PRF: 4500 pps

Pulse length: 96 microseconds

Footprint: 3 km diameter on smooth sea

Accuracy: 1. Waveheight to ± 0.5 cm
2. Scattering cross section to ± 1 dB
3. Altitude above sea surface to ± 1.5 cm
4. Ionospheric correction to 0.5 cm

POTENTIAL DERIVED PARAMETERS

1. Sea surface elevation
2. Sea surface wave height
3. Surface currents and circulation.

RETURN BEAM VIDICON CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: RBVC
INSTRUMENT TYPE: Imager
SPACECRAFT: Landsat -1,-2 &-3
CONTRACTOR: RCA Astro Electronics
P.I.: O. Weinstein, GSFC
T. Ragland, GSFC

OBJECTIVES

1. Provide continuous, overlapping multispectral photographic coverage of the Earth's surface along the orbital track.
2. Repeated observations of any given area within the minimum time interval possible.

DESCRIPTION

SUMMARY: The RBVC is a 3 camera system spanning the visible spectrum in 3 bands: .475-.575, .580-.680, and .690-.830 micron. Spectral bands are obtained through use of filters in acquisition optics. An electronically triggered, variable-speed, focal-plane shutter allows picture-taking over a wide range of scene brightness and provides uniform exposure of the vidicon. This sensor, a 2-inch return beam vidicon, combines the vidicon and orthicon tube. The video output is derived from the return scanning beam. A photoconductive surface charges the target surface in proportion to the light received. Then as the electron scanning beam traverses the target, the charge modulates this beam which is then amplified by an electron multiplier. The video output of the system may be fed directly to the modulator of the spacecraft communication system. The cameras are pointed at Nadir and a new scene is imaged on the photo conductor surfaces every 25 sec. The resolution capability of the system is 4500 TV lines. Equipped with a 130 mm FL, F/2.8 lens, each frame will cover an area of 100 x 100 nm at a resolution of about 150 feet per TV line from 496 nm altitude. The sensor is capable of resolving 90 line-pairs/millimeter on Landsat 2 or 3. The camera FL was changed to obtain a coverage of 50 x 50 nm and the resolution of 75 feet per TV line.

DATA

DATA PRODUCTS: Spectral images - data can be purchased as image products or as computer compatible tapes.

DATA ARCHIVES LOCATION: Earth Resources Data Center, Department of the Interior, Sioux Falls

PERIOD OF OPERATION: July 23, 1972 - January 6, 1978 (Landsat 1)
January 22, 1975 - July 1980 (Landsat 2)
March 5, 1978 - To present (Landsat 3)

REFERENCES

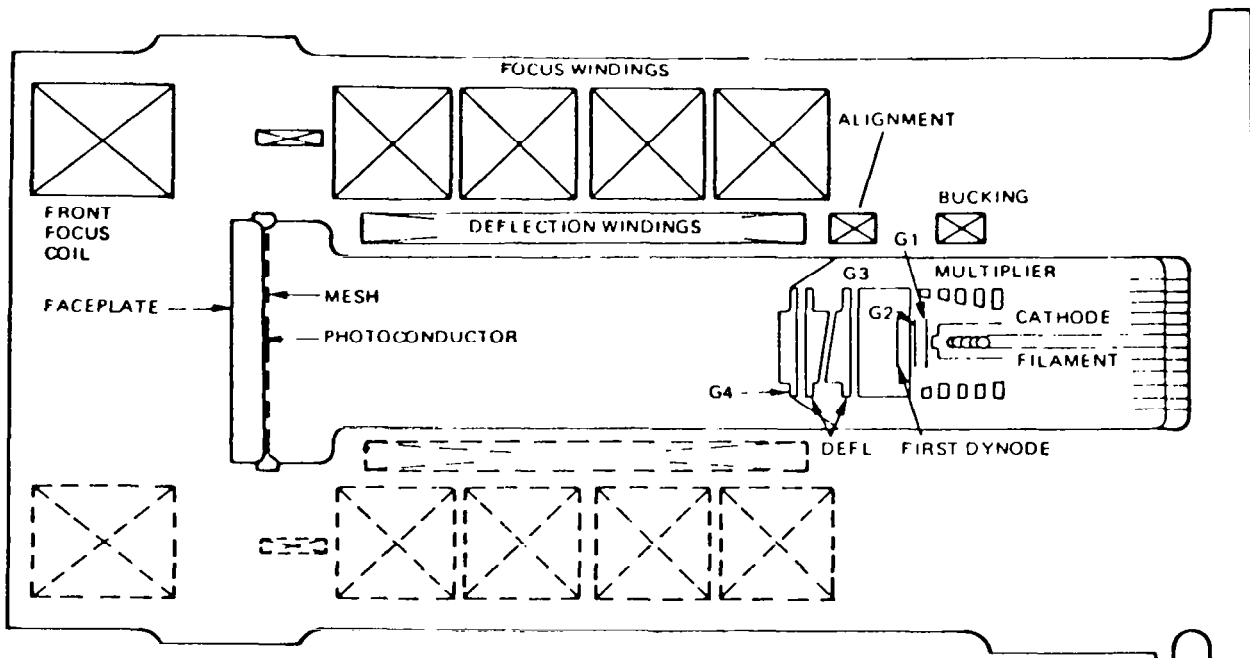
1. National Space Science Data Center, Fact sheets on U.S. and weather and Earth observation satellites.

RETURN BEAM VIDICON CAMERA SYSTEM (RBVC)

SYSTEM CHARACTERISTICS

Weight: 130 lbs.
Volume: 3.0 Cu. ft.
Avg. Power: 130 Watts
Peak Power: 145 Watts
MTBF: 12 months
Data Recovery: delayed telemetry

FUNCTIONAL DIAGRAM



Return Beam Vidicon Camera System Schematic Diagram

RETURN BEAM VIDICON CAMERA SYSTEM (RBVC)

MEASUREMENTS

Measures radiation from Earth's surface.

Spectral Range: 0.475 to 0.83 microns

Field of View: 11.5 by 11.5 degrees

Spectral Bands:	Landsat 1 and 2	Landsat 3
	0.475 - 0.575 microns	0.505 - 0.750 microns
	0.580 - 0.680 microns	
	0.690 - 0.830 microns	

Resolution: 80 meter (Landsat 1 and 2); 40 meter (Landsat 3)

Ground Swath: 185 km x 185 km (Landsat 1 and 2); 98 km x 98 km (Landsat 3)

POTENTIAL DERIVED PARAMETERS

1. High resolution multispectral photography of earth and cloud cover.

SATELLITE INFRARED SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: SIRS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-3, 4
CONTRACTOR: Culton Industries
P.I.: Dr. D. O. Wark

OBJECTIVES

1. Determine the worldwide three-dimensional distribution of temperature, from the ground or from cloud top to an altitude of 16 to 19 nm.
2. To measure surface temperature or the cloud-top temperature, and its height.
3. To measure the three-dimensional distribution of water vapor, from ground up to about 6.5 nm.

DESCRIPTION

SUMMARY: The instrument is a Fastie-Ebert fixed-grating infrared spectrometer with the following features: (1) a plane, light-collecting mirror to provide one fixed and two variable earth-viewing angles; (2) a balanced rotating chopping mirror which serves alternatively to collect space radiation and Earth radiation; (3) a spherical mirror of 12.5-inch focal length; (4) a 2.5-inch with 1250 lines per inch diffraction grating; (5) a set of 14 exit slits with associated inference filters for order limitation, and 14 wedge-immersed or similar thermistor bolometers; and (6) a blackbody radiation source for calibration purposes. The 15 micron radiation data is transformed into a single temperature-pressure profile by a mathematical inversion technique. A similar related technique yields the altitude profile of water vapor from the 18 to 35 micron data the 11.1 micron data compared with a blackbody temperature calibration curve yields surface of cloud-top temperatures. The bands monitored are centered at 11.12, 13.33, 14.01, 14.15, 14.31, 14.45, 14.76, 14.95, 18.82, 22.91, 23.50, 34.31, 33.11, 35.71 microns. Data is accumulated in six second intervals to give profiles each 50 miles along the strip.

DATA

DATA PRODUCTS:

NIMBUS-3

Data Set: SIRS radiance values on tape.

Tape: 60 reels of magnetic tape containing reduced radiance values.

NIMBUS-4

Data Set: Satellite Infrared Spectrometer Radiance Tapes

Tapes: 10 reels of magnetic tape containing reduced radiance values.

DATA ARCHIVES LOCATION: NESR, National Weather Records Center, National Space Science Data Center, National Climatic Center

SATELLITE INFRARED SPECTROMETER (SIRS)

PERIOD OF OPERATION:

NIMBUS-3

April 1969 to June 1970

NIMBUS-4

April 1970 to April 1971

REFERENCES

1. The NIMBUS-4 User's Guide; Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.
3. NIMBUS-3 Reference Manual, April 1969.

SYSTEM CHARACTERISTICS

Weight: 70 lbs.

Volume: 2.3 cu.ft.

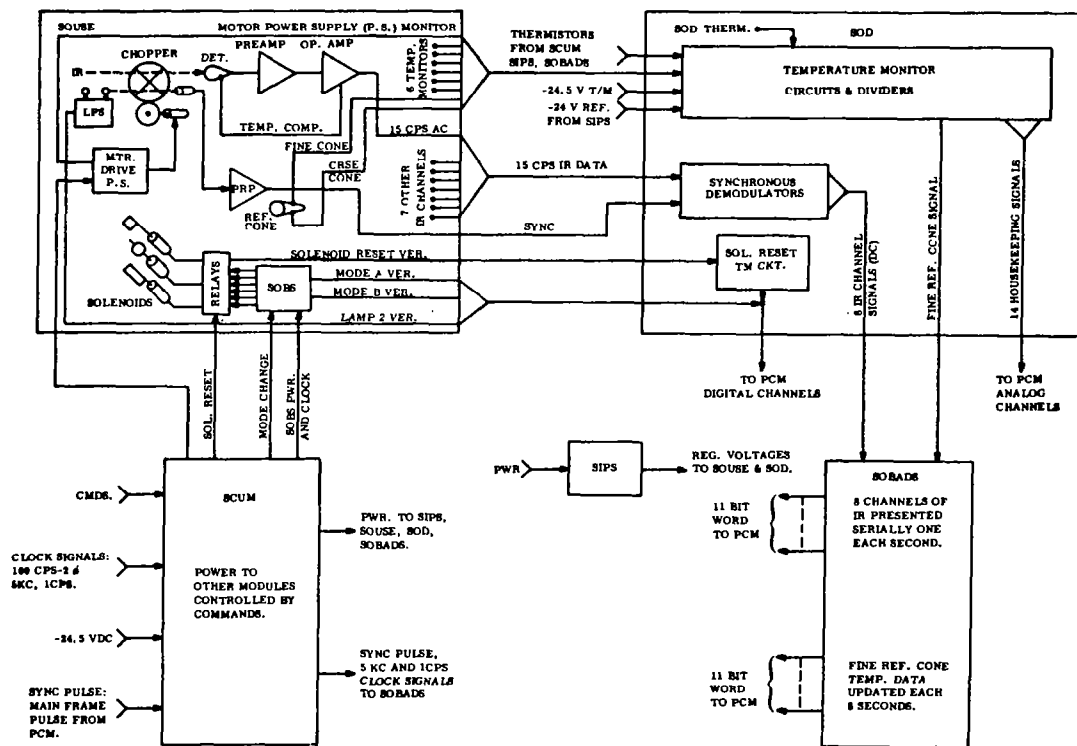
Avg. Power: 30 Watts

Components: spectrometer, mirrors, bolometers, electronics

Data Recovery: delayed telemetry

Measurement Precision and Accuracy: temperature to ± 1 deg K, water vapor to +1%

FUNCTIONAL DIAGRAM



Satellite Infrared Spectrometer Block Diagram

SATELLITE INFRARED SPECTROMETER (SIRS)

MEASUREMENTS

Measure IR radiation emitted from the Earth's atmosphere.

Measurement Range: 40 to 90 erg/sec-cm/steradian/wave no.

Spectral Resolution: 0.2 micron

Spectral Range: 11.0 by 36.0 microns

Number of Channels: 14

Center Frequency: 1. 11.12 microns
2. 13.33 microns
3. 14.01 microns
4. 14.15 microns
5. 14.31 microns
6. 14.45 microns
7. 14.76 microns
8. 14.95 microns
9. 18.82 microns
10. 22.91 microns
11. 23.50 microns
12. 34.31 microns
13. 33.11 microns
14. 35.71 microns

Field-of-View: 75.6 by 12.5 deg.

POTENTIAL DERIVED PARAMETERS

1. Cloud top temperature.
2. Surface temperature.
3. Vertical temperature profiles of atmosphere.

SCALAR MAGNETOMETER

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. Murphy
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Magnetometer
SPACECRAFT: MAGSAT
CONTRACTOR: Bell Aerospace
P.I.: R.A. Langel, GSFC

OBJECTIVES

1. To obtain magnetic anomaly data to develop accurate quantitative description of the Earth's magnetic field.

DESCRIPTION

SUMMARY: The MAGSAT scalar magnetometer is derived from optical pumping magnetometers flown on the Orbiting Geophysical Observatories. The basic sensor, a cross-coupled arrangement of absorption cells, photodiodes, and amplifiers, oscillates at the Larmor frequency of atomic moments precessing about the ambient field direction. The Larmor frequency output is accumulated digitally and stored for transfer to the spacecraft telemetry stream. In orbit the instrument has met its principal objective of calibrating the vector magnetometer and providing scalar field data.

HERITAGE/DERIVATION: OGO pumping magnetometer

DATA

DATA PRODUCTS: Magnetic field data on tape; Latitude plots on microfilm; Polar plots on microfilm.

DATA ARCHIVES LOCATION: National Space Science Data Center, GSFC

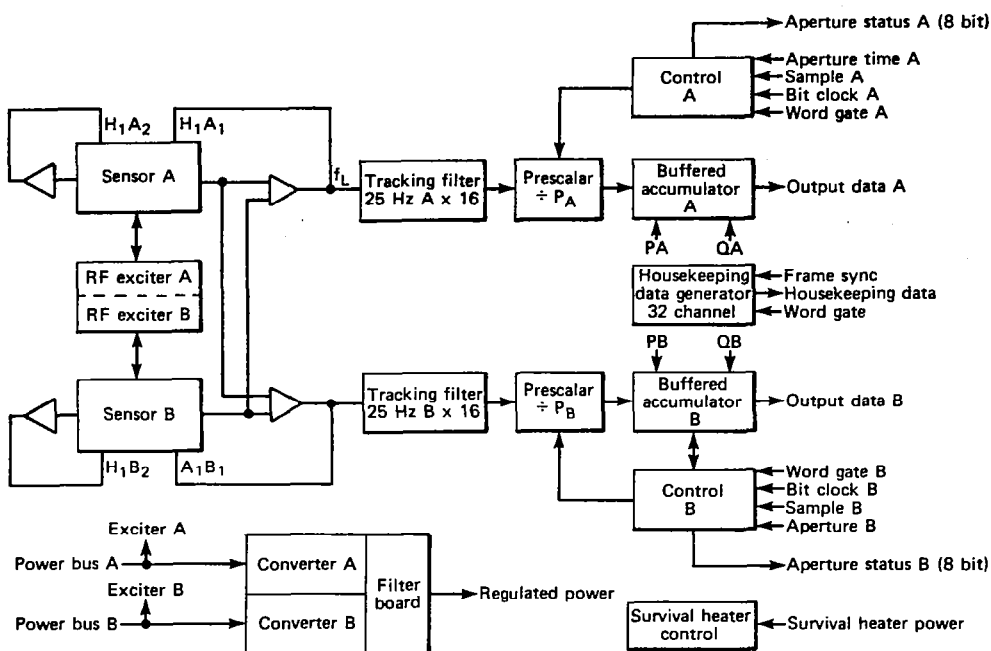
PERIOD OF OPERATION: October 30, 1979 - June 11, 1980.

REFERENCES

1. MAGSAT Program Summary, GSFC.
2. Technical Digest, Johns Hopkins Applied Physics Laboratory. July and September 1980. Vol. 1, No. 3.

SCALAR MAGNETOMETER

FUNCTIONAL DIAGRAM



Scalar Magnetometer Block Diagram

MEASUREMENTS

Measure the magnitude of the field independent of its orientation with respect to the sensor, with an absolute accuracy that is determined by atomic constants and not subject to change as a function of time.

Range: 15,000 to 64,000 gammas

Accuracy: ± 3 gamma

Telemetry Data Rate: 312 kbs

POTENTIAL DERIVED PARAMETERS

1. Scalar field data
2. Geopotential field
3. Crustal models
4. Secular variation.

SCANNING MICROWAVE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: SCAMS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NIMBUS-6
CONTRACTOR:
P.I.: D. H. Staelin, MIT

OBJECTIVES

1. To map tropospheric temperature profiles, water vapor abundance, and cloud water content.
2. To obtain such data for weather prediction purposes even in the presence of clouds, which block conventional satellite infrared sensors.
3. To map atmospheric temperature profiles from 0 km to 20 km.
4. To determine over oceans the abundance of liquid water and water vapor in the atmosphere in the presence of clouds.

DESCRIPTION

SUMMARY: The SCAMS continuously monitored emitted radiation at wavelengths of 22.234, 31.63, 52.85, 53.85, and 55.45 GHz. The three channels near the 5.0-mm oxygen absorption band were used primarily to deduce atmospheric temperature profiles. Two of the channels permitted water vapor and cloud water content over calm oceans to be estimated separately. The instrument, a dicke-superheterodyne type, scanned $\pm 45^\circ$ normal to the orbital plane with a 10° field-of-view. The three oxygen channels shared common signal and reference antennas. Both water vapor channels had their own signals and reference antennas. The absolute rms accuracy of the oxygen channels was better than 2°K and that of the water vapor channels better than 1°K. The dynamic range for all channels was 0-400°K.

HERITAGE/DERIVATION: NEMS on NIMBUS-5

DATA

Data Set Name: NIMBUS-6 SCAMS
Scanning Microwave Spectrometer Data on Film

Tape: 87 reels of 9-track, 1600 BPI, binary, magnetic tape.

Film: 3 frames are displayed as an image at full vertical scale or at part vertical scale.

DATA ARCHIVES LOCATION: National Space Science Data Center

PERIOD OF OPERATION: June 1975 to May 1976

REFERENCES

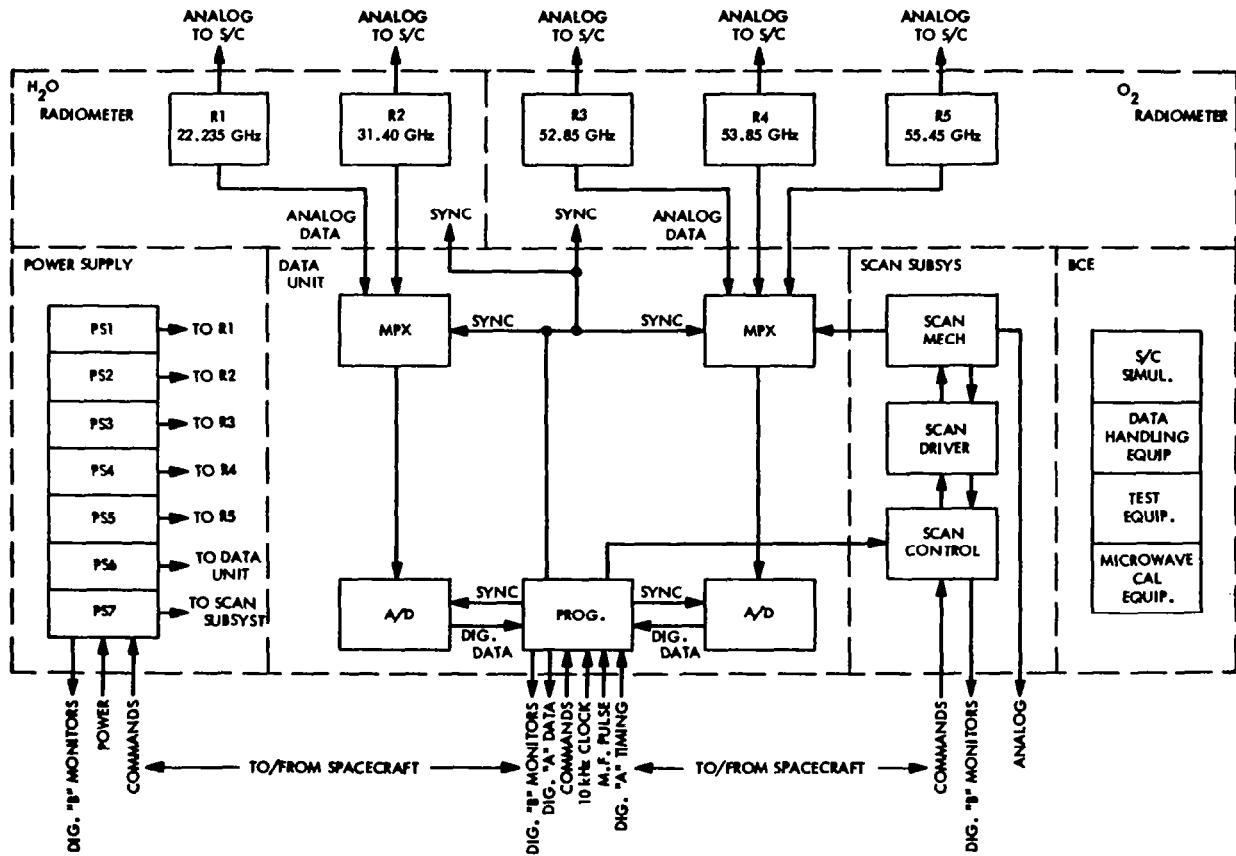
1. National Space Science Data Center computer printout, 1980.
2. NIMBUS-6 Users Guide, Goddard Space Flight Center, Greenbelt, Maryland.

SCANNING MICROWAVE SPECTROMETER (SCAMS)

SYSTEM CHARACTERISTICS

Components: radiometers, scanning horns, calibration plates
 Weight: 70 lbs.
 Volume: 1.5 cu. ft.
 Avg. Power: 40 Watts
 Data Recovery: telemetry
 Channels: 5

FUNCTIONAL DIAGRAM



Scanning Microwave Spectrometer Block Diagram

SCANNING MICROWAVE SPECTROMETER (SCAMS)

MEASUREMENTS

Measures emitted thermal radiation.

Measurement Range: oxygen and water vapor resonance lines

Field-of-View: 10° by 10°

Spectral Range: 22.234 GHz to 55.45 GHz

Resolution: 145 km at nadir

Channels: 1. 22.234 GHz

2. 31.63 GHz

3. 52.85 GHz

4. 53.85 GHz

5. 55.45 GHz

POTENTIAL DERIVED PARAMETERS

1. Determine the usefulness of global maps of these meteorological variables and of other parameters such as snow and ice properties.
2. Atmospheric temperature profiles.
3. Water vapor abundances.
4. Liquid water abundances.

SCANNING MULTICHANNEL MICROWAVE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: L. King
LOCATION: NASA/GSFC

ACRONYM: SMMR
INSTRUMENT TYPE: Microwave Radiometer
SPACECRAFT: NIMBUS-7 and SEASAT-1
CONTRACTOR: Jet Propulsion Laboratory
P.I.: P. Gloerson

OBJECTIVES

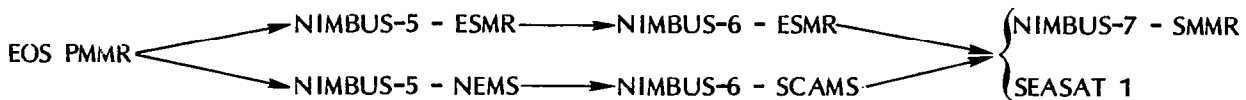
1. To obtain sea surface temperature and near-surface winds.
2. Extract geophysical parameters from the multispectral microwave radiances.
3. Verify the extraction algorithms.
4. Utilize the extracted parameters in climate modeling and assessment.
5. Support ongoing and new operational maritime uses (Fleet Weather Facility-USN/FWF, Fleet Numerical Weather Control-FNWC).
6. Identify new observables.

DESCRIPTION

SUMMARY: The SMMR is a ten-channel instrument delivering orthogonally polarized antenna temperature data at the five microwave wavelengths centered at 0.8 cm, 1.4 cm, 1.7 cm, 2.8 cm, and 4.6 cm. Polarization components of the microwave radiation are extracted for each channel. The smallest cell resolution is about 20 km for the 0.8 cm channel.

Six conventional Dicke-type radiometers are utilized. Those operating at the four longest wavelengths measure alternate polarizations during successive scans of the antenna; the others, at the shortest wavelength, operate continuously for each polarization. A two-point reference signal system is used, consisting of an ambient RF termination and a horn antenna viewing deep space. A switching network of latching ferrite circulators selects the appropriate polarization or calibration input for each radiometer. The most novel feature of the instrument is the antenna subsystem: A 42-degree offset-parabolic reflector focuses the received power into a single feedhorn covering the entire range of operating wavelengths provides coaxial antenna beams for all channels. The design of the feed utilizes a ridge-loaded corrugated conical horn with peripheral slot couplers, mode transducers, and filters. Scanning is achieved by oscillating the reflector about an axis coincident with the axis of the feedhorn.

HERITAGE/DERIVATION:



SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR)

DATA

DATA PRODUCTS:

NIMBUS-7:

<u>Tape</u>	<u>Film</u>
Antenna Temperature Tape	Maps Displays,
Horizontal and Vertical Polarization	Polar and Mercator
Brightness Temperature	
Parameters of Land-Ocean Tape	
Parameters of Sea Ice and Snow Tape	
Parameters of 37 GHz Tape	
Data available from Satellite Data User's Guide	

SEASAT-1:

Tape products 9 track, 1600 BPI. Latitude, longitude, and time located geophysical data of surface - wind speed (no direction), sea-surface temperatures integrated air column liquid water and water vapor, rain rate, atmospheric path length correction, and individual channel brightness temperatures.

DATA ARCHIVES LOCATION: National Space Science Data Center, Goddard Space Flight Center and Jet Propulsion Laboratory.

PERIOD OF OPERATION: July 7 through October 10, 1978 (SEASAT-1)
October 24, 1978 - Present (Nimbus-7)

REFERENCES

1. The NIMBUS-7 User's Guide, NASA/Goddard Space Flight Center, August 1978.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

SMMR Sensor Design Characteristics

<u>ITEM</u>	<u>CHARACTERISTICS</u>
Detectors:	RF diode - Dicke - Superheterodyne
Size:	a) Two 15.3- by 33.0- by 20.4-cm modules (two NIMBUS bays) b) One 15.3-by 16.5- by 20.4-cm module (one-half NUMBUS bya) c) Parabolic section antenna, 80 cm in diameter d) Multifrequency antenna feed

SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR)

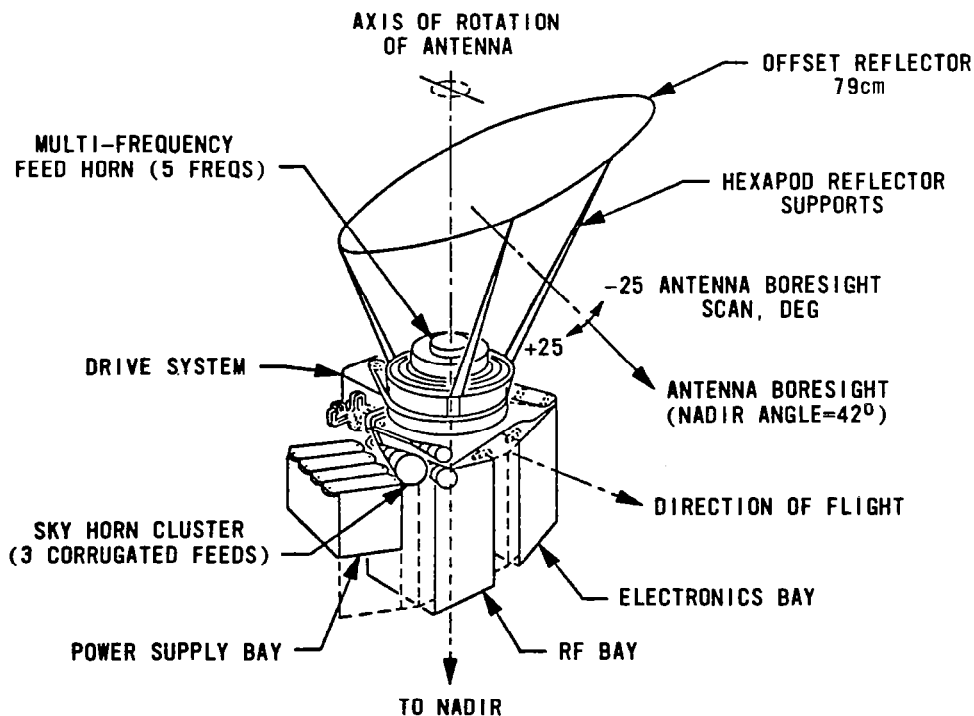
SYSTEM CHARACTERISTICS (cont.)

SMMR Sensor Design Characteristics

<u>ITEM</u>	<u>CHARACTERISTICS</u>
Weight:	52.3 Kg
Power:	60 Watts
Commands:	12
Data:	DAPS - 2 kbs (1)
Telemetry:	Digital B - 9 (2)
	Analog - 19
Clock:	Time code
	Strobe
	1 Hz
	10 kHz
	1.6 MHz

- (1) NIMBUS-7 data processing
- (2) Lower data rate in DAPS for collecting digital words.

FUNCTIONAL DIAGRAM



SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR)

MEASUREMENTS

SMMR Characteristics

Parameter	Channel				
	1	2	3	4	5
Wavelength (cm)	4.54	2.8	1.66	1.36	0.81
Frequency (GHz)	6.6	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, ΔT_{rms} (°K) (per IFOV)*	0.9	0.9	1.2	1.5	1.5
Antenna Beam Width ($\pm 0.2^\circ$)	4.2	2.6	1.6	1.4	0.8
Antenna Beam Efficiency (percent)	87.0	87.0	87.0	87.0	87.0
Scan Cycle ± 0.4 rad ($\pm 25^\circ$)/second**	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

*IFOV are remapped to form equal sized cells (150, 90, 50km) across the swath prior to retrieval of geophysical parameters; the ΔT_{rms} 's are correspondingly lower.

**Add 2 ms (used for integer dump) for complete IFOV cycle time.

POTENTIAL DERIVED PARAMETERS

1. Sea ice parameters.
2. Mesoscale soil wetness index.
3. Snow accumulation rates over continental ice sheets.
4. Atmospheric parameters over open ocean water of total water vapor, total non-precipitating liquid water, and rainfall rate.

SCANNING RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Mission
NASA TECH. OFFICER: M. Garbacz
LOCATION: NASA Headquarters

ACRONYM: SR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NOAA-1,2,3,4,5, ITOS-1
CONTRACTOR: Santa Barbara Research Center
P.I.: G. Gemunder

OBJECTIVES

1. To provide real time daylight cloud cover.
2. To measure emitted radiation from the Earth during day and night.
3. Determination of the surface temperature of the ground, sea, or cloud tops that are viewed by the radiometer.

DESCRIPTION

SUMMARY: The Scanning Radiometer (SR) subsystem consisted of two scanning radiometers, a dual SR processor, and two SR recorders. This subsystem permitted the determination of surface temperatures of the ground, the sea, or cloud tops viewed by the radiometer. The radiometer measured reflected radiation from the Earth-atmosphere system in the 0.52- to 0.73-micron band during the day and emitted radiation from the Earth and its atmosphere in the 10.5- to 12.5-micron band during the day and night. Unlike a camera, the SR did not take a picture but instead formed an image using a continuously rotating mirror. The mirror scanned the Earth's surface perpendicular to the satellite's orbital path at a rate of 48 rpm. As the satellite progressed along its orbital path, each rotation of the mirror provided one scan line of picture. Radiation collected by the mirror was passed through a beam splitter and spectral filter to produce the desired spectral separation. Up to two full orbits of data (145 min) could be stored on magnetic tape for subsequent transmission (1697.5 MHz) to an acquisition station. The data could also be transmitted in real time to local APT stations. Once the signal was received by the ground station. A continuous picture was formed by using a facsimile recorder whose scan was in phase with the satellite's forward motion. At normal spacecraft altitude (approximately 1450 km), the radiometer had a ground resolution of better than 4 km at Nadir. The radiometer was capable of yielding radiance temperatures between 185 and 330° K to an accuracy of 4 and 1° K, respectively.

HERITAGE/DERIVATION: ESSA 3, 5, 7, and 9.

DATA

DATA PRODUCTS:

NOAA 1-5:

1. Pictorial Index to SR Imagery 'Environmental Satellite Imagery'.
2. 35 mm Film with Local Visible and Local Infrared Satellite Imagery.

Paper

1. Digital indexes - each booklet contains 1 month of data.

SCANNING RADIOMETER (SR)

ITOS-1:

Magnetic Tape

1. Tapes of radiometer data.

Film

1. 35 mm positive or negative film of wide angle day imagery.

DATA ARCHIVES LOCATION: ITOS and NOAA/NESS, Suitland, MD; National Climatic Center, Asheville, N.C.

PERIOD OF OPERATION: December 1970 to August 1971 - ITOS-1
February 1970 to June 1971 - NOAA-1
October 1972 to January 1975 - NOAA-2
November 1973 to August 1976 - NOAA-3
November 1974 to November 1978 - NOAA-4
July 1976 to July 1979 - NOAA-5

REFERENCES

1. Satellite Data User's Bulletin, Vol. 1 & 2, August 1979
3. Design Study Report for the Improved TOS (ITOS) System, V. 1,2,3., RCA Astro-Electronics, Contract No. NAS5-9034, June 7, 1968.
3. Goldberg, I.: Meteorological IR Instruments for Satellites, Presented at 13th Annual Technical Symposium of Society of Photo-Optical Instrumentation Engineers, August 22, 1968.
4. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 40 lbs.
Volume: 0.5 cu. ft.
Avg. Power: 14 Watts

MEASUREMENTS

Measure reflected radiation from the Earth-Atmosphere system

Measurement range: Visible brightness - 50-10,000 ft. lamberts,
IR Temperature 180-300°K.

Spectral Range: .52 to 12.5 microns

Channels: 2

Bands: IR: 10.5 - 12.5 microns

Visible: 0.52 - 0.73 microns

Components: 2 radiometers, electronics systems, processor, tape recorder.

Precision and Accuracy: 1.0° K at 300° K; 4.0° K at 185° K

FOV: 150.0°

Spatial Resolution: 2 nm visible, 4 nm IR from 750 nm altitude

SCANNING RADIOMETER (SR)

POTENTIAL DERIVED PARAMETERS

1. Energy in the infrared.
2. Surface temperatures.
3. Day and night thermal radiation.
4. Global cloud cover.

SCANNING RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Flight Missions

NASA TECH. OFFICER: M. Garbacz

LOCATION: NASA Headquarters

ACRONYM: SR

INSTRUMENT TYPE: Radiometer

SPACECRAFT: TIROS-2, 3, 4, 7

CONTRACTOR: NASA/Goddard Space Flight Center

P.I.: R.M. Rados, GSFC

OBJECTIVES

1. To measure the emitted and reflected radiation of the Earth and its atmosphere.

DESCRIPTION

SUMMARY: The five-channel radiometer scanned the Earth and space as the satellite spun about its axis. The radiometer's bi-directional optical axes were inclined to the satellite spin axis at angles of 45 and 135°. The sensor used bolometer detectors and filters to limit the spectral response and to provide comprehensive data by measuring radiation intensities in selected portions of the spectrum. The spectral bandwidth of each channel (in micrometers) and its associated parameter were - channel 1, 6.0 to 6.5 (water vapor assumption), channel 2, 8.0 to 12.0 (atmospheric window), channel 3, 0.2 to 6.0 (reflected solar radiation), channel 4, 7.5 to 30 (terrestrial radiation), and channel 5, 0.55 to 0.75 (reflected solar radiation). Initially, all channels performed normally. However, channels 1 and 4 gradually deteriorated and by January 1961 were useless. The signal to noise ratio of channels 3 and 5 were extremely low, and the output was highly questionable.

DATA

DATA PRODUCTS:

- Data Set: 1. Final Meteorological Radiation Tapes (FMRT).
2. Catalog of Meteorological Radiation Data (microfiche).

TIROS-2

Tape

126 reels magnetic tape

Film

7 cards B/W microfiche

TIROS-3

Tape

74 reels magnetic tape

Film

8 cards B/W microfiche (data catalog published by Staff members of Aeronomy and Meteorological division of NASA/GSFC)

SCANNING RADIOMETER (SR)

DATA PRODUCTS (cont'd)

- Data Set: 1. Final Meteorological Radiation Tapes (FMRT)
2. Radiation Data Catalog and Users Manual (microfiche)

TIROS-4

<u>Tape</u>	<u>Film</u>
132 reels magnetic tape consisting of geographical locations	5 cards B/W microfiche (data in published reports)

TIROS-7

<u>Tape</u>	<u>Film</u>
692 reels magnetic tape	14 cards B/W microfiche

PERIOD OF OPERATION: November 1960 to April 22, 1961; July 1961 - October 1961; February 1962 to June 1962; June 1963 to June 1965.

REFERENCES

1. National Space Science Data Center computer printout.

SYSTEM CHARACTERISTICS

Number of channels: 5
Weight: 6 lbs.
Avg. Power: 3 Watts
Components: radiometer (5 thermistor bolometer detectors), electronics
Data Recovery: delayed telemetry
A S/N ratio of better than 30 dB.

MEASUREMENTS

Measure thermal and reflected radiation intensities in selected positions of spectrum.

Spectral Range: Channel 1 - 6.0 to 6.5 microns
Channel 2 - 8.0 to 12.0 microns
Channel 3 - 0.2 to 6.0 microns
Channel 4 - 7.5 to 30 microns
Channel 5 - 0.55 to 0.75 microns
Field-of-View: 5.0 degrees

SCANNING RADIOMETER (SR)

POTENTIAL DERIVED PARAMETERS

1. Reflected Solar Radiation
2. Terrestrial Emitted Radiation
3. Water Vapor Absorption
4. Cloud Cover Day and Night
5. Albedo.

SEASAT-A SATELLITE SCATTEROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: W. L. Grantham
LOCATION: Langley Research Center

ACRONYM: SASS
INSTRUMENT TYPE: Scatterometer
SPACECRAFT: SEASAT-1
CONTRACTOR: General Electric Co.
P.I.: D. W. Pearson, CUNY

OBJECTIVES

1. Provides a periodic and spatially distributed measurement of the radar backscatter coefficient (power return) for the determination of wind speed and direction (i.e., wind vector) at the sea surface.

DESCRIPTION

SUMMARY: The SASS employs four dual polarized, fan beam, stick antennas. The primary measurements swath is 500 km wide beginning 200 km off the satellite sub-track. Sequential antenna addressing provides orthogonal footprint crossings to the right, left, fore, and aft. These star-like patterns define 100 m grid spacing and 50 m resolution Doppler cells with incident angles of 25° to 55°. Sea State information is supplied from three resolution cells at and near nadir from side lobes generated by each antenna pattern. Also, a high winds swath, ($55^\circ < \theta < 65^\circ$) though less accurate, provides additional data and increases the effective coverage to over 1500 m. The measurement swath is illuminated with a 5 ms burst of microwave energy at a repetition rate of 40 Hz. The transmitted power, 100 W peak at 14.6 GHz is applied sequentially with appropriate polarization to four stick antennas. The illumination pattern is 25° x 0.5° directed 42° off nadir and aligned 45° across the satellite sub-track. Side lobes from the four stick arrays provide sea state information near nadir. Received RF energy from the proper antenna is directed to a preamplifier, band pass filter, and first conversion mixer. The resulting IF signal is fed to the SASS processor consisting of 15 band-pass Doppler filters, square-law detectors, DC amplifiers and signal integrators. Antenna gain is 32 dB with an efficiency of 48%. Receiver band is 14.6 GHz \pm 250 MHz. In-band noise is less than -155 dBm in any 2.5 kHz band within 14.6 GHz \pm 1 MHz.

HERITAGE/DERIVATION: The functional design of the SASS is the result of four major experimental efforts, these are: (a) AAFE RADSCAT, Langley Research Center, (b) 13.3 GHz SCAT, Johnson Space Center, (c) S-193, SKYLAB.

DATA

DATA PRODUCTS: Tape products (9 track, 1600 BPI). Latitude, longitude and time-located geophysical data of surface wind velocity and fully corrected backscatter coefficient.

- Satellite Data Users Bulletin, Volume 1, No. 1, January 1979.

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory

PERIOD OF OPERATION: July 7 through October 10, 1978

REFERENCES

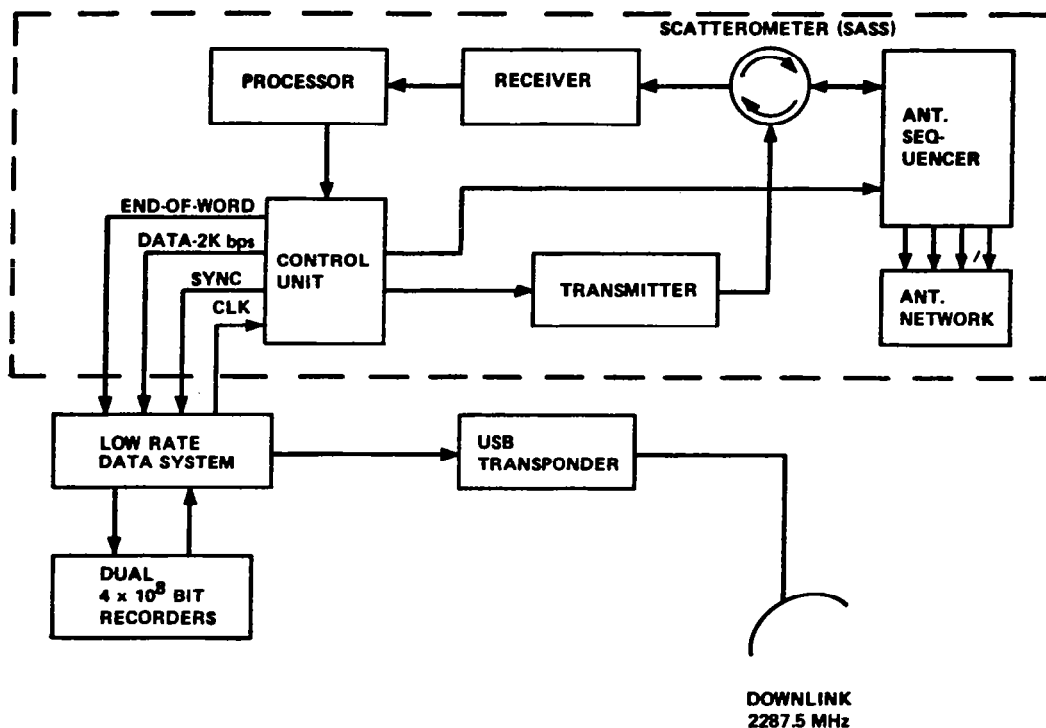
1. National Aeronautics and Space Administration, SEASAT-A Program Study, August 1974.

SEASAT-A SATELLITE SCATTEROMETER (SASS)

SYSTEM CHARACTERISTICS

Peak Power: 100 W
Avg. Power: 20 W
Weight: 80 kg
Size: 1.0 x 0.4 x 0.35 m

FUNCTIONAL DIAGRAM



Seasat-A Satellite Scatterometer Block Diagram

MEASUREMENTS

Measures backscatter coefficients.

Frequency: 14.59927 GHz

Resolution: 50 km (high gain)

200 km (low gain)

Swath Width/FOV: one 500 km; one 750 km (overlapping); one 280 km (at nadir).

POTENTIAL DERIVED PARAMETERS

1. Surface wind speed and direction.

SELECTIVE CHOPPER RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: SCR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-4 & 5
CONTRACTOR: Elliot-Automation
P.I.: Dr. J. Houghton,
Clarendon Lab, England
Dr. S. Smith,
Reading University, Reading, England

OBJECTIVES

1. To observe atmospheric temperature structure up to 50 km in altitude.
2. Provide quantitative information about the density and distribution of cirrus clouds and tropospheric water vapor.
3. Make supporting observations of water vapor distribution.
4. Determine the density of ice particles in cirrus clouds.

DESCRIPTION

SUMMARY: This instrument observes in 16 channels from two to 100 microns. Eight channels observe in the 15-micron CO₂ band, one sounds water vapor distribution, its a clear window channel, two observe reflected sunlight, two cirrus clouds, and two night emission from clouds. Channel separation is obtained by optical filtering. There are four groups of four channels each: a) 13.8-14.8, b) 15.0, c) 11.1-100, and d) 2.00-3.5 microns. The sensor is based on mirror optics and time-multiplexing of the four channels within each group. There is one detector and electronic system for each group. A filter wheel mounted in front of each detector contains four filters (or CO₂ cells in the group B channels) which define the four spectral intervals for that group. In the lower CO₂ temperature sounding channels, group A, the weighting functions may be sharpened by absorbing out the line centers of each band by means of a CO₂ path length within the optical system. Conversely, in the group B channels, for sounding in the upper atmosphere, good vertical resolution is obtained using a difference technique between adjacent channels but with increasing amounts of the line centers absorbed out by means of the CO₂-filled cells. This is the selective chopping principle from which the instrument is named.

DATA

DATA PRODUCTS:

NIMBUS-4:

Data Set Name

1. Selective Chopper Radiometer Radiance Tapes
2. SCR Global Stratospheric Analysis

Data - Tapes

51 reels of magnetic tape containing calibrated "declouded" radiance values.

Data - Paper

Six bound volumes of polar stereographic maps.

SELECTIVE CHOPPER RADIOMETER (SCR)

DATA (cont.)

NIMBUS-5:

Data Set Name: Selective Shopper Radiometer Radiance Data on magnetic tape.
Selective Chopper Radiometer Gridded Radiance Data on magnetic tape.

Tape: 70 reels of 7-track, binary, 800 BPI magnetic tape containing calibrated "declouded" radiances.
No data available for #2. Data is available at "another center".

DATA ARCHIVES LOCATION: National Space Sciences Data Center, Goddard Space Flight Center.

PERIOD OF OPERATION: August 1972 to December 1974 (Nimbus-5)
April 1970 to June 1973 (Nimbus-4)

REFERENCES

1. NIMBUS-4 and 5 User's Guide; Goddard Space Flight Center, Greenbelt, Maryland.

SYSTEM CHARACTERISTICS

Weight: 25 lbs.

Volume: .31 cu. ft.

Avg. Power: 7 Watts

Peak Power: 15 Watts

Components: radiometer with associated optics and electronics package

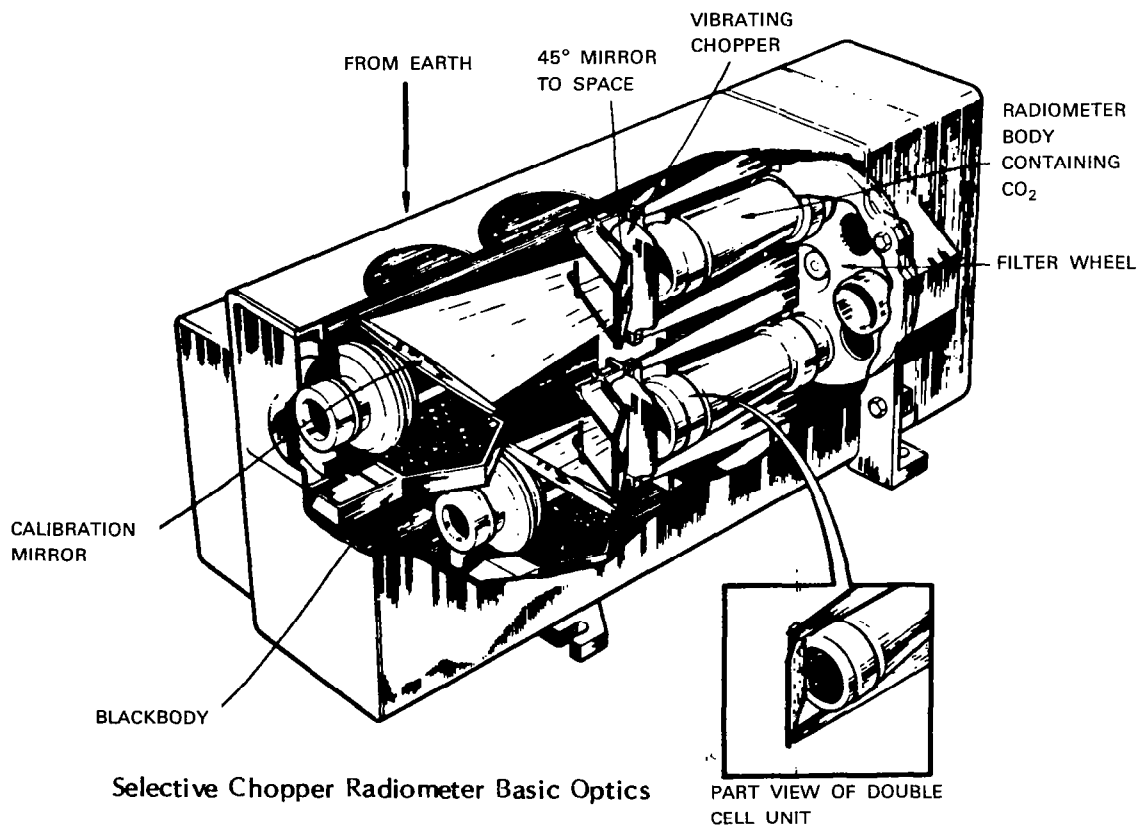
Data Recovery: delayed telemetry

Precision and Accuracy: better than 0.25 ERG/SEC/SQ-CM/STERADIAN/CM** -1

Standby Power: 6 Watts

Channels: 16

FUNCTIONAL DIAGRAM



SELECTIVE CHOPPER RADIOMETER (SCR)

MEASUREMENTS

Measures emitted radiation in 16 spectral bands.

Measurement Range: 0-200 ERGS/SEC/SQ-CM/STERADIAN/CM-1

Spectral Range: 2.08 to 133.3 microns

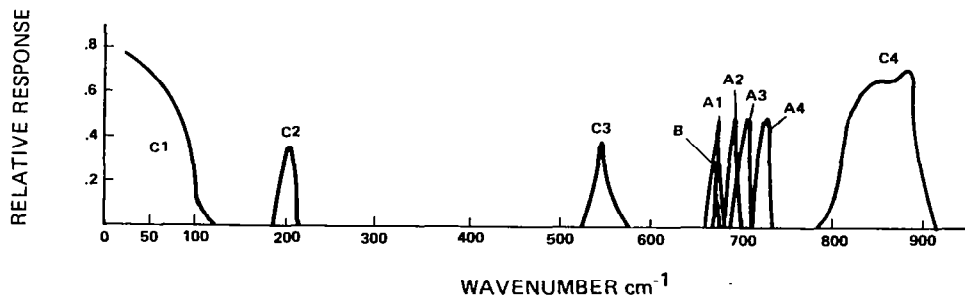
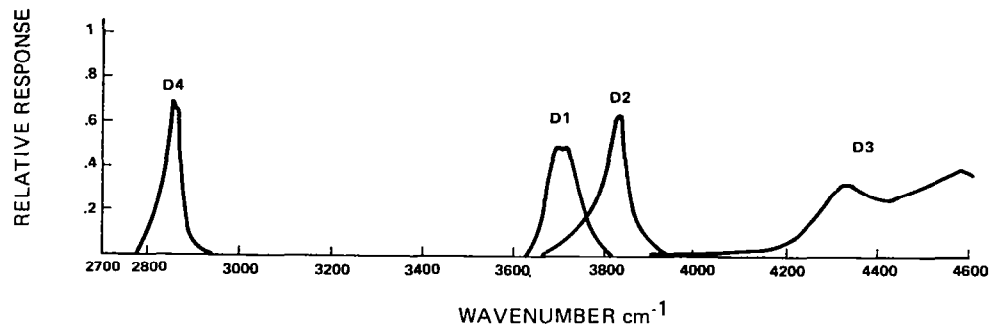
Channels: 4 - CO₂ at 13.8-14 microns; IR at 11.1; water vapor at 18.6 microns

2 - at 49.5 and 133.3 microns

4 - at 2.08, 2.59, 2.65 and 3.5 microns

FOV: 1.5 by 40 degrees

Spatial Resolution: 15 nm by 42 nm from orbit



Selective Chopper Radiometer Relative Response Curves

POTENTIAL DERIVED PARAMETERS

1. Temperature of atmosphere from Earth to cloud top level.

SHUTTLE IMAGING RADAR

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: K. Carver
LOCATION: NASA Headquarters

ACRONYM: SIR
INSTRUMENT TYPE: Imaging Radar
PAYLOAD: OSTA
CONTRACTOR: JPL
P.I.: Dr. Charles Elachi

OBJECTIVES

1. To gather image data at microwave frequencies for application to a variety of Earth observation studies planned for the Space Shuttle.
2. To understand radar signatures of surface features and cover type.
3. To determine the effect of radar parameters on image information content.
4. To develop analysis techniques for use of radar data.
5. Demonstrate utility of radar to Earth resources observation.
6. Develop and test technology for future use.

DESCRIPTION

SUMMARY: The SIR will be deployed by the Shuttle (sortie) and will have a variable orbit from 200 to 400 km at inclinations of 45°. The SIR will be designed for 7-day sortie missions with a useful life of approximately 5 years with refurbishment. The engineering model is planned for 1981 and the operational model is projected for 1982.

The SIR will transmit horizontal or vertical polarized power at X- and L-band frequencies and receive the backscatter data with dual-polarized, dual frequency antennas. The returned signals are received, amplified, and converted to digital format for later conversion to Image data. On board monitor functions are also provided.

Traveling Wave Tubes (TWT) provide the X-band (10 GHz) and L-band (1 GHz) microwave energy. Simultaneous transmission in the form of a pulse (15-25 s) with a repetition rate of 1200-1880 kHz allow nearly identical swaths to be illuminated for correlation after the returns are processed. Four different antennas are used for X-band transmission providing horizontal and vertical polarization at 25° off nadir. A beam width of 38° results in a total X-band coverage of 7° to 60° off nadir. Scanning is provided through vehicle motion. Two L-band antennas are sited at (TBD) of nadir with a beam width of (TBD).

Receivers for both bands are similar. The sequence in processing the microwave return is: pre-amplification, single conversion super-heterodyne, and pulse compression (4000:1 ratio) with range gates. Noise temperatures are 1100° and 1600°K and noise figures are 2.5 and 4 for L and X band respectively. Bandwidth for either receiver is ~35 MHz (TBD) and dynamic range is ~50 dB (8 bit conversion).



SHUTTLE IMAGING RADAR (SIR)

DATA

DATA PRODUCTS:

Data will be digitized on-board and stored on magnetic tape (240 Mbps tape recorder in development).

Optical signal films
Optical image films
Digital signal tapes
Digital image tapes (of video disks)
Limited registered digital data sets for common test sites.

REFERENCES

1. "SIR" for Earth Observations Implementation Plan", NASA/JPL, 21 July 1980.

SYSTEM CHARACTERISTICS

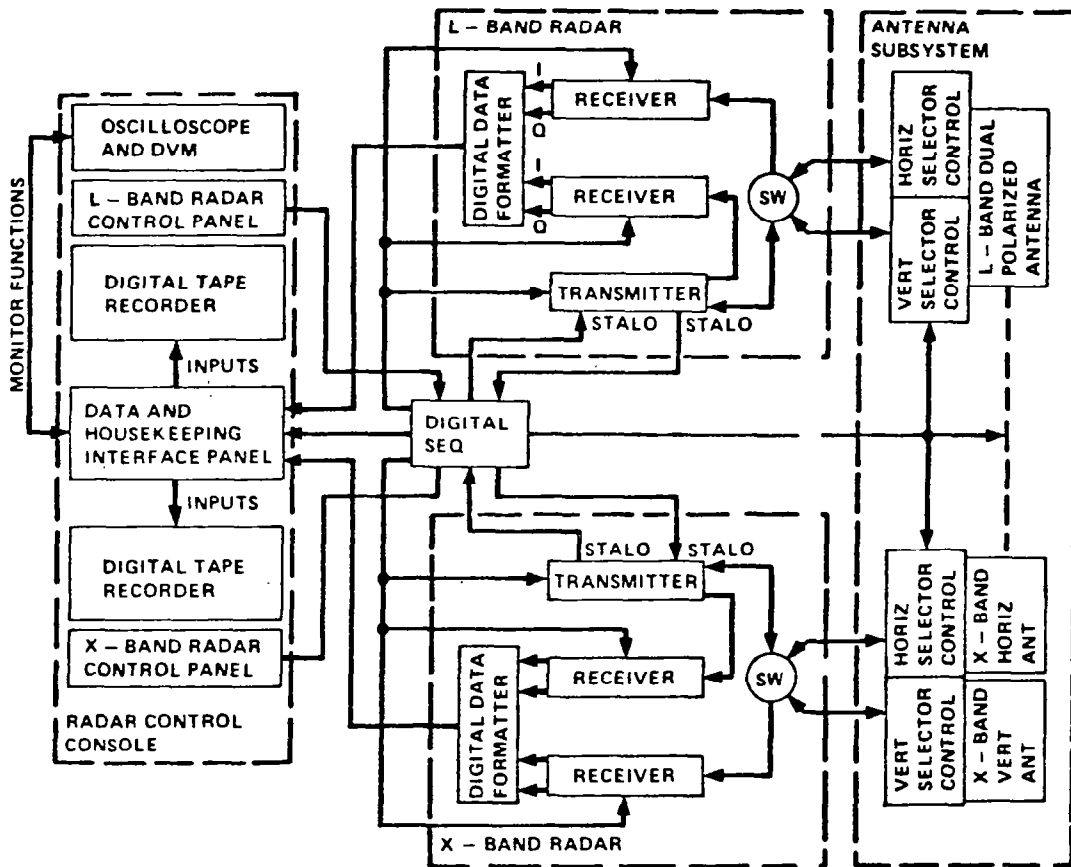
Size: 2.75 m³
Mass: 480 kg
Peak Power Requirement: 800 pallet
200 module
Data Rate: 120,000 Kbps (optical recorder)
Data Collection Capacity Per Flight: Nominal 50 hrs. of sensor operation time on digital link and
10 hrs. on optical recorder.
Modes and Configuration Control: Can be done by command or programming.
Data Handling: Digital and optical.
Data Processing: Digital and optical.
Calibration: Goal is to achieve: - 1 dB relative calibration and consistency
- 3 dB absolute calibration

	<u>L-Band</u>	<u>X-Band</u>
Number of Looks	2 6	1 6
Antenna Length (m)	12.1	12.1
Antenna Width (m)	2.16	0.6
Antenna Gain (dB)	34	44
Selectable PRF (kHz)	1.1 1.8	1.1 1.8
Transmitted Average Power (W)	60	150
Dispersed Pulse Length (usec)	33	25
Receiver Noise Temperature (°K)	1000	1000
Stalo Frequency (MHz)	91.07	91.07
A/D Conversion Rates (Msps)	15.2 and 45.5	15.2 and 45.5

Preferred Orbital Altitude: 200 km ± 20 km
Preferred Orbital Inclination: 50° for KSC launch; polar ±2° for VAB launch
Total Sensor Weight (Excluding Antenna): 600 kg
Total Power Required During Operations: 4.2 kW
Total Sensor Volume (Excluding Antenna): 1 m²

SHUTTLE IMAGING RADAR (SIR)

FUNCTIONAL DIAGRAM



Shuttle Imaging Radar Block Diagram

MEASUREMENTS

Measures radar backscatter cross-section.

Sensitivity: See Diagram 1 & 2

Amplitude Discrimination: See Diagram 3

	L-Band	X-Band
Frequency (GHz)	1.275	9.6
Wavelength (cm)	23.5	3
Transmitted Peak Power (kW)	1	2.5
Bandwidth (MHz)	6 and 18	6 and 18
Resolution (m)	10 → 30	10 → 30
Swath Width (km)	35 → 125	35 → 125
Incidence Angle	20° → 70°	20° → 70°
Polarization	HH (1 channel)	HH, VV, HV (3 channels)

SHUTTLE IMAGING RADAR (SIR)

MEASUREMENTS (cont.)

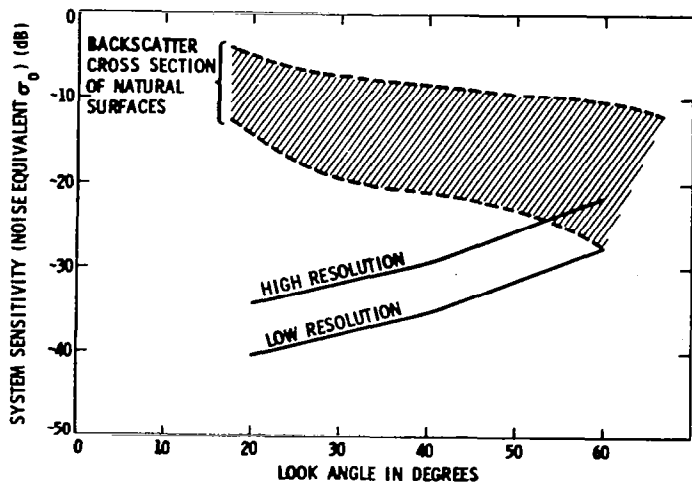


Figure 1. X-band system sensitivity as a function of the look angle.

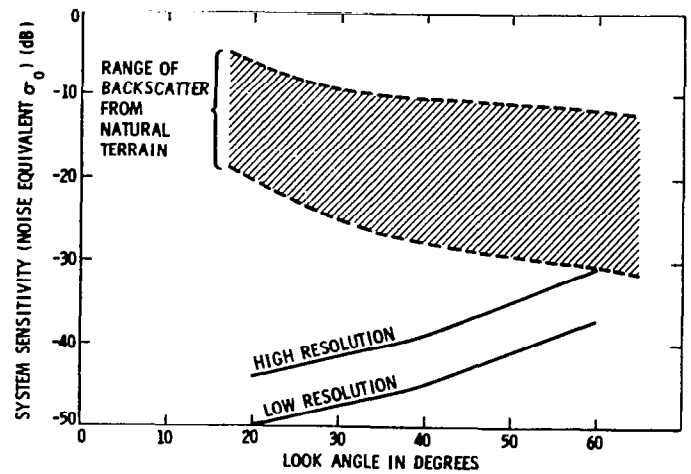


Figure 2. L-band system sensitivity as a function of the look angle. Range of backscatter from natural terrain is shown. A good signal-to-noise ratio will be obtained up to angles not exceeding 65°.

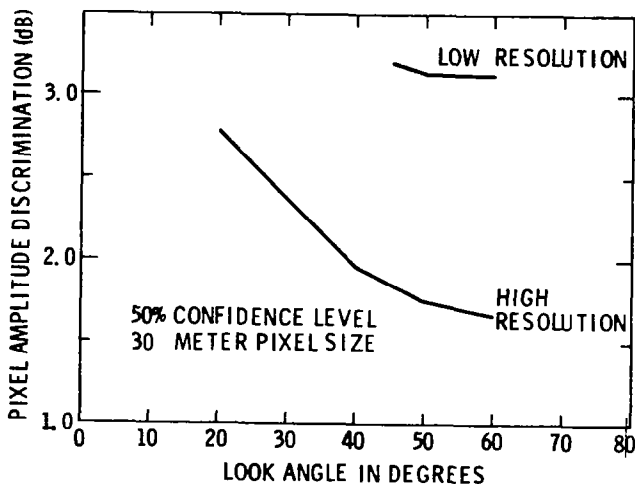


Figure 3. Baseline SIR system gray level discrimination capability.

POTENTIAL DERIVED PARAMETERS

1. Lineament mapping
2. Landform mapping
3. Textural discrimination
4. Urban mapping
5. Soil moisture
6. Snow properties
7. Vegetation classification
8. Rock units discrimination
9. Drainage network mapping.

SHUTTLE IMAGING RADAR-A

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: K. Carver
LOCATION: NASA Headquarters

ACRONYM: SIR-A
INSTRUMENT TYPE: Imaging Radar
PAYLOAD: OSTA-1
CONTRACTOR: Jet Propulsion Laboratory
P.I.: Dr. Charles Elachi

OBJECTIVES

1. To gather image data at microwave frequencies for application to a variety of Earth observation studies planned for the Space Shuttle.
2. To obtain measurement data on surface morphology, rocks and soils, vegetation canopies, surface water, and man-made structures.

DESCRIPTION

SUMMARY: The SIR-A will be deployed by the Shuttle on OSTA-1 and will have a variable orbit from 200 to 400 km at inclinations of 45°. The SIR will be designed for 7-day sortie missions with a useful life of approximately 5 years with refurbishment. The engineering model is planned for 1981 and the operational model is projected for 1982.

The SIR will have the same frequency and polarization as the Seasat-A SAR but will have a larger incidence angle (50° compared to 20°). It will transmit horizontal or vertical polarized power at L-band frequencies and receive the backscatter data with dual-polarized, dual frequency antennas.

SIR-A uses a side-looking, synthetic aperture radar to create two dimensional images of the Earth's surface. It will carry out in-depth analysis of specific geographical areas as well as do global mapping. Data from the in-depth analysis will be studied in conjunction with Landsat imager, Seasat radar imagery, aircraft radar imagery, infrared satellite imagery, and ground truth. The results can be used to identify faults, lineaments, and other geological features and to locate potential sites of oil and mineral deposits.

Coherent microwave pulses are emitted by the SIR-A antenna in a long, narrow, fan-shaped beam. The antenna is hard-mounted to the spacecraft, and the beam is swept across the ground track by the motion of the vehicle. The antenna points sideways from the spacecraft so that the beam hits the ground at an angle.

The antenna will be hard-mounted at a 47 degree angle from nadir pointing north and at a 270 degree clock angle from the velocity vector. A radar beam of width 40 km and maximum length 2800 km will be used, and a resolution of 40 m across track, 40 m along track can be obtained by the system. Data will be stored on an onboard optical recorder. The data film cassette will be removed immediately after landing. Housekeeping data will be telemetered to the ground.

SHUTTLE IMAGING RADAR-A (SIR-A)

DATA

DATA PRODUCTS:

Data will be digitized on-board and stored on magnetic tape (240 Mbps tape recorder in development).

SYSTEM CHARACTERISTICS

Transmit time/total time: 0.35
Pulse width: 33.8 microseconds
Chirp rate: 0.562 MHz/microsecond
Pulse compression: 642
Time bandwidth product: 642
Effective pulse width: 53 nsec
Peak transmitted power: 800 W nom, 1125 W max
PRF's: 1464, 1540, 1647 pulses/sec
Average transmitted power: 42 W
Average raw power:

Peak trans PWR, W	800 Nom.	1125 Max.
1464	401	515
1540	413	533
1647	430	558

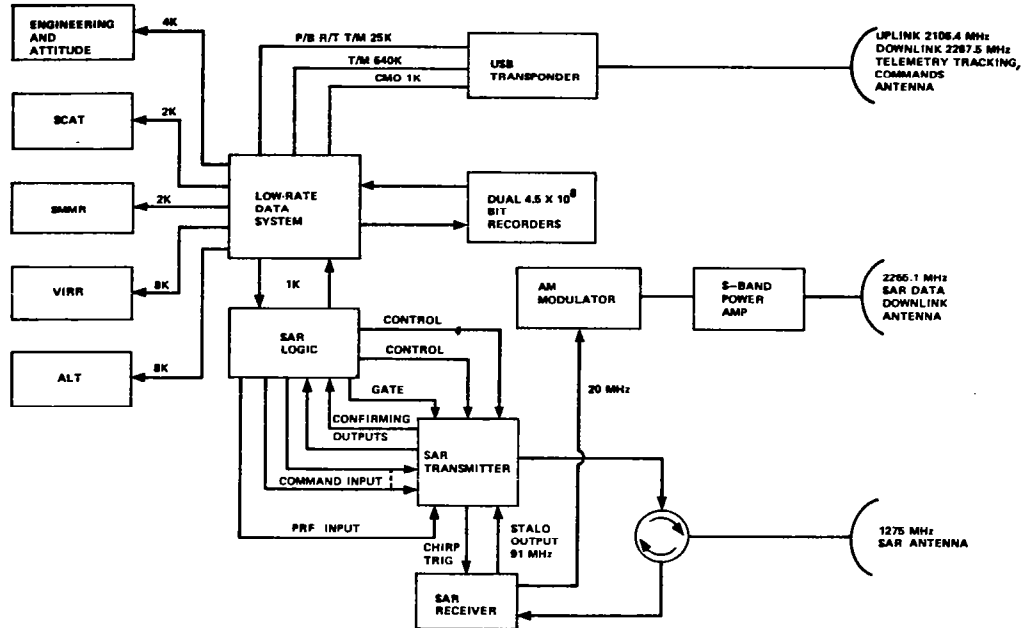
System noise temp: <550°K
Receiver gain: +77 to 98 dB
Gain: STC, Auto, Commandable
Average backscatter: -13 dB
Backscatter range: -26 to 0 dB
Received power range: -97 to -71 dbm
Antenna peak gain: 35 dB
Antenna polarization: horizontal
Eng. data rate: 500 bps
Size: 100 x 80 x 25 cm
Weight: 100 kg

MEASUREMENTS

Frequency: 1274.8 GHz (L-Band)
Nominal Range Resolution (3-dB width): 25 m
Nominal Azimuth Resolution (3-dB width): 25 m
Dynamic Range for Point Target: 50 dB
Dynamic Range for Distributed Target: 27 db
100 km swath width, 4000 km swath length in 10 min. pass
Four independent cell measurements (4 looks)
25 x 25 m cell resolution (4 looks)
0.5 sec integration time per cell measurement (per look)
Cell SNR of >5 dB over 100 km swath (4 looks)

SHUTTLE IMAGING RADAR-A (SIR-A)

FUNCTIONAL DIAGRAM



Shuttle Imaging Radar-A Block Diagram

POTENTIAL DERIVED PARAMETERS

1. Ocean surface imagery capable of yielding directional wave spectra in the open ocean.
2. Monitoring of coastal processes.
3. Charting ice fields.
4. Land imagery useful in geological, hydrological and glaciological studies.
5. Iceberg detection.
6. Fishing vessels.

SHUTTLE MULTISPECTRAL INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: SMIRR
INSTRUMENT TYPE: Radiometer
PAYLOAD: OSTA-1
CONTRACTOR: Jet Propulsion Laboratory
P.I.: Dr. Alexander R. Goetz

OBJECTIVES

1. To obtain earth surface radiance measurements in the 0.5-2.35 micron spectral region from orbit.
2. To design parameters for future imaging systems directed toward geological mapping, including determination of atmospheric and vegetation effects.

DESCRIPTION

SUMMARY: The telescope is a modified Mariner Venus Mercury 1973 telescope with all the refractive elements removed. The calibration lamp is mounted in the front of the telescope and an opaque tightly fitting cover rotates over the top of the telescope to protect the optics while SMIRR is not operating. The filter wheel contains fifteen evenly spaced positions to issue equal integration times for each sample. Every third position is a dark sample and the remaining ten positions contain the filters of interest. Optical pickoffs are mounted at the edge of the wheel to provide synchronization of the filter wheel and the detector electronics. The wheel is spun by an AC-synchronous motor at 100 revolutions per second. Two Mercury-Cadmium-Telluride detectors perform the optical-to-electronic conversion by emitting electrons proportional to the intensity of the electromagnetic radiation focused on them. On top of the detectors are the field lenses which focus the telescope image on the detectors and the field stops which determine the instrument field-of-view (FOV). This whole detector assembly is mounted on a thermoelectric cooler. The detector electronics assembly mounted to the detector/filter wheel assembly perform amplification of detector signal, integration of the signal over the time an individual filter is being viewed and analog-to-digital conversion of the signal so it can be sent to the payload recorder.

DATA

DATA PRODUCTS: Tape: data will be recorded on analog tape, converted to digital tape.
Film: two 400 ft. reels of 16 mm 4 milestar color or black and white film magazines.

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory

REFERENCES

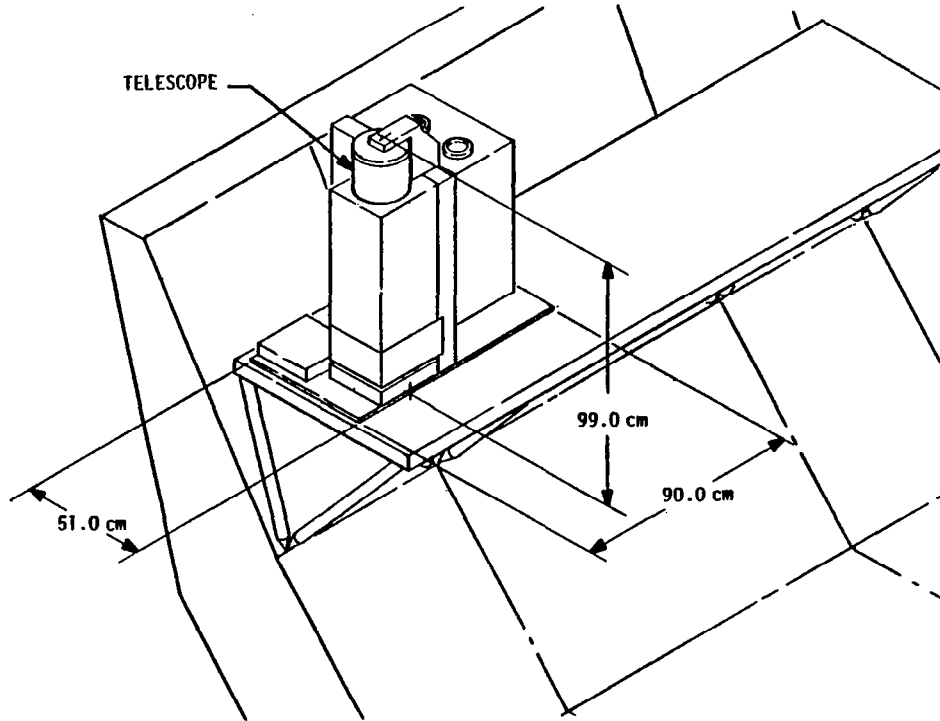
1. Office of Space and Terrestrial Applications-1, Handout, 1980.

SYSTEM CHARACTERISTICS

Weight: 86 kg
Physical characteristics: 0.9 x 0.559 x 1.226 meters
Radiometer and camera axis aligned to within ± 1 mrad.
Power requirements: 28 Vdc, 120 Watts maximum

SHUTTLE MULTISPECTRAL INFRARED RADIOMETER (SMIRR)

FUNCTIONAL DIAGRAM



Shuttle Multispectral Infrared Radiometer Schematic Diagram

MEASUREMENTS

Measures visible and infrared spectra of earth's surface.

Spectral range: 0.5 - 2.35 microns

Channels: 10

Bands:	1. .5-.5.2 microns	6. 1-1.1 microns
	2. .52-.6 microns	7. 1.2-1.6 microns
	3. .63-.69 microns	8. 1.7-1.9 microns
	4. .69-.76 microns	9. 2-2.15 microns
	5. .76-.9 microns	10. 2.15-2.35 microns

Radiometer FOV: 536 microradians, 150 x 150 meter ground track

Camera FOV: 74 x 104 mrad, 21 x 29 km ground track.

POTENTIAL DERIVED PARAMETERS

1. Geologic mapping of terrain
2. Atmospheric
3. Vegetation effects.

SOLAR BACKSCATTER ULTRAVIOLET SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: J. Lehmann
LOCATION: NASA Headquarters

ACRONYM: SBUV
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: NOAA F-J
CONTRACTOR: Ball Aerospace Division
P.I.: D. Heath, GSFC

OBJECTIVES

1. To increase our knowledge of climatic processes.
2. To begin an extensive ozone monitoring effort.
3. To develop techniques for short-term predictions--from a few months to a few years--for guiding government policy.

DESCRIPTION

SUMMARY: The SBUV determines the vertical ozone distribution by measuring the backscattered ultraviolet solar energy in the satellite nadir direction at 12 wavelengths in the ozone adsorption band. The principle of operation is based on the accurate measurement of the backscattered solar energy (albedo) in the ultraviolet, between approximately 2500 and 3400 Angstroms. The 12 wavelengths of interest are positioned on the edge of the ozone adsorption band. The shorter wavelengths are more sensitive to ozone high in the stratosphere, and the longer wavelengths are most sensitive to ozone low in the stratosphere. By mathematical inversion, it is possible to calculate the concentration of ozone as a function of altitude through the thickness of the stratosphere. The SBUV instrument is a double Ebert-Fastie spectrophotometer. The measurements at the 12 wavelengths are accomplished by a stepped-position grating in the double monochromator. When a diffuser plate is deployed to reflect light directly from the sun, the solar ultraviolet spectrum between 1600 and 4000 Angstroms can be measured. Operating the same monochromator in a continuous scan mode provides a detailed spectrum, either of the sun or the albedo radiation from the Earth. The wavelengths are repeatable and known to within 0.2 Angstrom.

HERITAGE/DERIVATION: Nimbus 4, 6, & 7

REFERENCES

1. Solar Backscatter Ultraviolet Spectrometer (SBUV), an Operational Ozone Sounding Unit for the TIROS Spacecraft. Technical Study Report, 1976.

SYSTEM CHARACTERISTICS

Physical Size (m): 0.078 m³
Mass (kg): 20
Power Requirement (We): 7 (step scan); 11 (continuous scan)
Data Rate (kpbs): 0.082 (step scan); 0.270 (continuous scan)

SOLAR BACKSCATTER ULTRAVIOLET SPECTROMETER (SBUV)

MEASUREMENTS

Measures backscattered ultraviolet solar energy.

Wavelengths: 2550-3400Å

FOV: 11.33 degrees

POTENTIAL DERIVED PARAMETERS

1. Vertical ozone profiles.
2. Solar spectrum.
3. Earth radiance spectrum.

SOLAR BACKSCATTER ULTRAVIOLET (SBUV) AND TOTAL OZONE MAPPING SPECTROMETER (TOMS)

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER:
LOCATION: Goddard Space Flight Center

ACRONYM: SBUV/TOMS
INSTRUMENT TYPE: UV/VIS Spectroradiometer
SPACECRAFT: NIMBUS-7
CONTRACTOR: Beckman
P.I.: D. Heath, GSFC
A. Kruger, GSFC

OBJECTIVES

1. To measure the extraterrestrial solar ultraviolet irradiance and radiation backscattered from the Earth and its atmosphere
2. To determine the total amount of atmospheric ozone in a vertical column above the subsatellite point
3. To determine the vertical profile of ozone above the ozone maximum
4. To measure the ultraviolet solar spectral irradiance and monitor its temporal variability over the wavelength range from 160 to 400 nm, with a spectral resolution of 1 nm
5. To obtain contiguous mapping of total ozone.

DESCRIPTION

SUMMARY: The Solar Backscatter Ultraviolet and Total Ozone Mapping Spectrometer (SBUV/TOMS) experiment is an expanded and improved version of the Backscatter Ultraviolet (BUV) experiment on NIMBUS-4, and is composed of two essentially independent instruments. The Solar Backscatter Ultraviolet (SBUV) subsystem consists of a double Ebert-Fastie spectrometer and a filter photometer similar to the BUV. Both channels simultaneously view identical fields of solar radiation scattered by the terrestrial atmosphere in the NADIR of the solar flux scattered from the instrument diffuser plate which is deployed on command. The spectrometer serially monitors 12 selected narrow wavelength bands in the spectral region from 250 nm to 340 nm, or continuously scans the wavelength range from 160 nm to 400 nm, while the photometer measures the light in a fixed band centered at 343 nm. This instrument is intended for use in determining the total ozone and its vertical distribution above the ozone maximum for measuring the ultraviolet solar spectral irradiance.

The Total Ozone Mapping Spectrometer (TOMS) subsystem employs a single monochromator whose IFOV is scanned through the subsatellite point and perpendicular to the orbital plane. The backscattered radiation is sampled at six wavelengths from 312.5 nm to 380 nm sequentially in three degree steps in the ± 51 degrees cross scan from the NADIR. This scanning creates a contiguous mapping of the total ozone since the scans of consecutive orbits overlap.

HERITAGE/DERIVATION: NIMBUS-4 Backscatter Ultraviolet Experiment

SOLAR BACKSCATTER ULTRAVIOLET (SBUV) AND TOTAL OZONE MAPPING SPECTROMETER (TOMS)

DATA

DATA PRODUCTS:

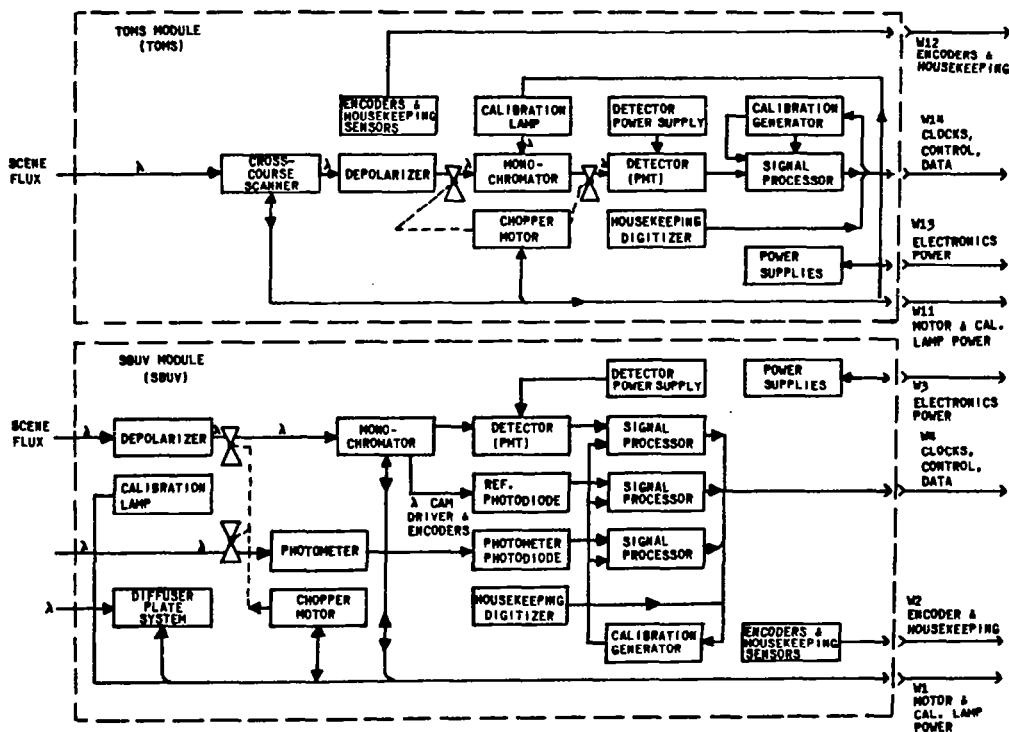
<u>TAPES</u>	<u>FILM</u>
Raw Units Tapes (SBUV and TOMS)	Total Ozone Maps
Ozone S and T Tapes	Cross Sections of Ozone Mass
Zonal Mean Tape	Montage of Data
Tables of Data	Solar Irradiance Tables
Map Data Matrix Tape	Ozone Tables
Montage Tape of TOMS Data	Plots

DATA ARCHIVES LOCATION: National Space Sciences Data Center, Goddard Space Flight Center.

REFERENCES

1. The NIMBUS-7 User's Guide, NASA, Goddard Space Flight Center, August 1978.
2. National Space Science Data Center computer printout, 1980.

FUNCTIONAL DIAGRAM



SBUV/TOMS Block Diagram

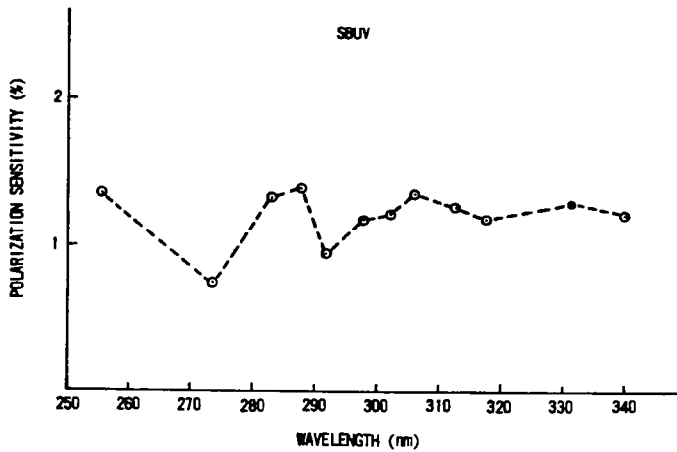
SOLAR BACKSCATTER ULTRAVIOLET (SBUV) AND TOTAL OZONE MAPPING SPECTROMETER (TOMS)

MEASUREMENTS

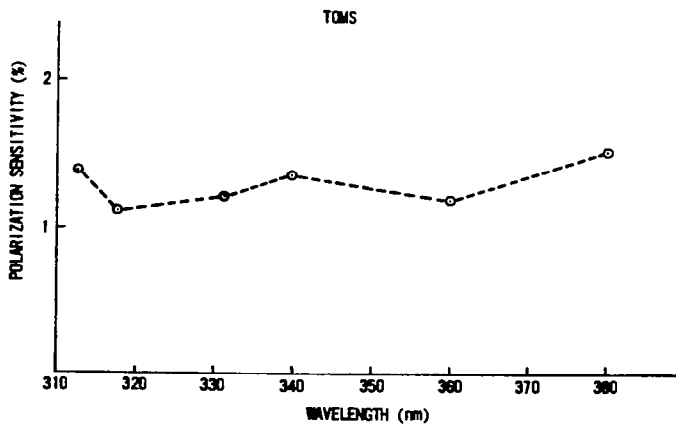
Measures solar ultraviolet irradiance and radiation backscattered from the earth.

The SBUV gathers radiometric data at 12 wavelengths between .25-.34 microns with a 1 micron resolution. A second mode of operation allows for spectral scanning from .16-.40 microns. TOMS consists of six wavelengths - .3125, .3175, .3312, .3398, .36, and .38 microns.

IFOV - SBUV 11.3° x 11.3°
TOMS - 3° x 3°

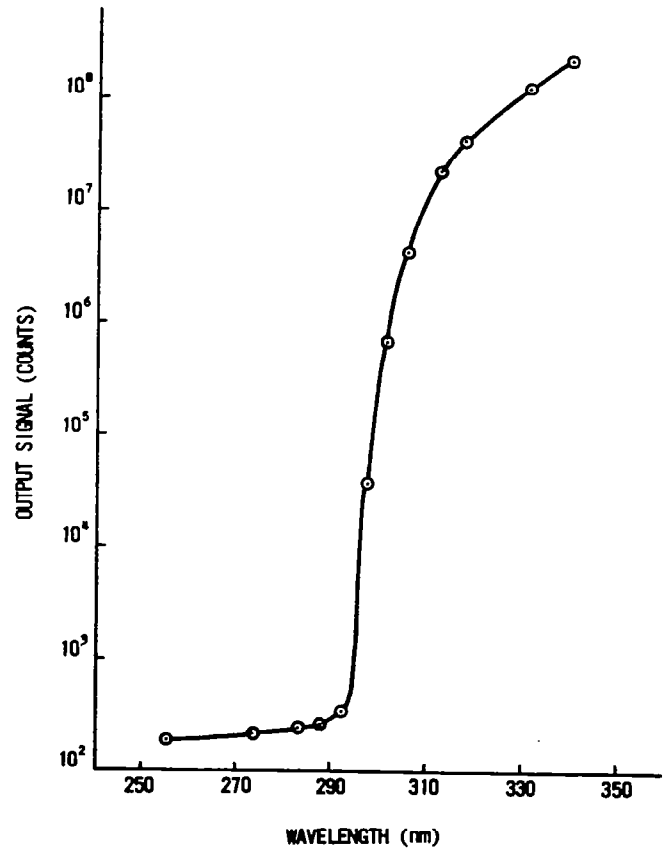


a. Polarization Sensitivities for SBUV



b. Polarization Sensitivities for TOMS

Polarization Sensitivities for SBUV/TOMS



Stray Light Rejection Capability of SBUV

POTENTIAL DERIVED PARAMETERS

1. Total Amount of Atmospheric Ozone in a Vertical Column
2. Vertical Profile of Ozone above the Ozone Maximum
3. UV Solar Spectral Irradiance.

SOLAR CONSTANT VARIATIONS

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: G. Eisenwine
LOCATION: NASA Headquarters

ACRONYM: SCV
INSTRUMENT TYPE: Radiometer
SPACECRAFT: Spacelab-1
CONTRACTOR: TBD
P.I.: Dr. D. Crommelynck,
Royal Met. Inst. Belgium

OBJECTIVES

1. To measure the absolute value of the solar constant.
2. To measure long term variations in the solar constant.

DESCRIPTION

SUMMARY: The instrument is currently under development and is proposed for flight on Spacelab-1. For the reflight only, a refurbishment of the instrument package will be required. The instrument is a self-calibrating differential radiometer. It essentially consists of two separate heat sensors mounted under separate shutters and a servo-system that keeps the heat flow through both sensors balanced. When one of the sensors is exposed to solar radiation, the servo system reduces the power supplied to its heater. Knowing the reduction in this power and the characteristics of the instrument, the solar constant can be calculated. By a planned sequence of shutter openings and use of a known power source, the self-consistency of the sensor and electronics can be checked.

REFERENCES

1. Report on Active and Planned Spacecraft and Experiments, August 1980, Goddard Space Flight Center.
2. Payloads for Environmental Observations Program Review Handout, 1980, NASA Headquarters.

SYSTEM CHARACTERISTICS

Weight: To be determined
Volume: To be determined
Power: To be determined.

MEASUREMENTS

Measures solar radiation.

Channels: 2
Bands: To be defined
Accuracy: To be defined

POTENTIAL DERIVED PARAMETERS

1. Variations in the solar constant.

SOLAR ULTRAVIOLET MONITOR

IDENTIFICATION

DISCIPLINE: Environmental Observation
STATUS: Flight Missions
NASA TECH. OFFICER: S. Tilford
LOCATION: NASA Headquarters

ACRONYM: SUM
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: Solar Mesosphere Explorer
CONTRACTOR: Jet Propulsion Laboratory
P.I.: C.A. Barth, University of Colorado

OBJECTIVES

1. Measure the solar ultraviolet flux.
2. To determine the effect of ozone concentrations.

DESCRIPTION

SUMMARY: The Solar Ultraviolet Monitor is one of five instruments to be carried on the SME spacecraft which will measure the ozone density and altitude distribution, monitor the incoming solar radiation, and measure other atmospheric constituents which affect ozone. The sensor is a dual-channel Ebert-Fastie spectrometer operating in the regions of 2200-3100Å and 1600-2500Å. It has a look direction of 45 degrees to the spacecraft axis of rotation.

HERITAGE/DERIVATION: Dual channel Ebert-Fastie spectrometer, NASA OSS, Jet Propulsion Laboratory.

DATA

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory, National Center for Atmospheric Research.

REFERENCES

1. Project Plan for Solar Mesosphere Explorer 1981 Mission, September, 1978.

SYSTEM CHARACTERISTICS

Physical Size: 0.35 x 0.15 x 0.11 m
Mass: 2.95 kg
Power: 2 We data mode
1.5 We orbit mode
Data Rate: 1.3 kbps

MEASUREMENTS

Measure the solar ultraviolet flux.
Number of channels: 2
Spectral range: 2200 to 3100 Å
1600 to 2500 Å
FOV: 45 degrees

POTENTIAL DERIVED PARAMETERS

1. Direct solar flux in ultraviolet range.

SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R. J. McNeal
LOCATION: NASA Headquarters

ACRONYM: SUSIM
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS, SPACELAB-2
CONTRACTOR: NRL
P.I.: G. E. Brueckner

OBJECTIVES

1. To improve the existing accuracy of solar flux measurements in the 120-400 nm region of the spectrum.
2. To establish the variations of this flux over a solar cycle.

DESCRIPTION

SUMMARY: The solar ultraviolet spectral irradiance monitor (SUSIM) consists of two identical double-dispersion scanning spectrometers, seven detectors and a deuterium calibration lamp. The spectrometers and detectors are sealed in a canister filled with 1.1 atm of argon gas. One spectrometer is used more-or-less continuously; the second is used infrequently to track the stability of the first. The deuterium lamp serves as a secondary standard for inflight calibration. Pre-flight and post-flight calibrations are carried out through a cooperative program between NRL and the National Bureau of Standards.

Magnesium fluoride diffuser windows in front of the two interchangeable entrance slits for each spectrometer provide leniency in the required pointing accuracy and stability.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center.
PERIOD OF OPERATION: Launch date in fall 1986.

REFERENCES

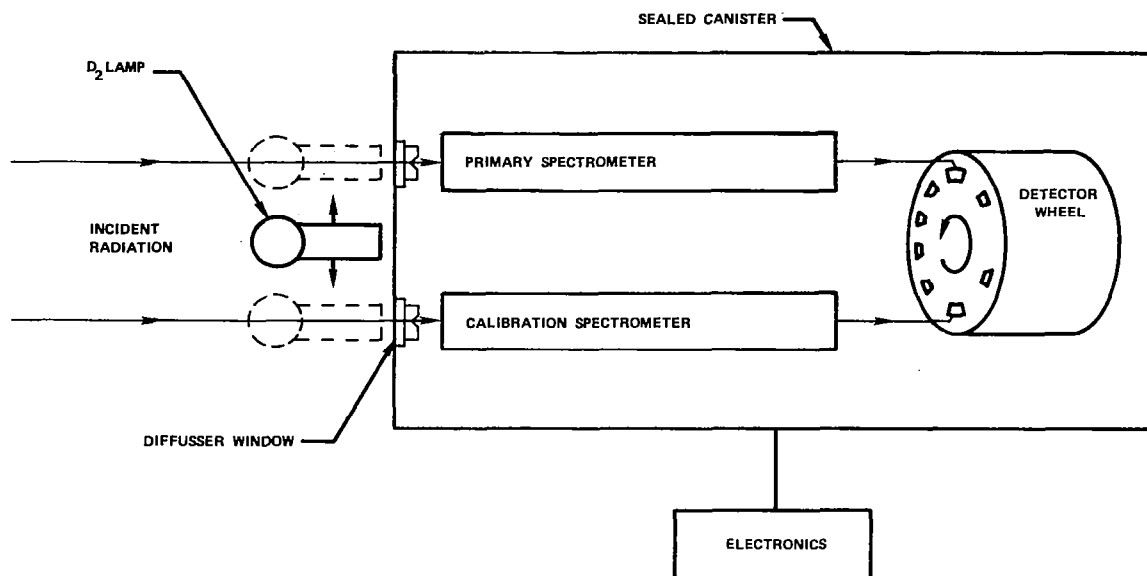
1. UARS Proposal, A Solar Ultraviolet Spectral Irradiance Monitor On-Board UARS Missions. Naval Research Laboratory, December 1978.

SYSTEM CHARACTERISTICS

Weight: 55 kg
Volume: 24 x 77 x 86 cm
Avg. Power: 45 W
Data Rate: 160 bits/sec

SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM)

FUNCTIONAL DIAGRAM



Solar Ultraviolet Spectral Irradiance Monitor Schematic Diagram

MEASUREMENTS

Channels: 8 broadband; 8 narrowband

Wavelengths: (nm)

1. 121.6	5. 215	9. 120.6	13. 155.0
2. 145	6. 270	10. 121.6	14. 190.0
3. 160	7. 330	11. 133.1	15. 215.0
4. 190	8. 390	12. 145.0	16. 396.0

1. Measure solar continuum irradiance in the 140-400 nm region.
2. Measure solar emission line irradiance in the 120-400 nm region.
3. Measure the intensities of the continuum below 208 nm relative to the intensities of the continuum above 208 nm.
4. Measure the intensities of solar emission lines relative to the stable solar continuum above 208 nm.
5. Measure the (wavelength dependent) degree of correlation of the solar fluxes in the 120-400 nm region with the following ground observables: the Zurich sunspot number, the solar 10.7 cm radio and the Ca II plage index and the full-sun Ca II H and K indices.

POTENTIAL DERIVED PARAMETERS

1. Detect aperiodic flares, lasting several minutes to 1 hour.
2. Detect the birth and death of an active region, with a time scale of a few days.
3. Observe solar rotation, with a 27-day period.
4. Measure changes in the number of active regions, with a period of about 11 years.
5. Possible long-term changes in the chromospheric and transition zone network or a varying degree of scattered, small activity not included in the classified active regions, with about an 11 year period.

SPIN SCAN CLOUD COVER CAMERA

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. R. Burke
LOCATION: NASA Headquarters

ACRONYM: SSCC
INSTRUMENT TYPE: Imager
SPACECRAFT: ATS-1
CONTRACTOR: Santa Barbara Research Center
P.I.: Dr. V. E. Suomi
Dr. R. J. Parent

OBJECTIVES

1. To provide high resolution pictures of the whole Earth's disk between 52°N and 52°S altitude on a continuous basis to permit surveillance of short duration weather changes.

DESCRIPTION

SUMMARY: The ATS-1 Spin Scan Cloud Cover Camera (SSCC) optical system consisted of a two-element cassegrain-type telescope. Light entering the system was reflected from a 13.7-cm-diameter (25.4-cm focal length) primary parabolic mirror onto a flat secondary quartz mirror to produce an image on the face of an aperture plate. The light then passed through the 0.025-mm-diameter aperture and a haze filter to impinge on a photocathode in front of a photomultiplier tube. The telescope photomultiplier assembly could be tilted in discrete steps from +7.5° to -7.5° to produce a north-south scan, corresponding to an Earth coverage from 52° N to 52° S. The east-to-west scan was provided by the spin of the satellite itself. A total time of 20 minutes was required to scan one picture and two minutes to retrace at a nominal satellite rotation of 100rpm. From its geostationary equatorial orbit (approximately 35,000 km above the Earth), the camera system had a ground resolution of better than 4 km at the subsatellite point. The experiment was highly successful, with almost six years of real-time cloud cover data obtained.

DATA

DATA PRODUCTS:

Data Set Name: The ATS Meteorological Data Control on microfiche.

Film: Five volumes on B/W microfiche describing the SSCC, the MSSCC, and the IDCS.

DATA ARCHIVES LOCATION: National Weather Record Center, National Space Science Data Center.

PERIOD OF OPERATION: December 1966 to October 1972.

REFERENCES

1. Meteorological Data Catalog for ATS, Volume 1, Goddard Space Flight Center, October 1967.
2. Suomi, V. E. and Parent, R. J.: Proposal for a Spin Scan Camera System for a Synchronous Satellite, July 1965.
3. Ostrow, H. and Weinstein, O.: A Review of a Decade of Space Camera Systems Development for Meteorology Presented at Society of Photo-Optical Engineers 13th Annual Technical Symposium, August 23, 1968.
4. National Space Science Data Center computer printout, 1980.

SPIN SCAN CLOUD COVER CAMERA (SSCC)

SYSTEM CHARACTERISTICS

Weight: 16 lbs.

Volume: 0.45 cu. ft.

Standby Power: 7 Watts

Peak Power: 24 Watts

Special Requirements: operates only during daylight: highly sensitive to sweep distort. Components: 1-inch photomultiplier, 5-inch paraboloid, 2-inch flat mirror.

Frequency of Observation: 22 minutes

Data Recovery: realtime telemetry

MEASUREMENTS

Observe sunlight reflected from the Earth's surface and/or clouds.

Spectral Range: 0.475 to 0.630 microns

Field-of-View: 15.0 by 15.0 degrees

Telemetry Requirements: 150 kHz video bandwidth

Spatial Resolution: 2.5 nautical miles at center

POTENTIAL DERIVED PARAMETERS

1. Full Earth disk photography.
2. Complete recording of storm histories.

SPIN SCAN CLOUD COVER CAMERA

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. R. Burke
LOCATION: NASA Headquarters

ACRONYM: SSCC
INSTRUMENT TYPE: Imager
SPACECRAFT: ATS-3
CONTRACTOR: Santa Barbara Research Center
P.I.: Dr. V. E. Suomi
Dr. R. J. Parent

OBJECTIVES

1. To obtain high resolution color photographs from synchronous altitude so the cloud cover development, cloud displacements, and in the terminator zone, cloud altitudes, can be determined for use in studies of tropical convection.
2. Determine horizontal extent of ocean currents.
3. Scattering of the atmosphere in broad spectral bands view mid-latitude storms.

DESCRIPTION

SUMMARY: The ATS-3 Multicolor Spin Scan Cloud Cover Camera (SSCC) represented a significant advance over a similar but monochromatic spin scan camera on ATS-1. The SSCC was mounted with its optical axis perpendicular to the spacecraft's spin axis and viewed the Earth through a special aperture in the spacecraft's side. The camera consisted of a high-resolution telescope, three photomultiplier light detectors (red, blue, and green), and a precision latitude step mechanism. Light entering the system was focused alternately on a set of three 0.038-mm aperture plates and then passed through various filters to impinge on the appropriate photodetector. The telescope multiplier assembly could be tilted in discrete steps to provide pole-to-pole coverage in 2400 scan lines. East-to-west scan was provided by the spin of the satellite itself. A total time of 24 minutes was required to scan one frame and four minutes to retrace with a nominal satellite rotation of 100rpm. From its geostationary equatorial orbit (approximately 36,000 km above the Earth), the camera had a ground resolution of better than 4 km at nadir, the experiment was successful, with ATS-3 being the first spacecraft to transmit operational multicolor Earth-cloud photographs. Approximately three months after launch, however, the red and blue channels failed, and the system subsequently has been limited to producing black and white pictures.

HERITAGE/DERIVATION: ATS-1 Spin Scan Cloud Cover Camera

SPIN SCAN CLOUD COVER CAMERA (SSCC)

DATA

DATA PRODUCTS:

- Data Set Name: 16 mm color cloud motion movies for November 18, 1967.
B/W movies of severe storms and tornados on April 23, 1969.
Meteorological data catalog for the applications technology satellites.
16 mm movies of tornados on April 19, 1968.
B/W 16 mm movies of hurricanes Abby, Brenda, and Candy in 1968.
- Film: 16 mm full color, silent film of cloud cover conditions
16 mm silent movie of numerous short film sequences of tornado and severe storm conditions
16 mm silent movie of short film sequences of tornado and tornado conditions
16 mm silent movie B/W cloud photography and geographic grids for selected storms.
- Paper: 5 books or bound volumes that describe and index the ATS-1 SSCC, ATS-3 SSCC, and the ATS-3 IOCS.

DATA ARCHIVES LOCATION: ESSA, Asheville, North Carolina for B/W and at NIMBUS/ATS Data Utilization Center, Goddard Space Flight Center for Color.

PERIOD OF OPERATION: May 25, 1970

REFERENCES

1. ATS Meteorological Data Catalog - Goddard Space Flight Center
2. Minzner, R. A. Ed: Interim Report on Satellite Met. Instruments PM-6713, NASA/ERC PR 67.
3. Suomi, V.; Parent, R. J.: Proposal and Supplement for Spin Scan Camera for ATSC, University of Wisconsin, November 1965 and June 1966.
4. National Space Science Data Center computer printout 1980.

SYSTEM CHARACTERISTICS

Weight: 23 lbs.
Volume: .54 cu. ft.
Avg. Power: 10 Watts
Peak Power: 22 Watts
Components: telescope, 3 photomultiplier light detectors, step drive mechanisms
Data Recovery: realtime telemetry
Frequency of Observations: every 28 minutes
Peak Power: 22 Watts

SPIN SCAN CLOUD COVER CAMERA (SSCC)

MEASUREMENTS

Measures Earth's reflectivity in the blue, green, and red portion of the spectrum.

Spectral Range: 0.39 to 0.70 microns

Field-of-View: 15.0 by 15.0 degrees

Spatial Resolution: 2 nautical miles at center

POTENTIAL DERIVED PARAMETERS

1. High resolution color photograph of clouds.
2. First color photographs of the Earth.
3. Horizontal extent of ocean currents.

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: D. Diller
LOCATION: NASA Headquarters

ACRONYM: SAGE
INSTRUMENT TYPE: Radiometer
SPACECRAFT: AEM-2
CONTRACTOR: Boeing Aerospace Co.
P.I.: P. McCormick, NASA/LaRC

OBJECTIVES

1. To determine the spatial distribution of stratospheric aerosols and ozone on a global scale;
2. To develop a viable satellite-based remote sensing technique for measuring stratospheric aerosols and ozone;
3. To map vertical extinction profiles of stratospheric aerosols and ozone globally from 70°S to 79°N latitude, and
4. To investigate aerosol optical properties using flight experiment and ground truth data.

DESCRIPTION

SUMMARY: The Earth-orbital SAGE mission is to map vertical profiles in the stratosphere of ozone, aerosol, nitrogen dioxide and molecular extinction in a wide band around the globe. The ozone data will extend from about 9 to 46 kilometers (6 to 29 miles); aerosol data from the cloud tops to 35 km (22 miles); nitrogen dioxide data from about 25 to 40 km (16 to 25 miles); and molecular extinction from about 15 to 40 km (9 to 25 miles).

The SAGE sensor is a four-spectral channel radiometer which measures the extinction of solar radiation during solar occultation. As the spacecraft emerges from the Earth's shadow during each orbit, the sensor will acquire the Sun and measure solar intensity in four wavelength bands centered at 0.385 micrometers, 0.45 micrometers, 0.65 micrometers and 1.0 micrometers.

As the spacecraft continues in orbit, the line-of-sight from the spacecraft to the rising Sun will scan the Earth's atmosphere, resulting in a measurement of the attenuated solar intensity at different atmospheric layers. The procedure will then be repeated in a reverse sense during spacecraft sunset.

The solar input is reflected from the scan mirror through the Cassegrain telescope, which produces a solar image upon the science detector aperture. The radiation through the aperture is dispersed by a holographic to four silicon photo diode detectors. The outputs of the detectors are fed to signal conditioning amplifiers. Their outputs go to the PCM encoder, which multiplexes the signals and then transfers data to the AEM-B data system.

HERITAGE/DERIVATION: Nimbus-7 Stratospheric Aerosol Measurements (SAM)

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT (SAGE)

DATA

DATA PRODUCTS:

1. Types of data products
 - Digitized computer tapes
 - Computer plots
2. Vertical profiles (10 to 100 km) of the SAGE instrument radiance as well as the SAGE output products of ozone, aerosol, nitrogen dioxide, and molecular extinction, there will be approximately 14 sunrise and 14 sunset measurements per day.
3. Monthly cross sections of these products are generated as zonal means and plotted as a function of latitude and altitude.
4. Seasonal maps of the SAGE output products (ozone, aerosol, nitrogen dioxide, and molecular concentrations) are generated at fixed-pressure levels and plotted as a function of latitude and longitude.

DATA ARCHIVES LOCATION: National Space Science Data Center

PERIOD OF OPERATION: January 1979 to present

REFERENCES

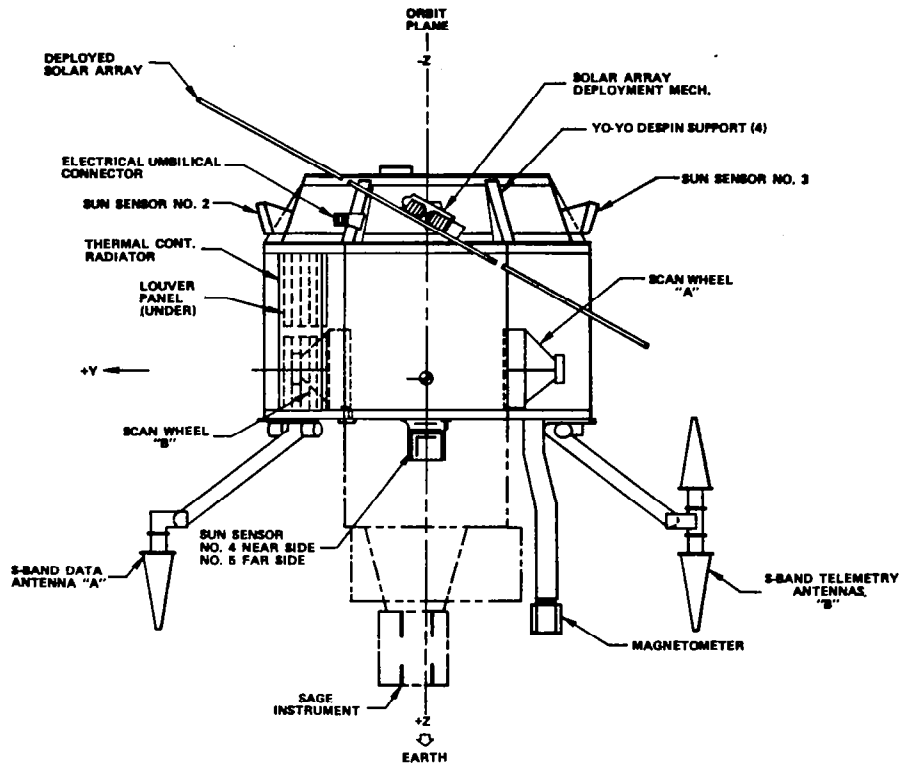
1. Stratospheric Aerosol and Gas Experiment of the Applications Explorer Missions Program, GSFC.

SYSTEM CHARACTERISTICS

Altitude range: 10 to 100 km above Earth horizon
Detector operating temperature: 19° to 30°C
Scan rate: 15 km/sec
Sampling rate: 64 samples/sec
Information bandwidth: 1 Hz/km/channel
S:N Ratio (1.0 micron channel): 1.5×10^5 at peak
Weight: 39 kg

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT (SAGE)

FUNCTIONAL DIAGRAM



Stratospheric Aerosol and Gas Experiment Schematic Diagram

MEASUREMENTS

Measures solar radiation at four separated wavelengths.
Channels: 0.38, 0.45, 0.60, and 1.0 microns
Field of view: 0.15 milliradians (0.5 km)
Vertical resolution: 1 km
Horizontal resolution: 250 km

POTENTIAL DERIVED PARAMETERS

1. Long term distribution throughout the stratosphere of high-volume aerosols and other gases.
2. Map vertical extinction profiles of stratospheric aerosols and ozone globally from 78°S to 78°N latitude.
3. Determine global concentrations of aerosols and ozone and their spatial distribution.
4. Determine the optical properties of stratospheric aerosols.
5. Investigate transient phenomena.
6. Determine hemispherical differences.
7. Investigate transport phenomena.
8. Investigate the tropospheric-stratospheric exchange.
9. Determine the radiation effects of stratospheric aerosol and ozone on the global climate and available solar energy.

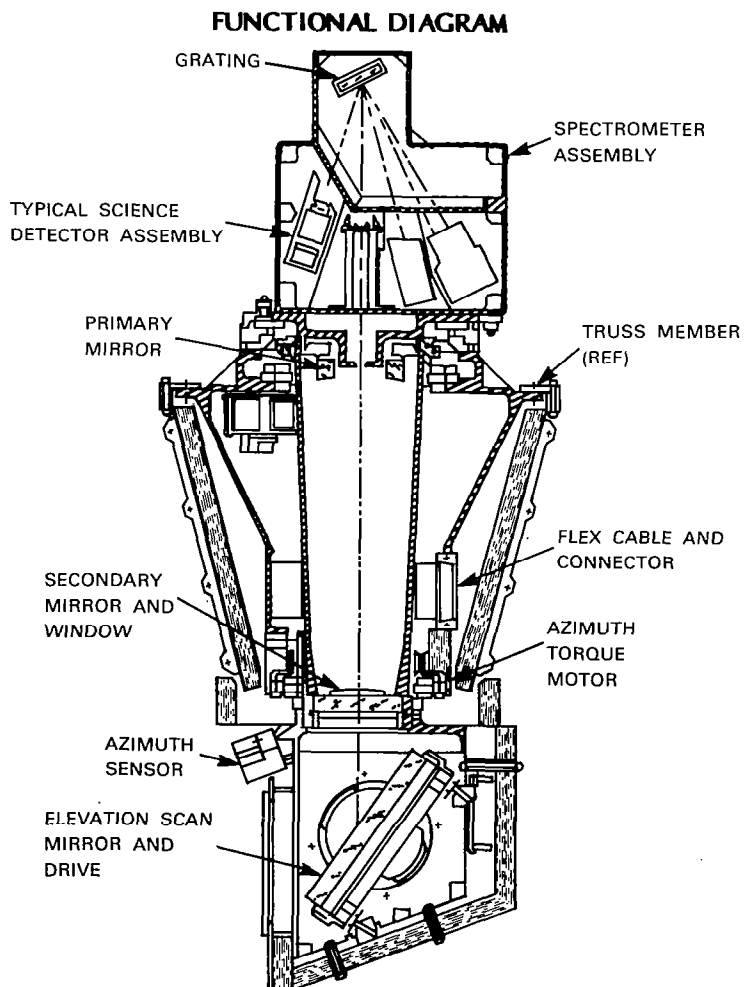
STRATOSPHERIC AEROSOL AND GAS EXPERIMENT II (SAGE II)

REFERENCES

1. Execution Phase Project Plan, Earth Radiation Budget Experiment (ERBE)
2. Stratospheric Aerosol and Gas Experiment II (SAGE II)
3. Halogen Occultation Experiment (HALOE)
4. On-Orbit Radiation Budget Satellite, Appendix B - Experiments, LaRC, February 1979.

SYSTEM CHARACTERISTICS

Weight: 30 kg
Power: 10-40 We
Data rate: 6.144 Kbps
Altitude range: 10-100 km above horizon
Wavelength (μm): 0.385 - 1.0
Detector operating temperature: 292°K - 303°K
Scan rate: 15 km/sec
Sampling rate: 64/sec
SNR: 1.5×10^5 at peak
Information bandwidth: 1 Hz/km channel



Stratospheric Aerosol and Gas Experiment-II Sensor Assembly

STRATOSPHERIC AEROSOL AND GAS EXPERIMENT II (SAGE II)

MEASUREMENTS

Measure extinction of solar radiation intensity during solar occultation.

Channels: 0.385, 0.45, 0.6, 1.0 microns

Field-of-view: 0.15 milliradians (~0.5 km)

Horizontal resolution: 250 km

Vertical resolution: 1 km

POTENTIAL DERIVED PARAMETERS

1. Stratospheric trace gases
2. Photo-chemical and chemical rate coefficients
3. Ozone characteristics
4. Aerosols of stratosphere
5. Submicron particulates.

STRATOSPHERIC AEROSOL MEASUREMENT (SAM II)

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: L. E. Mauldin
LOCATION: Langley Research Center

ACRONYM: SAM II
INSTRUMENT TYPE: VIS/IR Spectroradiometer
SPACECRAFT: NIMBUS-7
CONTRACTOR: University of Wisconsin
P.I.: M. McCormick, LaRC

OBJECTIVES

1. Produce a baseline data set on stratospheric aerosols in high-latitude regions with one-kilometer vertical resolution.
2. Aerosol transport, sources and sinks in the stratosphere.
3. Seasonal variations and sudden warming phenomena.
4. Volcanic injection phenomena.
5. Mesospheric aerosols, noctilucent and nacreous clouds, and thin cirrus clouds near the tropopause will also be detected when their optical thickness is sufficiently large.
6. To map the concentration and optical properties of stratospheric aerosols as a function of altitude, latitude, and longitude.

DESCRIPTION

SUMMARY: The instrument, basically a Sun photometer, measured the extinction of solar radiation at 1.0-micrometer wavelength during spacecraft sunrise and sunset. The photometer viewed a portion of the solar disk with a 0.145-MRAD IFOV and a sampling rate of 50 samples per second. As the spacecraft first viewed the sunrise, the photometer-pointing axis was depressed approximately 0.52 RAD with respect to the spacecraft horizontal. The photometer continued looking at the Sun until its depression angle was on the order of 0.44 RAD (approximately 1.4 min observing time). Before sunset, the photometer head rotated 3.14 RAD in azimuth and viewed the Sun from a depression of approximately 0.44 to 0.52 RAD as the spacecraft orbited to the dark side of the Earth. For the expected high noon orbit, latitudes of between 1.12 and 1.40 RAD in both hemispheres were scanned for 3 months. The extinction measurements were inverted for the number-density times the aerosol scattering cross section by using the Lambert-Beer Law and assuming the atmosphere to be composed of layers. To determine the stratospheric aerosol optical properties, ground-truth in situ balloon-borne aerosol measurements were also made.

PERIOD OF OPERATION: October 24, 1978 to present.

DATA

DATA PRODUCTS:

TAPES

Raw Data Archives Tape
Beta-aerosol Number Density Tape
Mapped Data Matrix Tape
SAM II Output Products Profiles

16mm FILM

Profiles
Cross Sections/Contours
Maps
Time Histories

STRATOSPHERIC AEROSOL MEASUREMENT (SAM II)

DATA ARCHIVES LOCATION: National Space Sciences Data Center, Goddard Space Flight Center.

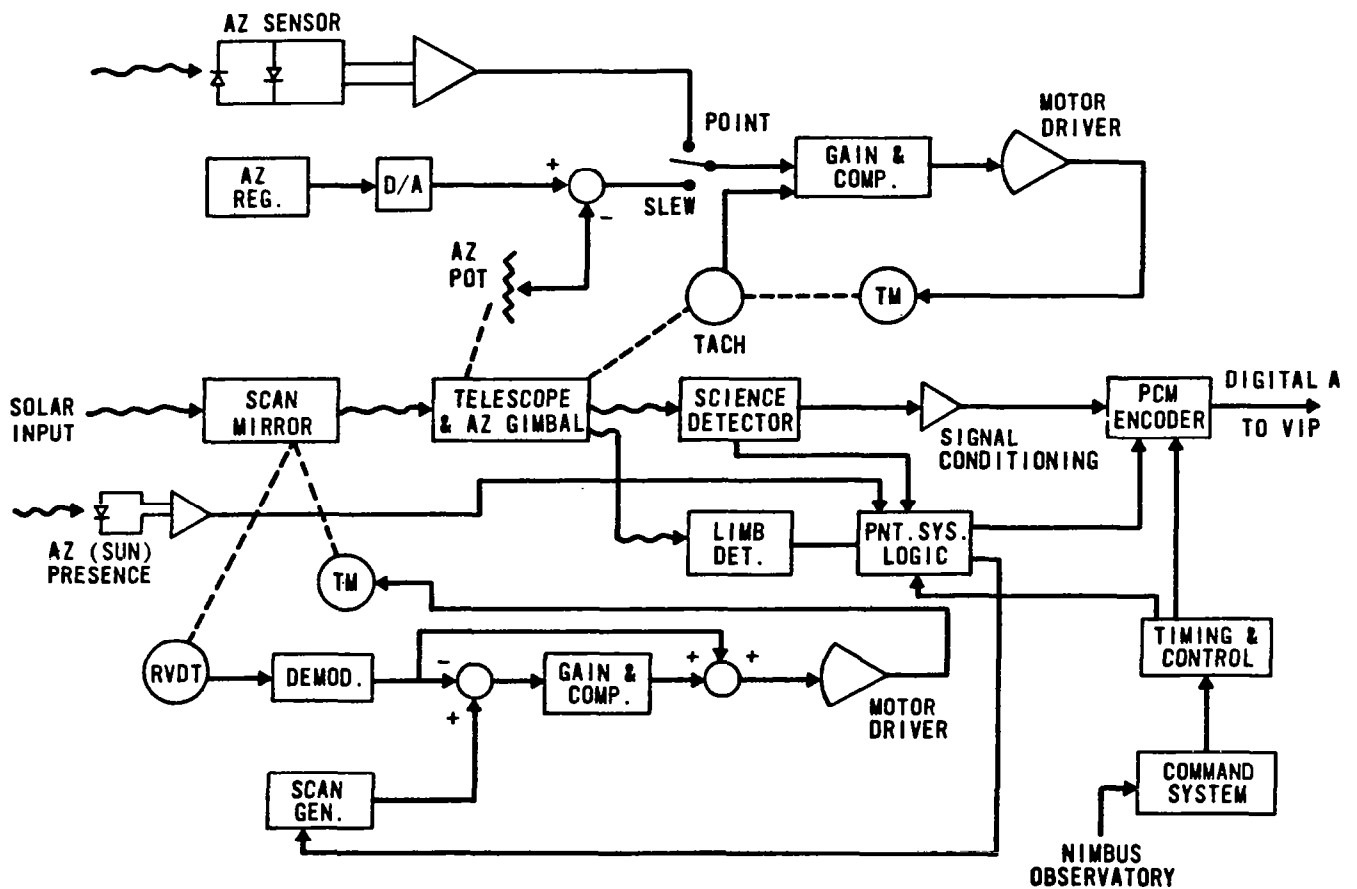
REFERENCES

1. The NIMBUS-7 User's Guide, NASA, Goddard Space Flight Center, August 1978.
2. National Space Sciences Data Center.

SYSTEM CHARACTERISTICS

Weight: 17 kg
Size: 36 cm by 20 cm by 51 cm
Design Temperature: -5 to 45°C

FUNCTIONAL DIAGRAM



Stratospheric Aerosol Measurement Block Diagram

STRATOSPHERIC AEROSOL MEASUREMENT (SAM II)

MEASUREMENTS

Channels: 1 centered at 1.0 microns.
Channel Wavelength Range: 0.98 microns to 1.02 microns
Mirror Scan Rate: 180 arc minutes per second (LOS)
Sampling Rate: 50 samples per second
Slew Motion: 5 degrees per second
IFOV: Circular .61 arc minutes in diameter.

POTENTIAL DERIVED PARAMETERS

1. Solar Irradiance vs. Altitude
2. Solar Irradiance vs. Time
3. Aerosol Coefficients
4. Total Extinction Ratios
5. Aerosol Number Density
6. Average Aerosol Coefficients.

STRATOSPHERIC AND MESOSPHERIC SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: R. White
LOCATION: NASA/Goddard Space Flight Center

ACRONYM: SAMS
INSTRUMENT TYPE: IR Spectroradiometer
SPACECRAFT: NIMBUS-7
CONTRACTOR: Hawker-Sidley
P.I.: J. Houghton, Oxford, England

OBJECTIVES

1. To observe emission from the limb of the atmosphere through various pressure modulator radiometers.
2. To determine temperature and vertical concentrations of H₂O, N₂O, CH₄, CO, and NO in the stratosphere and mesosphere to approximately 90 km.

DESCRIPTION

SUMMARY: The Stratospheric and Mesospheric Sounder (SAMS) instrument is the fourth in a series of multichannel infrared radiometers designed to measure emission from the upper atmosphere, for which conventional spectral filtering techniques do not give adequate performance. The SAMS gathers radiometric data in the CO₂ (15 (2 channels) and 4.3 microns), NO (5.3 microns), CH₄ (7.7 microns), CO (4.7 microns), H₂O (2.7 and 25-100 microns) and N₂O (7.7 microns) for the purpose of determining temperature and atmospheric composition in the stratosphere and mesosphere (10-120 km). Measurements of zonal wind shift in the 50-120 km region also were made using a Doppler shift of emissions lines. The SAMS produces simultaneous radiometric measurements in each band as it scans the Earth's limb. Radiation is reflected off the azimuth-elevation scanning mirror, focused through a 15 cm telescope, filtered by pressure modulated cells and detected. The IR detectors are uncooled (290°K) except for one channel radiatively cooled (130°K). The azimuth-elevation feature of the scanning mirror is used for inducing doppler shift between the emission lines from the atmosphere and the absorption lines in the cells for zonal wind measurements.

HERITAGE/DERIVATION:

NIMBUS-4 Selective Chopper Radiometer → NIMBUS-5 SCR → NIMBUS-6 Pressure Modulator Radiometer

DATA

DATA PRODUCTS:

TAPE

(RAT) Radiance Archive Tape
(MATRIX) Mapped Data Matrix Tape

16 MM MICROFILM

Map Sets of each Species
Cross Sections of each Species

STRATOSPHERIC AND MESOSPHERIC SOUNDER (SAMS)

DATA ARCHIVES LOCATION: National Space Sciences Center, Goddard Space Flight Center.
PERIOD OF OPERATION: October 1978 to present.

REFERENCES

1. The NIMBUS-7 User's Guide, NASA, Goddard Space Flight Center, August 1978.
2. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

1.3 adjacent FOV, each 28 by 2.8 MRAD

Signal Channel Parameters

Gas	Filter Bandpass (μm)	Modulated Bandwidths		Detectors				
		*Black (cm^{-1})	†Line (cm^{-1})	Designation	Type	Temp	**NEP (f_B)	**NEP (f_L)
CO ₂	14.4-15.7	2.9	0.5	A1	TGS	290K	2.0×10^{-10}	0.9×10^{-10}
			6.0					
CO	4.1-5.4	26	1.6	A2/3/4	InSb	140K	8×10^{-13}	6×10^{-13}
NO			1.0					
H ₂ O	2.5-2.6	10	0.8	B1	Pbs	260K	5×10^{-13}	6×10^{-13}
	25-100	15	0.6	B2	TGS	290K	2×10^{-10}	0.9×10^{-10}
CO ₂	14.4-15.7	2.9	0.9	C1	TGS	290K	2×10^{-10}	0.9×10^{-10}
N ₂ O	7.6-7.8	1.7	3.0	C2/3	TGS	290K	2×10^{-10}	0.9×10^{-10}
CH ₄			0.4					

*5 percent modulation depth allowed for
†mean cell pressures at highest settings
**watts for 1-8 second integrating time (i.e. single sample)

SURFACE COMPOSITION MAPPING RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: SCMR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-5
CONTRACTOR: Elliot-Automation
P.I.: W. A. Hovis, GSFC

OBJECTIVES

1. To measure terrestrial radiation in the 8.3 to 9.3 micron and 10.2 to 11.2 micron intervals.
2. Reflected solar radiation in the 0.8 to 1.1 micron range.

DESCRIPTION

SUMMARY: The Surface Composition Mapping Radiometer (SCMR) for NIMBUS-5 is a three channel instrument with two channels sensing terrestrially emitted radiation in the 8.3 to 9.3 (8.8) and 10.2 to 11.2 (10.7) micrometer range and one channel sensing reflected solar energy in the 0.8 to 1.1 (0.95) micrometer interval. Because of telemetry limitations, only two channels can be utilized at one time--either the 8.8 and the 10.7 micrometer channels or the 0.95 and the 10.7 micrometer channels. The selection of channels is by real-time or stored command and will be determined on a case by case basis by the experimenter. For nighttime operation, only the 8.8 and 10.7 micrometer channels will be used. The instrument scans across the direction of the spacecraft track with a rotating mirror. The instantaneous field-of-view of each channel is 0.6 x 0.6 milliradians resulting in a field-of-view of 660 x 660 meters, in the nadir, from the projected 1100 km orbital altitude. The scan mirror rotates at 10 rps to provide contiguous scan lines with a useful scan width limited to about 800 km because of distortion and atmospheric interference. The detectors for the two long wavelength channels are cooled by a radiative cooler to approximately 100°K. The instrument began malfunctioning soon after launch.

DATA

DATA PRODUCTS:

Data Set Name: Surface Composite Mapping Radiometer Data on magnetic tape.

Tape: 45 reels on magnetic tape on 9-track, 1600 BPI, binary magnetic tape. Contain temperature radiance, for precisely located geographical locations.

DATA ARCHIVES LOCATION: Goddard Space Flight Center

PERIOD OF OPERATION: November 1972 to January 1973

REFERENCES

1. National Space Science Data Center computer printout 1980.
2. NIMBUS-5 Users Guide, Goddard Space Flight Center, November 1972.

SURFACE COMPOSITION MAPPING RADIOMETER (SCMR)

SYSTEM CHARACTERISTICS

Precision and Accuracy: noise equivalent $\Delta T = 0.17^\circ\text{K}$ at 280°K and 10 microns

Components: scan mirror, optics and detector, electronics, radiant cooler

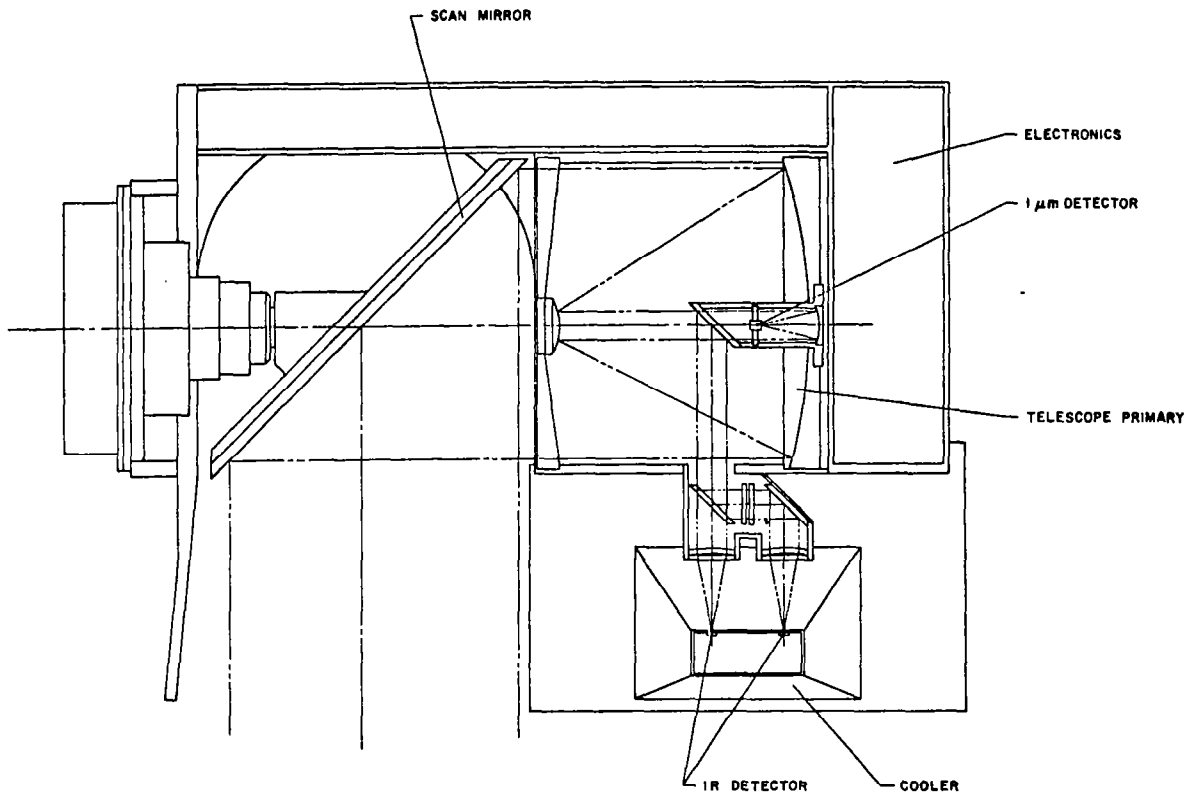
Weight: 55 lb.

Volume: 1.0 cu. ft.

Standby Power: 8 Watts

Peak Power: 15 Watts

FUNCTIONAL DIAGRAM



Surface Composition Mapping Radiometer Optical Configuration

SURFACE COMPOSITION MAPPING RADIOMETER (SCMR)

MEASUREMENTS

Measures terrestrially emitted radiation.
Measures solar reflected energy.

Measurement Range: detectivity of about 10 to the tenth at 100°K

Spectral Range: 8.3 to 11.2 microns

Channels: Three

1. 8.3-9.3 microns
2. 10.2-11.2 microns
3. 0.8-1.1 microns

Field-of-View: 60° by .035°

POTENTIAL DERIVED PARAMETERS

1. Surface composition.
2. Sea surface temperatures.

SYNTHETIC APERTURE RADAR (SAR)

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER:
LOCATION:

ACRONYM: SAR
INSTRUMENT TYPE: Radar
SPACECRAFT: SEASAT-A
CONTRACTOR: Jet Propulsion Laboratory
P.I.: Frank T. Barath

OBJECTIVES

1. To obtain microwave imagery at 1275 MHz of the sea surface.
2. To discern the length and direction of ocean waves.
3. The size, location and speed of sea ice, oil spill and coastal features.

DESCRIPTION

SUMMARY: The Synthetic Aperture Radar (SAR) emits and gathers radiation at 1.275 GHz for the purpose of determining wave patterns and providing high resolution pictures of ice, oil spills, current patterns and similar features. The radar, a chirped pulse SAR, will look off Nadir with a fan beam normal to the satellite track. Coherent processing, as the beam sweeps out a swath, will produce the images. Using an antenna measuring 10 m (azimuth) x 2 m (elevation) the SAR receives reflected radiation from a swath of 100 km width, starting 250 km off nadir. Data is transmitted directly to ground via S-band link, video pass band is 2-21 MHz. No on-board storage is provided due to high data rates. The swath is illuminated by 1275 MHz microwave pulses of 32 microsecond duration occurring at 1400 pps.

HERITAGE/DERIVATION: Apollo-17 and AAFE Radar

DATA

DATA PRODUCTS: Four negatives of 70 mm rolls, each measuring 25x up to 4000 km in length, with calibration wedges and time, location marks, for up to 500 passes will be available.

DATA ARCHIVES LOCATION: Jet Propulsion Laboratory

PERIOD OF OPERATION: July 7 through October 10, 1978.

REFERENCES

1. NASA, SEASAT-A Program Summary, August 1974.

SYNTHETIC APERTURE RADAR (SAR)

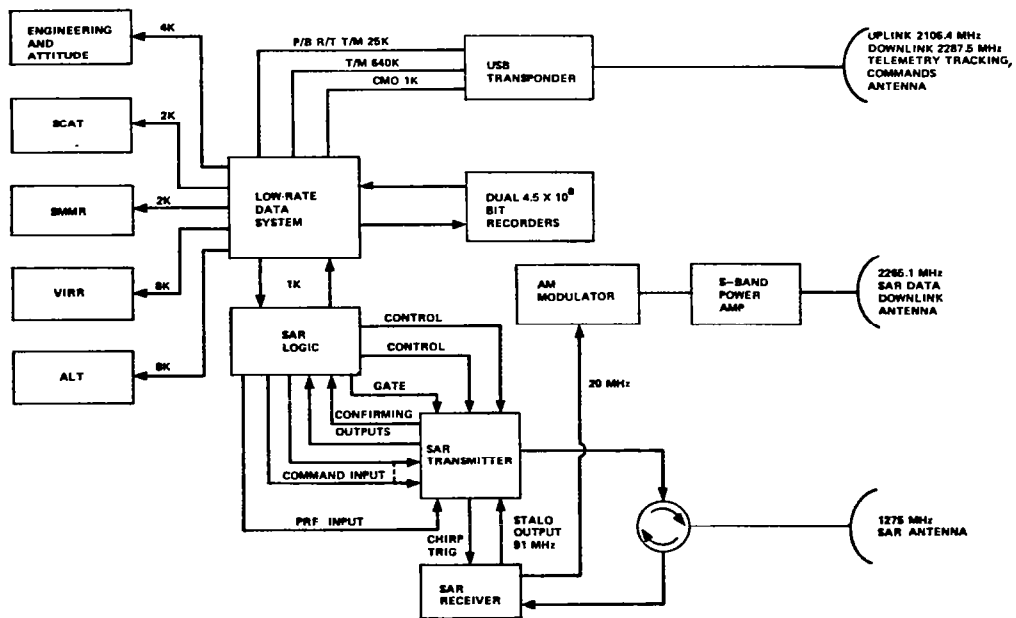
SYSTEM CHARACTERISTICS

Transmit time/total time: 0.35
 Pulse width: 33.8 microseconds
 Chirp rate: 0.562 MHz/microseconds
 Pulse compression: 642
 Time bandwidth product: 642
 Effective pulse width: 53 nsec
 Peak transmitted power: 800 W nom, 1125 W max
 PRF's: 1464, 1540, 1647 pulses/sec
 Average transmitted power: 42 W
 Average raw power:

Peak trans PWR, W	800 Nom.	1125 Max.
1464	401	515
1540	413	533
1647	430	558

System noise temp: <550°K
 Receiver gain: +77 to 98 dB
 Gain: STC, Auto, Commandable
 Average backscatter: -13 dB
 Backscatter range: -26 to 0 dB
 Received power range: -97 to -71 dBm
 Antenna peak gain: 35 dB
 Antenna polarization: horizontal
 Eng. data rate: 500 bps
 Size: 100 x 80 x 25 cm
 Weight: 100 kg

FUNCTIONAL DIAGRAM



Synthetic Aperture Radar Block Diagram

SYNTHETIC APERTURE RADAR (SAR)

MEASUREMENTS

Frequency: 1274.8 GHz (L-Band)
Nominal Range Resolution (3-dB width): 25 m
Nominal Azimuth Resolution (3-dB width): 25 m
Dynamic Range for Point Target: 50 dB
Dynamic Range for Distributed Target: 27 db
100 km swath width, 4000 km swath length in 10 min. pass
Four independent cell measurements (4 looks)
25 x 25 m cell resolution (4 looks)
0.5 sec integration time per cell measurement (per look)
Cell SNR of >5 dB over 100 km swath (4 looks)

POTENTIAL DERIVED PARAMETERS

1. Ocean surface imagery capable of yielding directional wave spectra in the open ocean.
2. Monitoring of coastal processes.
3. Charting ice fields.
4. Land imagery useful in geological, hydrological and glaciological studies.
5. Iceberg detection.
6. Fishing vessels.

TEMPERATURE AND WIND MEASUREMENT IN THE MESOSPHERE AND LOWER THERMOSPHERE

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: D. Broome, S. Chandra
LOCATION: NASA Headquarters

ACRONYM: TWM
INSTRUMENT TYPE: Telescope/Interferometer
SPACECRAFT: UARS
CONTRACTOR: Service d'Aeronomie du CNRS
P.I.: Dr. G. Thuillier

OBJECTIVES

1. To measure simultaneously the wind and temperature in the high mesosphere and low thermosphere.
2. To derive the eddy diffusion coefficient by a remote sensing method.
3. To measure absolute intensity of lines.

DESCRIPTION

SUMMARY: The instrument is composed of two main units. The upper part is a telescope which collects the photons emitted by the atmospheric layers. The entrance plane mirror scans a total field of view of 8.5 degrees. It is foreheaded by a baffle to prevent stray light from entering the experiment. The lower part consists of the Michelson interferometer and associated optics, detectors, laser unit, electromechanisms and electronics. In the mesospheric mode the scanning mirror stops on each elementary step for measurement, which corresponds to a vertical FOV of 4 arc. min, while in the thermospheric mode the mirror moves four steps and stops for measurement, which corresponds to a vertical FOV of 16 arc. minute. In both cases, five layers of the atmosphere are simultaneously analyzed.

DATA ARCHIVES LOCATION: Goddard Space Flight Center
PERIOD OF OPERATION: Launch date in Fall 1986.

REFERENCES

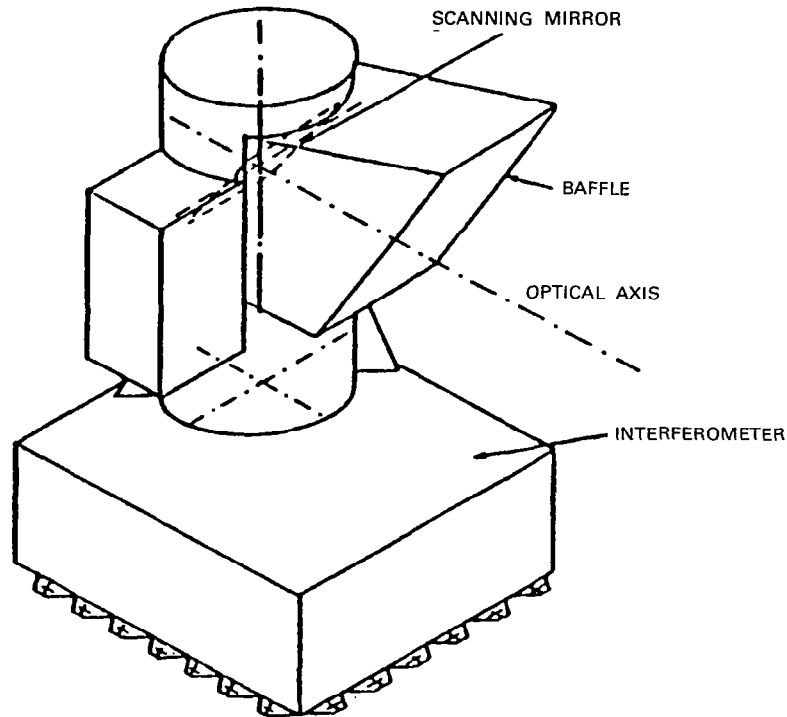
1. UARS Proposal, Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere. Service d' Aeronomic du CNRS, France, December 1978.

SYSTEM CHARACTERISTICS

Weight: 37 kg
Size: .88m x .52m x .59m
Power: 52 Watts
Data Rate: 1.07 kb/s

TEMPERATURE AND WIND MEASUREMENT IN THE MESOSPHERE AND LOWER THERMOSPHERE

FUNCTIONAL DIAGRAM



Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere Schematic Diagram

MEASUREMENTS

Measures electromagnetic radiation emanating from the atmosphere.

FOV:	<u>Thermosphere</u>	<u>Mesosphere</u>
horizontal	2°	2°
vertical	16°	4°

Vertical Resolution: 3 km at 90 km altitude

Basic observations of the mesospheric and thermospheric modes.

Field of view: 8.5 deg.

- Bands:
1. 5577Å
 2. 6300Å
 3. 7319Å
 4. 7278 and 7371Å

POTENTIAL DERIVED PARAMETERS

1. Seasonal and latitudinal variation of temperature wind, atomic oxygen and eddy diffusion coefficient.
2. Relation between global circulation and eddy diffusion for observed seasonal and latitudinal changes.
3. Height and intensity of eddy diffusion related to observed change of composition as function of season and latitude in standard and disturbed conditions.

TEMPERATURE HUMIDITY INFRARED RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: B. Schardt
LOCATION: NASA Headquarters

ACRONYM: THIR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NIMBUS-4,5,6,7
CONTRACTOR: Santa Barbara Research Center
P.I.: A. W. McCulloch, GSFC
I. L. Goldberg, GSFC

OBJECTIVES

1. To provide night and day time cloud cover.
2. To obtain IR temperature maps of clouds.
3. To map temperatures of land and ocean surfaces of the Earth.
4. To provide synoptic humidity patterns.
5. To trace air mass boundaries, vertical motions and jet streams.

DESCRIPTION

SUMMARY: This radiometer like the HRIR is a scanning radiometer. The scan is accomplished by a plane mirror rotating at 48 rpm. Radiation from the scanning mirror is collected and focused by a Cassegranian telescope with a 5 inch primary mirror. A dichroic beam splitter and filters then divide the beam into 2 channels, a 6.5–7.0 micron channel for surface or cloud top temperature measurements and a 10.5 to 12.5 micron channel. Immersed thermistor bolometers are the detectors in both channels. During a scan period of 1.25 sec, there is a sync signal, a stepped voltage calibration signal, a scan of cold space for a zero level, the scan of Earth, another space scan, and a housing scan to give a warm body calibration point. There is no radiation chopping in this instrument. The sweep rate and the field-of-view are chosen so that continuous scanning occurs along the subsatellite track with increasing overlap toward the horizon. The 11 micron channel has a 0.4° (7.0 millirad) field-of-view which gives a 4.2 nm resolution from a 600 nm orbit. The 6-micron channel has a 1.2° (21 milliradians) field-of-view giving a 12.5 nm resolution from a 600 nm orbit.

HERITAGE/DERIVATION: High Resolution Infrared Radiometer – Nimbus 1 & 2
High Resolution Infrared Radiometer – Nimbus 3

DATA

DATA PRODUCTS:

NIMBUS-4

Data Set: THIR 11.5-micron photofacsimile film strips
THIR 6.7-micron photofacsimile film strips
THIR data catalogs on microfiche
11.5-micron THIR radiation tapes
6.7-micron THIR radiation tapes

Film: 8049 70-mm photofacsimile film strips of NIMBUS-4 Temperature Humidity Infrared Radiometer
4419 THIR 70-mm photofacsimile film strips
48 B/W cards on microfiche that pictorially describe data acquired by NIMBUS

Tapes: 1291 reels of 7-track 800-BPI binary magnetic tape
1030 reels of 6.7 micron 7-track, 800 BPI, binary magnetic tape

TEMPERATURE HUMIDITY INFRARED RADIOMETER (THIR)

DATA PRODUCTS (cont'd):

NIMBUS-5

Data Set: 11.5 micron THIR photofacsimile film
6.7 micron THIR photofacsimile film
11.5 micron THIR data tapes
6.7 micron THIR data tapes

Film: 18,554 70 mm photofacsimile film strips, positive or negative, 100 - 500 ft. rolls of film
19,213 70 mm photofacsimile film strips, arranged chronologically on 100 - 500 ft. rolls of film

Tape: 1828 reels of 7-track, 800 BPI, binary magnetic tapes; tapes describe orbit
1020 reels of magnetic tape, 7-track, 800 BPI, binary magnetic tapes; 'The NMRT-THIR format is presented in section 2 of the 'NIMBUS-5 User's Guide,' along with instructions for ordering the data.'

NIMBUS-6

Data Set: 6.7 micron photofacsimile black and white 70 mm film
11.5 micron photofacsimile black and white 70 mm film
11.5 micrometer temperature-humidity infrared radiometer data on tape
6.7 micron THIR data on tape

Film: 21,293 frames on 70 mm photofacsimile film strips separated into daytime or nighttime swaths
21,923 frames on 70 mm photofacsimile film separated in day and nighttime swaths

Tape: 242 reels of magnetic tape; contain one orbit of data per file
111 reels of magnetic tape; documents and instruments describing orbit

NIMBUS-7

Data Set: 11.5 micron THIR photofacsimile film

Film: 241 mm world montage
241 mm daily montage

Tape: calibrated located data tape of all THIR data collected and deemed of satisfactory quality

DATA ARCHIVES LOCATION: National Space Sciences Data Center, NASA/Goddard Space Flight Center

PERIOD OF OPERATION: Nimbus-4 - April 1970 to April 1971
Nimbus-5 - December 1972 to January 1973
Nimbus-6 - June 1975 to February 1977
Nimbus-7 - October 1978 to present.

REFERENCES

1. The NIMBUS-4, 5, 6, and 7 Users Guide, Goddard Space Flight Center, Greenbelt, Maryland.
2. National Space Science Data Center computer printout, 1980.

TEMPERATURE HUMIDITY INFRARED RADIOMETER (THIR)

SYSTEM CHARACTERISTICS

Weight: 20 lbs.

Volume: 0.5 cu.ft.

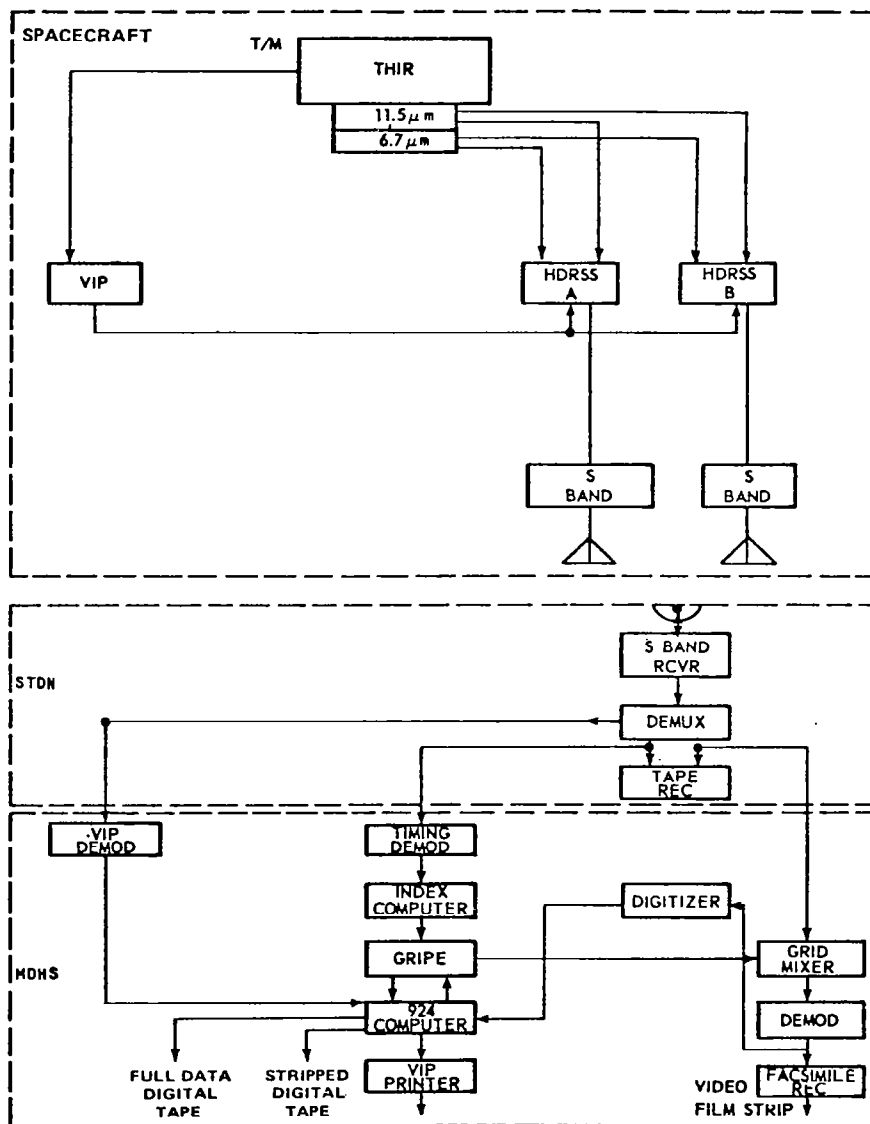
Avg. Power: 9 Watts

Components: interference filter radiometer, electronics, mirrors, telescope

Precision and Accuracy: $\pm 7K^\circ$

Data Recover: delayed and realtime

FUNCTIONAL DIAGRAM



Temperature Humidity Infrared Radiometer Block Diagram

TEMPERATURE HUMIDITY INFRARED RADIOMETER (THIR)

MEASUREMENTS

Measure IR radiation from the Earth's surface and clouds.

Measurement Range: 185 to 300°K

IFOV: 7 milliradians

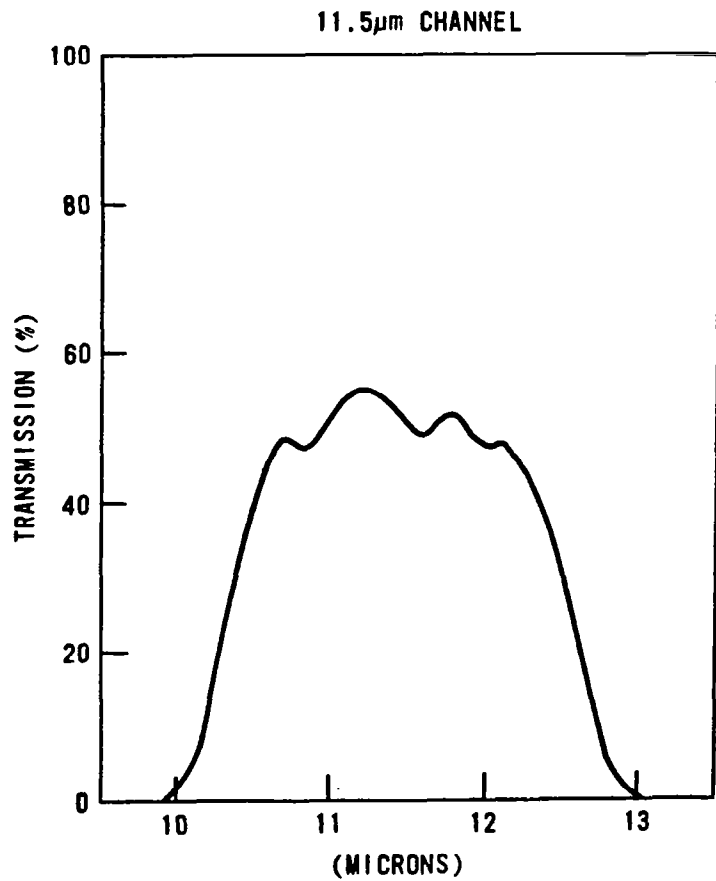
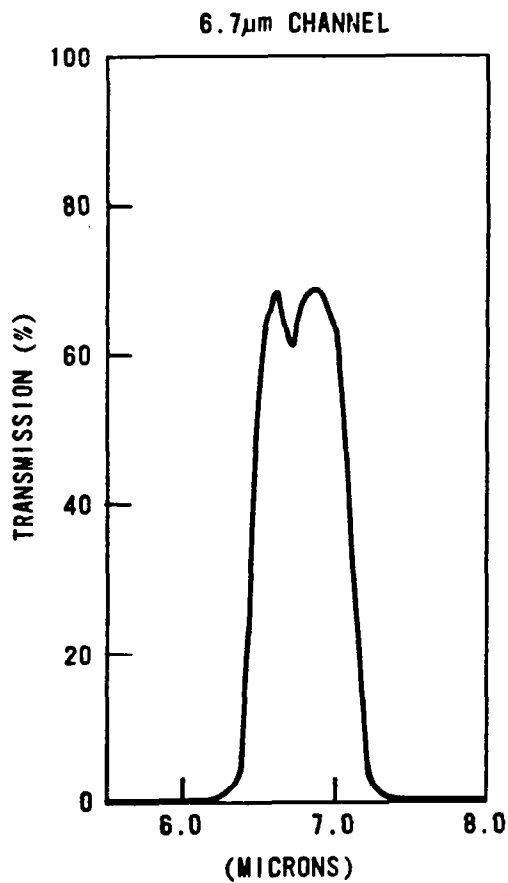
Resolution: 7.67 kilometers

Spectral Range: 6.5 to 12.5 microns

Channels: 2

1. 6.5-7 microns

2. 10.5-12.5 microns



Relative Spectral Response of the 6.7 microns and 11.5 microns Channels

POTENTIAL DERIVED PARAMETERS

1. Daytime and nighttime surface and cloud top temperatures.
2. Cloud mapping.
3. Atmospheric water vapor mapping.

THEMATIC MAPPER

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: H. Manheimer
LOCATION: NASA Headquarters

ACRONYM: TM
INSTRUMENT TYPE: Multispectral Scanner
SPACECRAFT: Landsat D
CONTRACTOR: Hughes Aircraft Co.
P.I.: Oscar Weinstein, GSFC

OBJECTIVES

1. Improve land use, water resources and food supply/distribution/management by imaging filtering and detecting reflected solar radiation from the surface of the Earth in several spectral bands simultaneously through the same optical system.

DESCRIPTION

SUMMARY: The Thematic Mapper (TM) is a seven-band, Earth-looking, scanning radiometer with a 30 m ground element resolution covering a 185 km ground swath from a 705 km altitude. The instrument consists of primary imaging optics, scanning mechanism, spectral band discrimination optics, detector arrays, radiative cooler, in-flight calibrator, and required operating and processing electronics. The scanning mechanism provides the cross-track scan while the progress of the spacecraft provides the scan along the track. The optical system images the Earth's surface on a field stop or a detector sized to define an area on the Earth's surface 30 M sq. Several lines are scanned simultaneously to permit suitable dwell time for each resolution element. The variation in radiant flux passing through the field stop onto the photo and thermal detectors creates an electrical output that represents the radiant history of the line. Seven spectral bands are used to provide the spectral signature capability of the instrument. The information outputs from the detector channels are processed in the TM multiplexer for transmission via the tracking and data relay satellites (TDRS) and/or direct readout to local receiving stations.

HERITAGE/DERIVATION: Landsat MSS

DATA

DATA PRODUCTS: Computer compatible tape; 9 1/2 by 9 1/2 latent film made from band sequential format tapes and are fully radiometrically and geometrically correct.

DATA ARCHIVES LOCATION: EROS Data Center (EDC), National Space Science Data Center.

PERIOD OF OPERATION: 1982 on

REFERENCES

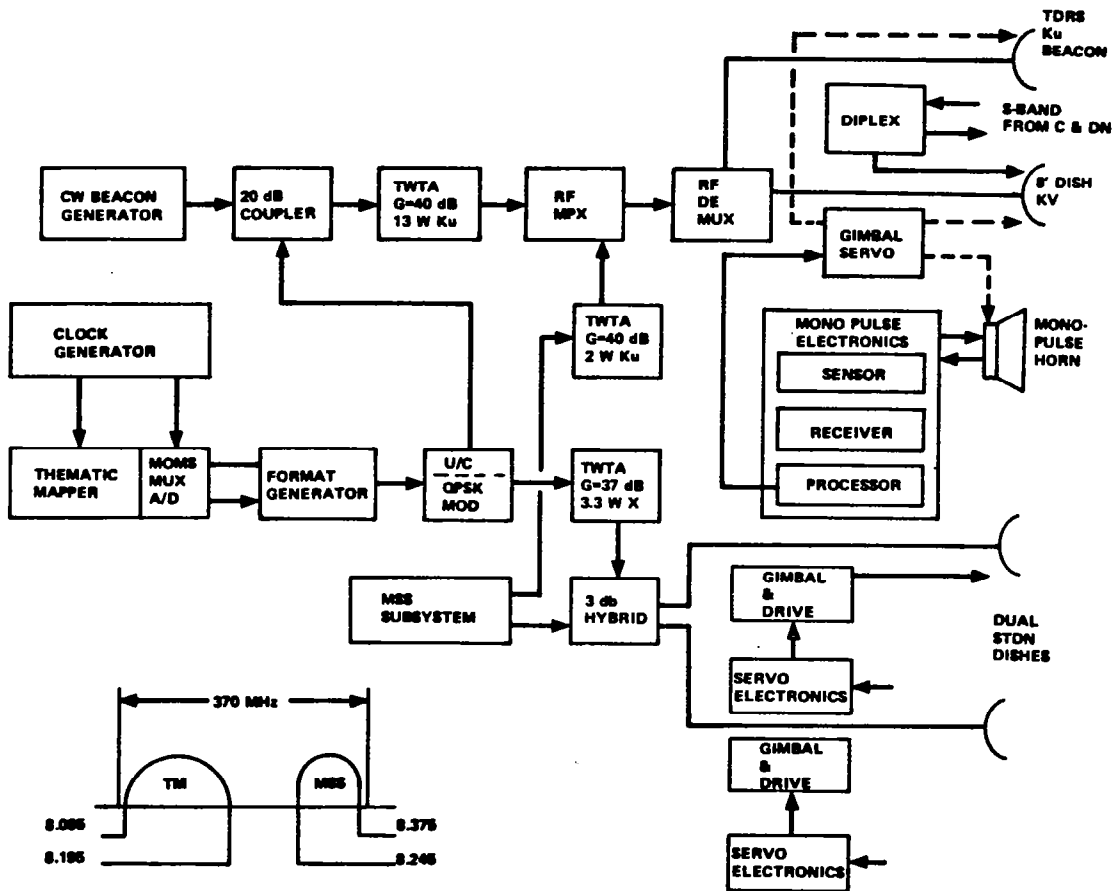
1. National Space Science Data Center computer printout, 1980.
2. Landsat D Project Plan, April 1978, Goddard Space Flight Center.

THEMATIC MAPPER (TM)

SYSTEM CHARACTERISTICS

Size: $1.1 \times 0.7 \times 2.0 = 1.54 \text{ m}$
 Mass: 239 kg
 Power Requirement: 320 W
 Data Rate: 85 mbps
 Quantization Levels: 256
 Interband Registration: 0.1 IFOV
 Long Term Scan Stability: 0.5 IFOV

FUNCTIONAL DIAGRAM



Thematic Mapper Block Diagram

THEMATIC MAPPER (TM)

MEASUREMENTS

Number of Bands: 7

Spectral Bands:	1	0.45 - 0.52 micron
	2	0.52 - 0.60 micron
	3	0.63 - 0.69 micron
	4	0.76 - 0.90 micron
	5	1.55 - 1.75 microns
	6	10.40 - 12.50 microns
	7	2.08 - 2.35 microns

Ground Resolution: 30 m (bands 1-5 and 7)
120 m (band 6)

Swath Width: 185 km

POTENTIAL DERIVED PARAMETERS

1. The measurement of crop acreages and the associated errors with differing field sizes.
2. Mapping of flood plains, flooded areas, and inland wet lands.
3. Mapping of geomorphic features and structural, geologic features.
4. Mapping of landuse categories in urban and suburban areas.
5. Shoreline changes.
6. Attainment of national map accuracy standards at various scales.
7. Delineating areas of crop stress including moisture, salinity, disease, insect damage and nutrient deficiency stress.
8. Eliminating confusion in land use categories i.e. urban and non-urban categories.
9. Objectively discriminating between cloud covered and snow covered areas.
10. Defining intrusives of different iron-mineral content from surrounding rock and hydrothermally altered rocks from unaltered rocks.

**13-BAND MULTISPECTRAL SCANNERS:
EARTH RESOURCES EXPERIMENT PACKAGE (EREP)**

IDENTIFICATION

DISCIPLINE: Resource Observation
STATUS: Flight Missions
NASA TECH. OFFICER: T. L. Fischetti
LOCATION: NASA Headquarters

ACRONYM: TBMS
INSTRUMENT TYPE: Conical Scanning Rdmtr.
SPACECRAFT: Skylab-1
CONTRACTOR: Honeywell Radiation Center
P.I.: C. L. Korb

OBJECTIVES

1. To gather high resolution line scan imagery of selected Earth resources ground calibration sites in simultaneous spectral bands comparable to ERTS data.
2. Feasibility evaluation of spectrum matching data processing techniques for identification of Earth resources features.

DESCRIPTION

SUMMARY: The instrument consists of an optical-mechanical scanner, a spectral dispersion system, a group of three in-flight calibration sources, and an array of detectors. The output of the detectors is amplified, digitized, reformatted and recorded on tape. A folded 12-inch reflecting telescope is the collector. The use of this large collector will provide the necessary diffraction-limited resolution for the thermal IR channel (10.1-12.5 microns) as well as providing the necessary energy throughout to achieve moderate s/n ratios in a high resolution system. The radiant energy collected by the scan mirror is constrained to pass through two nearly adjacent entrance slits which are sized for equivalent angular field-of-views. The slits act as both the field stop of the telescope and the entrance slit for the prism spectrometer. Since the radiant energy passes through the field stops prior to spectral separation, each detector on a given scan line observes the same spatial element on the ground, but in a different spectral region. The thirteen spectral bands are 0.41-0.46, 0.46-0.52, 0.52-0.556 and 0.565-0.609, 0.62-0.67, 0.68-0.762, 0.783-0.88, 0.98-1.08, 1.09-1.9, 1.20-1.30, 1.55-1.75, 2.10-2.35 and 10.2-12.5 microns.

DATA

DATA PRODUCTS: Tape

DATA ARCHIVES LOCATION: EROS Data Center, Sioux Falls, S.D.

REFERENCES

1. Experiment Implementation Plan for Manned Space Flight Experiments, Title: Ten-Band Multispectral Scanner No. S-192. Skylab A, EREP User's Handbook, NASA MSC, February 1971.
2. National Space Science Data Center computer printout, 1980.
3. Skylab Experiments, August 1972, NASA.
4. Skylab A EREP User's Handbook, March 1971.

**13-BAND MULTISPECTRAL SCANNERS:
EARTH RESOURCES EXPERIMENT PACKAGE (EREP) (TBMS)**

SYSTEM CHARACTERISTICS

Weight: 300 lbs.

Volume: 19.3 cu. ft.

Avg. Power: 180 Watts

Peak Power: 266 Watts

Components: optical-mechanical scanner, prism spectrometer, dichroic filter

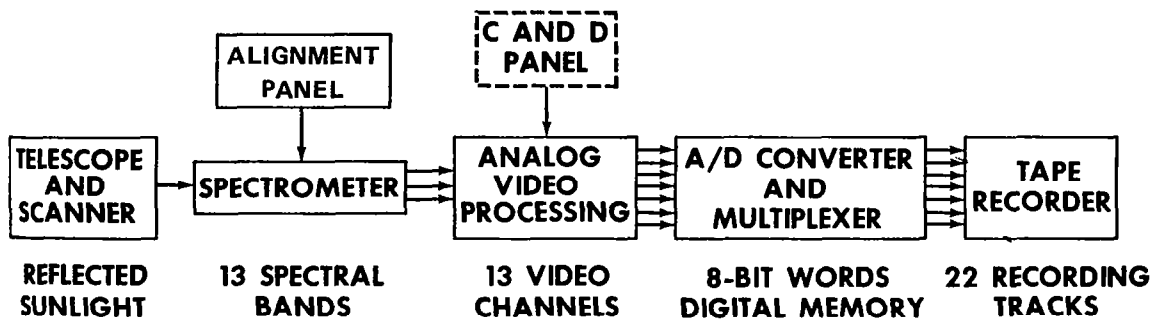
Freq. of Observations: flexible

Data Recovery: manual tape return

Precision & Accuracy: about 1% in visible and reflective IR, 0.4°K in thermal IR

Standby Power: 90 Watts

FUNCTIONAL DIAGRAM



Multispectral Scanner Block Diagram

MEASUREMENTS

Measures reflected and thermal radiation from the Earth's surface.

Swath Width: 39.1 nautical miles

Spectral Ranges: 0.41 to 12.5 microns

Field-of-View: 260 ft.

Number of Bands: 13

- | | |
|------------------------|-----------------------|
| 1. 0.41-0.46 microns | 8. 0.980-1.08 microns |
| 2. 0.46-0.51 microns | 9. 1.09-1.19 microns |
| 3. 0.52-0.556 microns | 10. 1.20-1.30 microns |
| 4. 0.565-0.609 microns | 11. 1.55-1.75 microns |
| 5. 0.620-0.670 microns | 12. 2.10-2.35 microns |
| 6. 0.680-0.762 microns | 13. 10.2-12.5 microns |
| 7. 0.783-0.880 microns | |

**13-BAND MULTISPECTRAL SCANNERS:
EARTH RESOURCES EXPERIMENT PACKAGE (ERP) (TBMS)**

POTENTIAL DERIVED PARAMETERS

1. Vegetation mapping
2. Surface soil mapping
3. Geologic surface mapping
4. Crop identification
5. Forest/rangeland mapping.

TIROS OPERATIONAL VERTICAL SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: R. Ratuff, E. Mundy,
F. Cunningham
LOCATION: NASA/Goddard Space Flight Center

ACRONYM: TOVS
INSTRUMENT TYPE: Spectroradiometer
SPACECRAFT: NOAA-6, B-G; TIROS-N
CONTRACTOR: JPL, Marconi, ITT
P.I.: A. McCulloch, GSFC

OBJECTIVES

1. To obtain atmospheric temperature and humidity soundings, surface temperature measurements, and cloud detection and measurements.

DESCRIPTION

SUMMARY: The TIROS Operational Vertical Sounder consisted of three instruments designed to determine radiances needed to calculate temperature and humidity profiles of the atmosphere from the surface to the stratosphere (approximately 1 mb). The first instrument, the Basic Sounding Unit (BSU), has 20 channels and made measurements in the following spectral intervals: Channel 1 - the 3.7-micrometer window region, Channel 2 - the 4.3-micrometer CO₂, Channel 3 - the 9.7-micrometer ozone band, Channel 4 - the 11.1-micrometer window region, Channels 5 through 11 - the 15-micrometer CO₂ band (13.3, 13.6, 14.0, 14.3, 14.5, 14.75, and 15.0), and Channels 12 through 14 - the 18-micrometer rotational water vapor bands (18.8, 23.15, and 29.4). The second instrument, the Stratospheric Sounding Unit, had three channels operating at 14.97 micrometers using selective absorption by passing the incoming radiation through three pressure modulated cells containing CO₂. The third instrument, the Microwave Sounding Unit, has four channels operating in the 50 to 60 GHz oxygen band (50.3, 53.7, 55.0, and 57.9) to obtain temperature profiles which were free of cloud interference. The instruments were cross-course scanning devices utilizing a step to provide a traverse scan while the orbital motion of the satellite provided scanning in the orthogonal direction.

HERITAGE/DERIVATION: HIRS: NIMBUS-V ITPR, NIMBUS-VI HIRS
MSU: NIMBUS-V Microwave Spectrometer, NIMBUS-6 - SCAMS
SSU: NIMBUS-V Selective Chopper Radiometer, NIMBUS-6 Pressure Modulator Radiometer

DATA

DATA PRODUCTS: Global Coverage of TOVS data available. Index and lists of data from NOAA-6 and TIROS-N are published by the NOAA Satellite Data Services Division.

DATA ARCHIVES LOCATION: Satellite Data Services Division, NOAA

PERIOD OF OPERATION: October 1978 to present.

REFERENCES

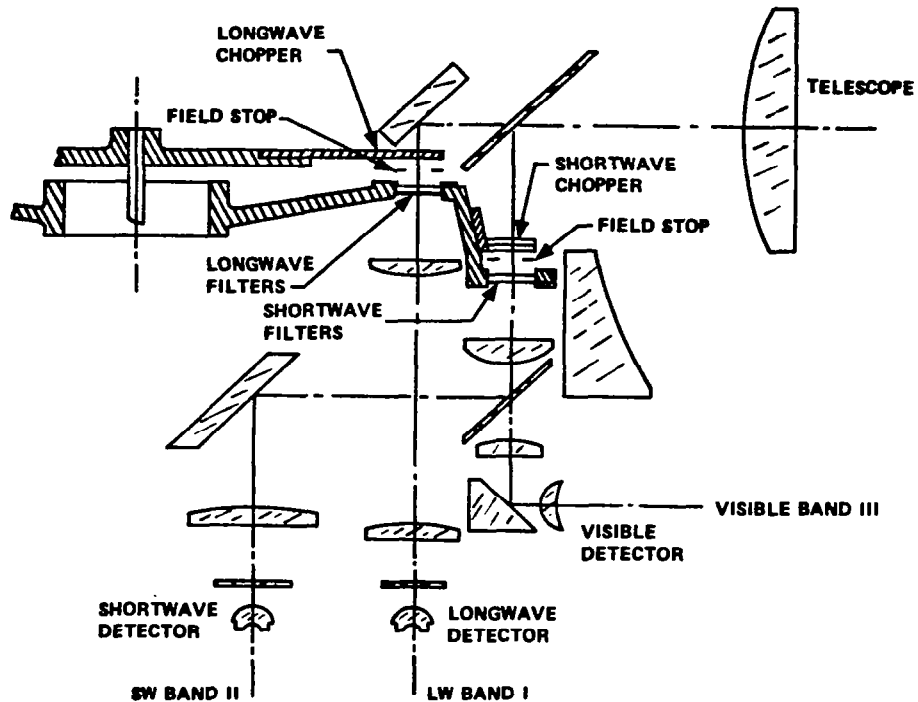
1. National Space Sciences Data Center computer printout, 1980.
2. Remote Sensor Handbook, Marshall Space Flight Center, 1977.
3. Satellite Data Users Bulletin, Volumes 1 and 2, August 1979.

TIROS OPERATIONAL VERTICAL SOUNDER (TOVS)

SYSTEM CHARACTERISTICS

- HIRS: Samples 20 channels
Calibration every 90 seconds
Two detectors cooled (IR)
One detector uncooled (visible)
Cassegrainian telescope
- MSU: 4 Dicke radiometers
Noise temperature 0.3°K
Calibration - two measurements per scan
- SSU: 3 pyroelectric detectors uncooled at 290°K

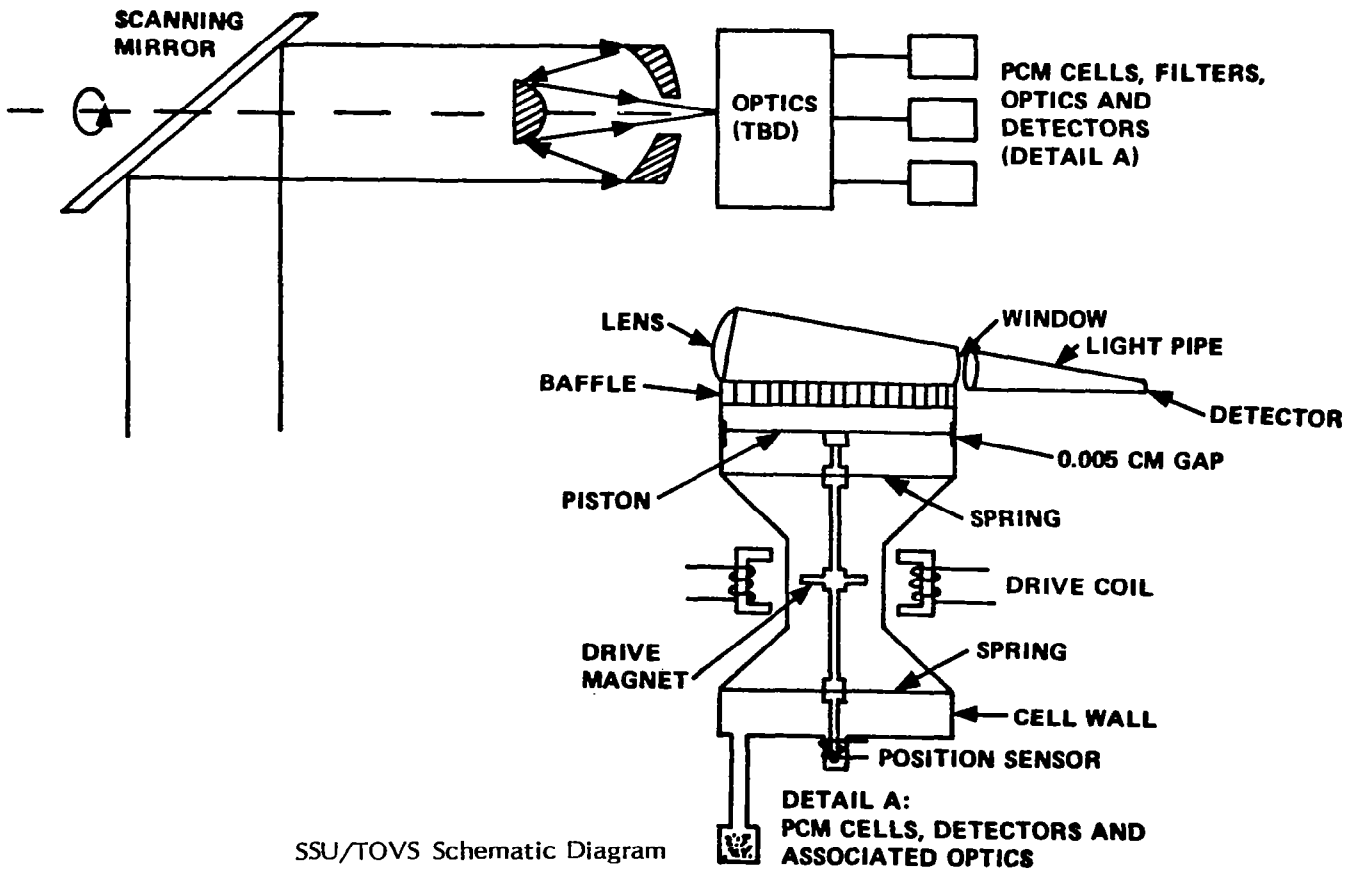
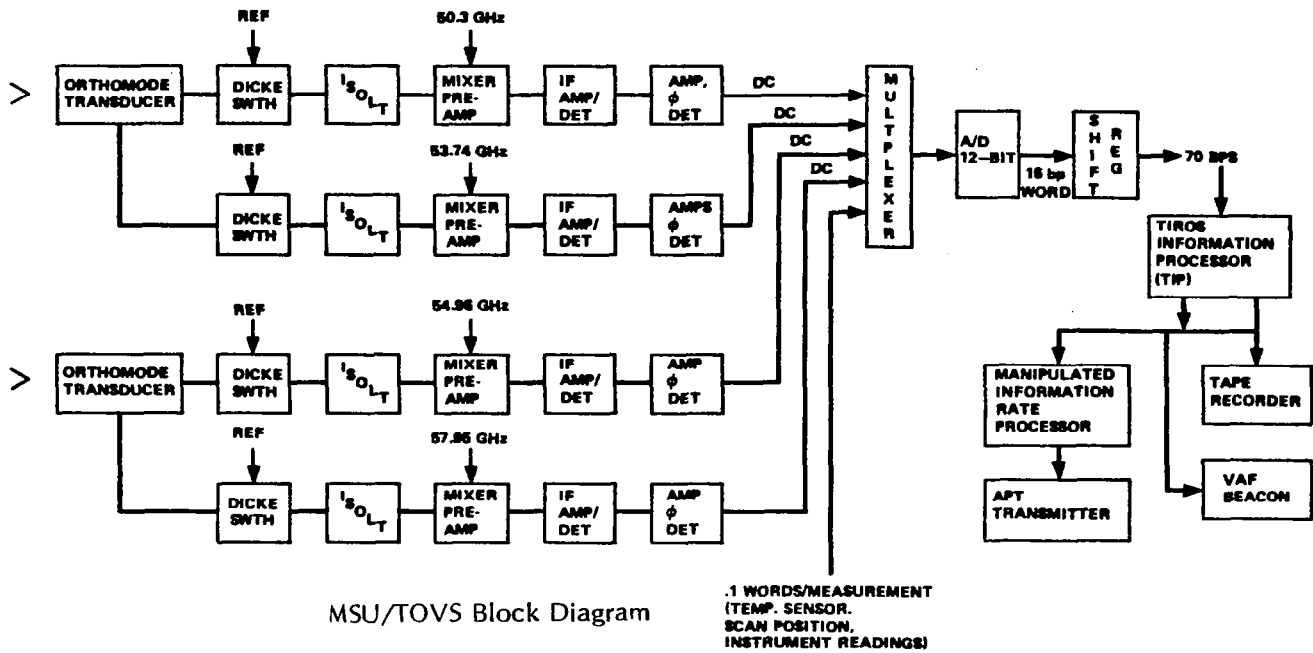
FUNCTIONAL DIAGRAMS



HIRS/TOVS Schematic Diagram

TIROS OPERATIONAL VERTICAL SOUNDER (TOVS)

FUNCTIONAL DIAGRAMS (cont.)



TIROS OPERATIONAL VERTICAL SOUNDER (TOVS)

MEASUREMENTS

Spectral ranges: HIRS/2: 14 channels - 0.69-29.4 microns

- | | |
|-----------------|-------------------|
| 1. 3.7 microns | 8. 14.3 microns |
| 2. 4.3 microns | 9. 14.5 microns |
| 3. 9.7 microns | 10. 14.75 microns |
| 4. 11.1 microns | 11. 15.0 microns |
| 5. 13.3 microns | 12. 18.8 microns |
| 6. 13.6 microns | 13. 23.15 microns |
| 7. 14.0 microns | 14. 29.4 microns |

SSU: 3 channels - 14.97 microns

MSU: 4 channels - 50.3, 53.7, 54.9, 57.9 microns

Measurements:

HIRS: Makes radiance measurements from surface to 40 km. The IFOV is 1.24° (25 km at subpoint, 31.3 km at scan end).

SSU: Makes radiance measurements in the 25 km to 5 km altitude range with an IFOV of 244 km x 186 km.

MSU: Makes radiance measurements from 0-20 km through clouds. The IFOV is 110 km.

POTENTIAL DERIVED PARAMETERS

HIRS: Vertical Temperature Profile
Water Vapor Profiles from Surface to 10 km
Liquid Water Content of Clouds
Pressure Altitudes and Amount of Clouds Albedo

MSU: Atmospheric Temperature Profiles

SSU: Temperature Profiles

2-CHANNEL MICROWAVE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Development
NASA TECH. OFFICER: W. Townsend
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Radiometer
SPACECRAFT: TOPEX
CONTRACTOR: Jet Propulsion Laboratory
P.I.: To be assigned

OBJECTIVES

1. To measure the water vapor content in the satellite-to-nadir point column to permit removal of atmospheric effects on propagation of radar altimeter signal for TOPEX mission.
2. To measure atmospheric and surface emissivities.

DESCRIPTION

SUMMARY: The 2-channel radiometer planned for the TOPEX mission will be designed to operate at the baseline frequencies of 20.3 GHz and 31.4 GHz. The microwave radiometer will measure the water vapor path correction to an accuracy consistent with TOPEX measurement uncertainty allocation. The radiometer footprint will be no larger than 50 km (half power) in diameter and contain the associated altimeter footprint. The radiometer will use a nadir-looking 50 cm offset parabolic antenna with a dual focal point feed. The telemetered data for each frequency will include temperature measurements and signals proportional to the received microwave power.

HERITAGE/DERIVATION: Nimbus-5 Radiometer

REFERENCES

1. W. Townsend, NASA Headquarters, EBC-8
2. C. Yamarone, Jet Propulsion Laboratory, 264-470.

SYSTEM CHARACTERISTICS

Mass: 14 kg (11 electronics; 3 antenna)
Volume: 0.028 cubic meter
Antenna diameter: 50 cm
Power: 20 Watts
Data rate: 100 bps

2-CHANNEL MICROWAVE RADIOMETER

MEASUREMENTS

Measure horizontal and vertical components of microwave radiation.

Channels: 2

Frequency: 1. 20.3 GHz

2. 31.4 GHz

Footprint: 50 km

Design goal: 0.7 cm (1 sigma) in wet tropospheric path length correction.

POTENTIAL DERIVED PARAMETERS

1. Precipitation
2. Water vapor
3. Brightness temperature of snow.

ULTRAVIOLET OZONE SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Flight Missions

NASA TECH. OFFICER: R.J. McNeal

LOCATION: NASA Headquarters

ACRONYM: UOS

INSTRUMENT TYPE: Spectrometer

SPACECRAFT: UARS, SME

CONTRACTOR: University of Colorado

P.I.: George H. Mount

OBJECTIVES

1. To measure the ozone density from 40-90 km in the Earth's atmosphere by observing the attenuation of Rayleigh scatter sunlight in the near ultraviolet 2400-3400Å.
2. To determine the nitric oxide density 80-250 km in the Earth's atmosphere by observing the sunlight fluorescently scattered in the NO gamma bands 2100-2400Å.

DESCRIPTION

SUMMARY: The UOS uses a limb scanning technique to obtain altitude information on optically observed phenomenon. The flight instrument will employ a 250 mm focal length off-axis parabolic telescope and a dual channel 1/8-meter Ebert-Fastie spectrograph employing two photomultiplier tubes operating in the spectral range 2100-3100Å and 2400-3400Å at 20Å resolution. The instrument will be mounted onto a scan platform allowing scanning of the Earth's limb in 3 km height increments in a time period of 12 seconds. The projected slit width will be 3 x 3.5 km. Instrument gate time will be 2.5 msec.

HERITAGE/DERIVATION: OGO-6, Atmospheric Explorer C&D.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center, Jet Propulsion Laboratory

REFERENCES

1. UARS Proposal, An Ultraviolet Ozone Spectrometer for the Ultraviolet Upper Atmosphere Research Satellite, University of Colorado, December 1978.
2. Project Plan for Solar Mesosphere Explorer 1981 Mission, Jet Propulsion Laboratory 629-1, September 1978.

ULTRAVIOLET OZONE SPECTROMETER (UOS)

SYSTEM CHARACTERISTICS

Spectrometer

Mounting:	Ebert-Fastie, 125 mm focal length
Diffraction grating:	
Blank material:	Fused silica
Coating:	Aluminum
Angle of incidence:	13.5° to 26.5°
Ruling frequency:	3600 g/mm
Radius of curvature:	Plane
Blaze angle:	22° (2400Å)
Ruled area:	2.5 cm x 1.5 cm
Area of entrance aperture:	275 x 2.75 mm
Wavelength bandpass:	20Å (at exit slit)
Wavelength dispersion (2400Å)	18Å/mm
Grating angle (normal):	23° to 34°

Detectors

Two EMR 510-F photomultiplier tubes with quartz windows.

Weight

Telescope-spectrometer system: 3.5 kg

Size

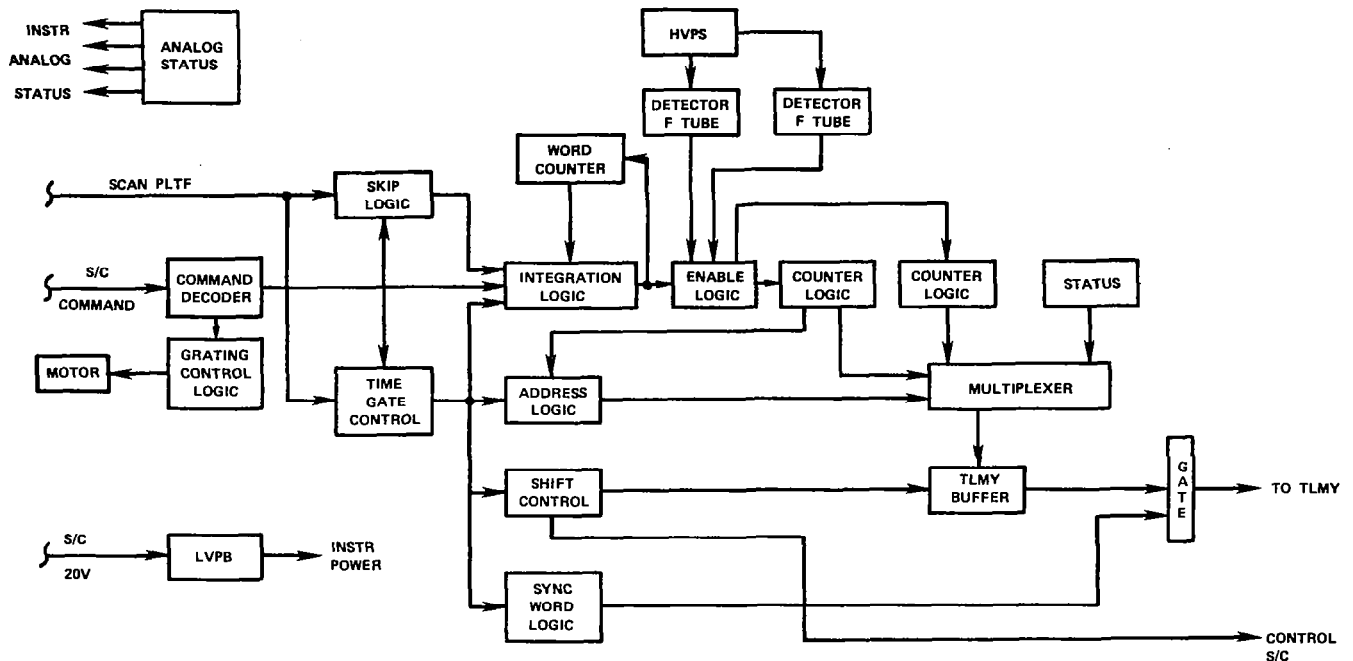
Length:	38.1 cm
Width: (short end)	14.0 cm
(long end)	21.5 cm
Thickness:	11.5 cm

Power Requirements

Approximately 2.0 Watts, data channels - two.
Housekeeping channels - four.

ULTRAVIOLET OZONE SPECTROMETER (UOS)

FUNCTIONAL DIAGRAM



Ultraviolet Ozone Spectrometer Block Diagram

MEASUREMENTS

Measure radiances of reflected and scattered sunlight.

Channels: 2

Resolution: 20\AA

Spectral range: $2100\text{-}3100\text{\AA}$
 $2400\text{-}3400\text{\AA}$

POTENTIAL DERIVED PARAMETERS

1. Ozone concentration
2. Nitric oxide density
3. Altitude profiles
4. Energy budget.

ULTRAVIOLET SOLAR SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: R.J. McNeal
LOCATION: NASA Headquarters

ACRONYM: USS
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: UARS
CONTRACTOR: University of Colorado
P.I.: G.J. Rottman, University of Colorado

OBJECTIVES

1. To measure the solar spectrum at wavelengths between 120 and 500 nanometers with an absolute accuracy better than 10%.
2. To measure day to day variations in solar irradiance on the order of 1% over periods of the solar rotation.
3. To measure short term variations in solar irradiance associated with solar flares.

DESCRIPTION

SUMMARY: The Ultraviolet Solar Spectrometer is a small 1/8 meter Ebert-Fastie spectrometer which measures solar ultraviolet irradiance in the spectral region 120 to 500 nanometers with 0.15 nanometers spectral resolution. The instrument has three separate data channels, each using a phototube optimized for different, but overlapping, portions of the instrument spectral range.

Solar data will be taken on a daily basis and will be analyzed to establish correlations of the spectral irradiance with solar rotation and with solar activity (10.7 cm flux levels, sunspot number, calcium plage, solar flares, etc.). The normal mode operation will involve a four hour duty cycle per day. Of this total time, one hour will be spent observing the Sun, and the remainder of the time will be spent in calibration activities.

The data rate will be 48 bits per second (8 bps orbit average) and the power consumption less than 7 watts. The instrument will be small (<43.3 kg) and must be mounted to a solar/stellar pointed platform capable of pointing the spectrometer at the Sun and stellar targets.

HERITAGE/DERIVATION: Modification of the spectrometer aboard the Pioneer Venus orbiter.

DATA

DATA ARCHIVES LOCATION: National Space Science Data Center
PERIOD OF OPERATION: Launch date in Fall 1986.

REFERENCES

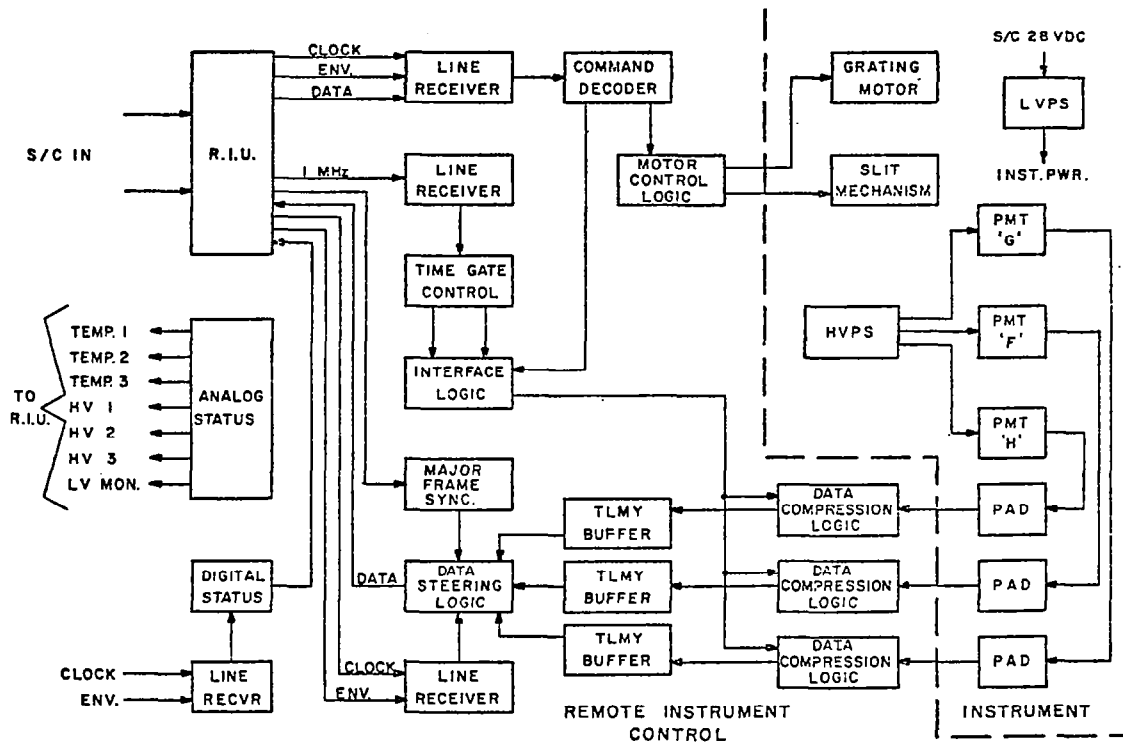
1. UARS Proposal, An Ultraviolet Solar Spectral Irradiance Experiment for the Upper Atmosphere Research Satellite Program, University of Colorado, December 1978.

ULTRAVIOLET SOLAR SPECTROMETER

SYSTEM CHARACTERISTICS

Weight: 4.3 kg
Size: .28m x .15m x .11m
Power: 7 Watts
Data rate: 48 b/s

FUNCTIONAL DIAGRAM



Ultraviolet Solar Spectrometer Block Diagram

MEASUREMENTS

Measures solar ultraviolet irradiance.

Channels: 3

Spectral region: 120 to 500 nanometers

Spectral intervals:

1. 120-200 nanometers
2. 200-300 nanometers
3. 300-500 nanometers

Resolution: 0.15 nm

Absolute accuracy of irradiance measurements: 10% or better.

ULTRAVIOLET SOLAR SPECTROMETER

POTENTIAL DERIVED PARAMETERS

1. The average absolute value of the distribution of solar irradiance in the spectral interval 120 to 500 nm for "quiet" and "active" solar conditions.
2. The range of variation of ultraviolet solar irradiance (200-500 nm) from day to day over solar rotation periods and through different phases of the solar cycle.
3. The short period variations of solar irradiance (120-500 nm) associated with impulsive solar activity. These data will be determined on demand where feasible.

ULTRAVIOLET STRATOSPHERIC IMAGING SPECTROMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations

STATUS: Future Flight Missions

NASA TECH. OFFICER: R. J. McNeal

LOCATION: NASA Headquarters

ACRONYM: USIS

INSTRUMENT TYPE: Imaging Spectrometer
Observatory

SPACECRAFT: UARS

CONTRACTOR: University of Michigan,
Utah State University

P.I.: D. G. Torr, University of Michigan

OBJECTIVES

1. To measure the atmospheric constituents O₃, OH, ClO, NO, NO₂.
2. To explore the possibility of detecting several other trace constituents where cross sections are not well known.

DESCRIPTION

SUMMARY: The Ultraviolet Stratospheric Imaging Spectrometer is a high resolution (0.04Å) instrument covering a broad wavelength range (2000Å to 4600Å). An area array detector system permits simultaneous imaging of spectral information in one dimension and spatial information (the stratosphere and mesosphere can be simultaneously measured at 5 km altitude resolution) in another. The instrument is based on an imaging spectrometer that has been built for flight on Spacelab, using an optical design upgraded in order to achieve the higher resolution, and the detector system already developed for the Spacelab instrument. As such it incorporates only existing designs. The high wavelength resolution is achieved by using an echelle grating, together with a cross-disperser grating to separate orders on the detector. The desired resolution and complete order separation is achieved using existing gratings. The instrument is relatively large in size, but composite materials are used in its construction, thus minimizing the weight. Onboard data compression is achieved using a microprocessor system in order to obtain the advantages of imaging without requiring unfeasible data rates.

HERITAGE/DERIVATION: Imaging Spectrometer Observatory (ISO) on Spacelab 1.

DATA

DATA PRODUCTS: Data reduced to usable spectra tagged with time, position pointing vectors, and other necessary information.

DATA ARCHIVES LOCATION: National Space Science Data Center

PERIOD OF OPERATION: Launch date in Fall 1986.

REFERENCES

1. UARS Proposal, Ultraviolet Imaging Spectrometer for UARS, the University of Michigan, November, 1978.

ULTRAVIOLET STRATOSPHERIC IMAGING SPECTROMETER

SYSTEM CHARACTERISTICS

Weight: 60 kgms
Power: 30 watts
Data rate: 1.7 kbps

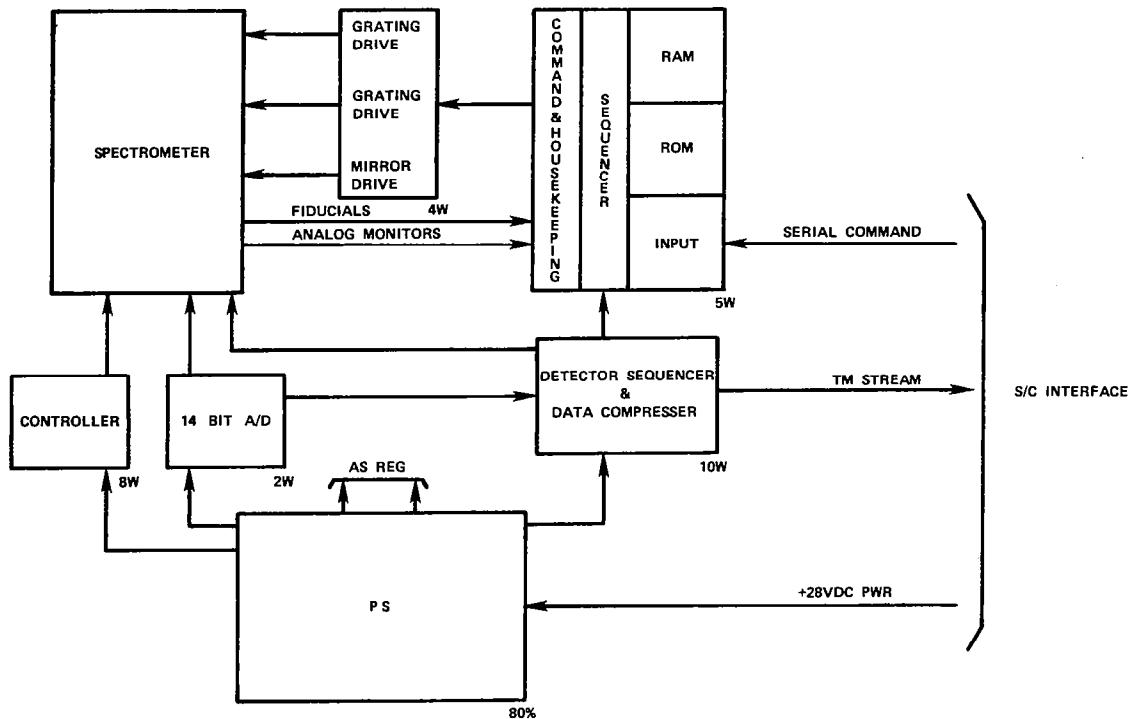
Cooling requirements: 8 watts from detector thermoelectric cooler to be dissipated to cold sink or space.

Pointing requirement: Mode A - entrance slit perpendicular to limb, centered at 40 km, pointing stability 0.1°;
Mode B - nadir viewing; position knowledge accuracy 0.1°.

Volumetric envelope: 1.60 m x 0.84 m x 0.30 m.

Thermal requirements: heat sink for 8 watts.

FUNCTIONAL DIAGRAM



Ultraviolet Stratospheric Imaging Spectrometer Block Diagram

ULTRAVIOLET STRATOSPHERIC IMAGING SPECTROMETER (USIS)

MEASUREMENTS

Measure concentrations of trace constituents in stratosphere and mesosphere.

Spectral range: 2000Å - 4600Å

Wavelength resolution: 0.04Å

Field of view: 1° x .008°

Sensitivity: 0.25 counts R⁻¹ sec⁻¹

Spatial resolution: altitude 5 km, latitude 3°

Temporal resolution: 40 sec

POTENTIAL DERIVED PARAMETERS

Concentrations of:

O₃
OH
ClO
NO
NO₂

High resolution atlas of absorption and emission features in the UV.

VECTOR MAGNETOMETER

IDENTIFICATION

DISCIPLINE: Resource Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. Murphy
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Magnetometer
SPACECRAFT: MAGSAT
CONTRACTOR: Goddard Space Flight Center
P.I.: Dr. M. Acuna

OBJECTIVES

1. To determine the directional characteristics of anomaly regions and to resolve ambiguities in their interpretation.

DESCRIPTION

SUMMARY: The Vector Magnetometer aboard the Magsat spacecraft consisted of an alkali-vapor scalar magnetometer and a precision vector magnetometer. In addition, information concerning the absolute orientation of the spacecraft in inertial space was provided by two star cameras, a precision sun sensor, and a system to determine the orientation of the sensor platform, located at the tip of a 6 m boom, with respect to a reference coordinate system on the spacecraft. The MAGSAT precision vector magnetometer was a state-of-the-art instrument that covered the range of $\pm 64,000$ nanoteslas (nT) using a ± 2000 nT basic magnetometer and digitally controlled current sources to increase its dynamic range. Ultraprecision components and extremely efficient designs minimized power consumption. The precision vector magnetometer measured the projections of the ambient field in three orthogonal directions with an absolute accuracy determined by calibrations with respect to a standard; thus they were subject to error and drift. Accuracy goals for the mission required a vector magnetometer capable of measuring the ambient field with a maximum error of ± 1 part in 64,000 in magnitude and 5 arc-s in orientation ($1 \text{ arc-s} = 0.00028^\circ$).

HERITAGE/DERIVATION: OGO pumping magnetometer

DATA

DATA PRODUCTS: Magnetic field data on tapes; Latitude plots on microfilm;
Polar plots on microfilm.

DATA ARCHIVES LOCATION: National Space Sciences Data Center, GSFC

PERIOD OF OPERATION: October 30, 1979 - June 11, 1980

REFERENCES

1. MAGSAT Program Summary, NASA/Goddard Space Flight Center

VECTOR MAGNETOMETER

SYSTEM CHARACTERISTICS

Basic Magnetometer:

Noise: 0.008 nT rms (8 Hz bandwidth)

Zero level stability:

Sensor (-60 to + 60°C): ± 0.2 nT

Electronics (-20 to + 50°C): ± 0.2 nT

Drive frequency: 12.5 kHz

Linearity error (compensated): less than 1 part in 10^5

Angular stability better than ± 3 arc-s over a temperature range of 10 to 40°C

Offset Digitally Controlled Current Sources

Dynamic range: $\pm 64,000$ nT

Quantization step: 1000 nT

Temperature coefficient: less than 0.5 ppm/°C

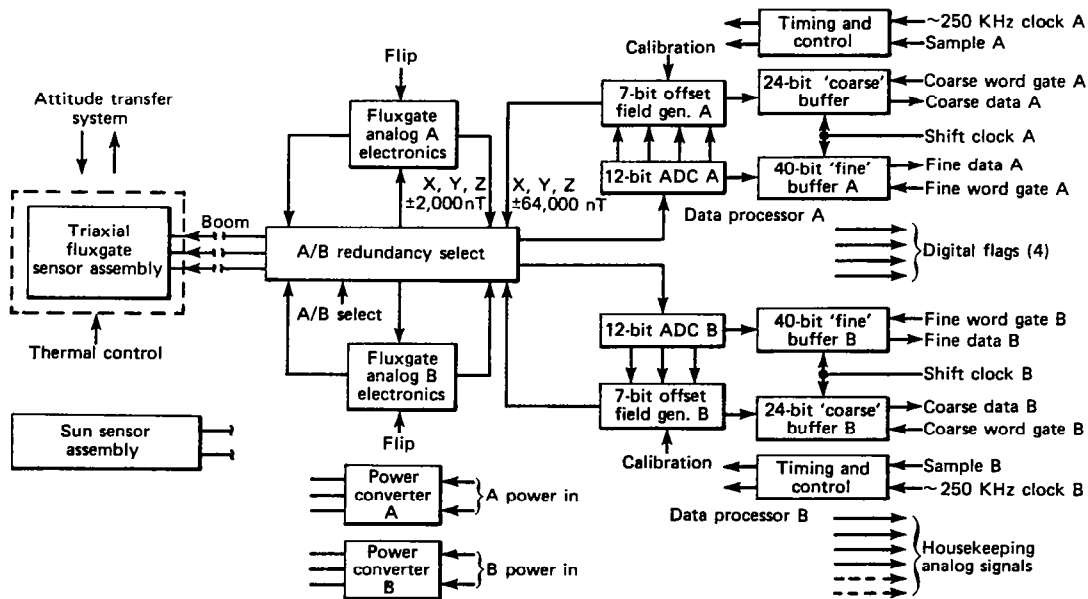
Long-term stability: within 2 parts in 10^5 per year

Sensor Assembly

Mass: 0.6 kg

Dimensions: 11.4 x 5.72 x 5.8 cm

FUNCTIONAL DIAGRAM



Vector Magnetometer Block Diagram

VECTOR MAGNETOMETER

MEASUREMENTS

Measured the projections of the ambient field in three orthogonal directions with an absolute accuracy determined by calibrations with respect to a standard.

Accuracy: measure the ambient field with a maximum error of ± 1 part in 64,000 in magnitude and 5 arc-s in orientation.

Basic magnetometer dynamic range: ± 2000 nT

Resolution: 12 bit A/D converter (± 0.5 nT)

POTENTIAL DERIVED PARAMETERS

1. Accurate global representation of secular variation
2. Geomagnetic field parameters
3. Tectonic processes of inner Earth
4. Crustal models.

VERTICAL TEMPERATURE PROFILE RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: G. Cunningham
LOCATION: Goddard Space Flight Center

ACRONYM: VTPR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NOAA-2-5
CONTRACTOR: Barnes Engineering
P.I.: NOAA/NESS Staff

OBJECTIVES

1. To obtain temperature and water vapor measurements at 15 altitude levels of the atmosphere (up to 30 km).

DESCRIPTION

SUMMARY: The VTPR measures spectral radiation in 8 bands: 12 microns, 13.8 microns, 13.4 microns, 14.1 microns, 14.8 microns, 14.4 microns, 14.97 microns, 18.7 microns, 62.5 ms are required for each band measurement, allowing one set of 8 measurements each 1/2 second. (Following the 8th band measurement, the scanner steps to the next scan cell.) The single pyroelectric detector (triglycene sulphate) has a Noise Equivalent Power of less than $1.5 \times 10^{-10} \text{W(Hz)}^{-1/2}$ and operates at a temperature of 290° K (uncooled). Its effective area is 1.5 mm. The detector is modulated at 16 Hz Space (40° K) and internal black (258° K) body calibration is performed each 15 sec. One complete measurement (8 bands) is completed each 1/2 second. The scanner is stepped after each measurement by 2.23°, sec. plus one sec. for return. Ground resolution is 59 km at the satellite subpoint. Ground coverage for each scan is approximately 1400 km. As each area was scanned, the optical system collected, filtered, and detected the radiation from the Earth into the eight spectral intervals. The field-of-view contributing to one profile was approximately 50 km square at the ground. The radiometer operated continuously, taking measurements over every part of the Earth's surface twice a day. The data were recorded throughout the orbit and played back on command when the satellite was within communication range of a command and acquisition station. Ground personnel used the data to compute temperature-pressure profiles to altitudes as high as 30 km. Identical experiments will be flown on ITOS-E, -F, and -G.

HERITAGE/DERIVATION:

NOAA-2	10-15-72	(ITOS-D)
NOAA-3	11-06-73	(ITOS-F)
NOAA-4	11-15-74	(ITOS-G)
NIMBUS-5	(NEMS)	
NIMBUS-6	(Adv. Atmos. Sounder)	

DATA

DATA PRODUCTS:

Magnetic tape of temperature and water vapor profiles.
Tapes consist of sounding (Tape 1 is 0600-1800 GMT and Tape 2 is 1800-0600 GMT)
Tape consists of: (a) Raw Radiance, (b) Clear Radiances, (c) Profiles

DATA ARCHIVES LOCATION: NOAA/NESS, Suitland, Maryland.

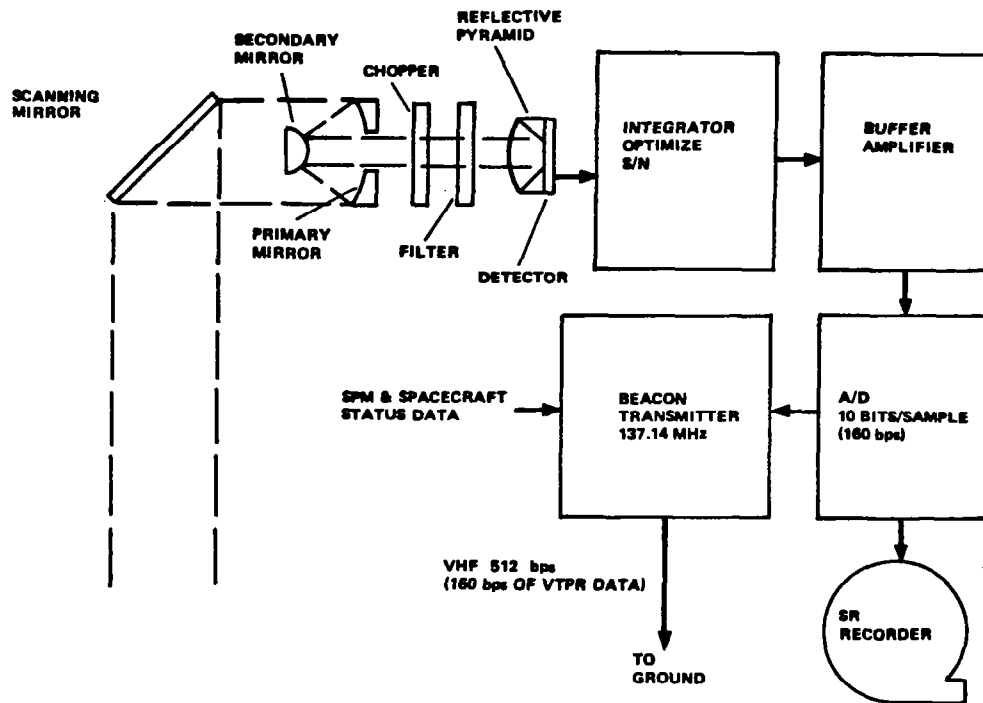
PERIOD OF OPERATION: NOAA-2: October 1972 to January 1975
NOAA-3: November 1973 to August 1976
NOAA-4: November 1974 to November 1978

VERTICAL TEMPERATURE PROFILE RADIOMETER (VTPR)

REFERENCES

1. National Space Science Data Center.
2. Satellite Data User's Bulletin, Vol. 1, #2, August 1979.

FUNCTIONAL DIAGRAM



Vertical Temperature Profile Radiometer Block Diagram

MEASUREMENTS

Measures emitted radiation.

Ground Resolution: 59 km

Spectral Range: 12-18.7 microns

Channels: 8

- Bands:
1. 12 microns
 2. 13.8 microns
 3. 13.4 microns
 4. 14.1 microns
 5. 14.8 microns
 6. 14.4 microns
 7. 14.97 microns
 8. 18.7 microns

VERTICAL TEMPERATURE PROFILE RADIOMETER (VTPR)

POTENTIAL DERIVED PARAMETERS

1. Temperature profiles up to 30 km
2. Surface cloud top temperatures
3. Atmospheric water vapor content
4. Amount of cloud cover.

VERY HIGH RESOLUTION RADIOMETER (Geostationary Orbit)

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: J. R. Burke
LOCATION: NASA Headquarters

ACRONYM: VHRR
INSTRUMENT TYPE: VIS/IR Scanning Radiometer
SPACECRAFT: ATS-6
CONTRACTOR: ITT
P.I.: W. E. Schenk, GSFC
I. L. Goldberg, GSFC

OBJECTIVES

1. Demonstrate that a three-axis stabilized sensor could accurately determine winds from cloud motions.
2. Study the life cycles of severe storms, tropical and extratropical cyclones and other important events.
3. Improve techniques of estimating surface temperatures.

DESCRIPTION

SUMMARY: The Very High Resolution Radiometer (VHRR) experiment provided both day and night cloud cover information for determining cloud motions, tropical and extratropical storm life cycles, and mesoscale phenomena. They were also used for cloud climatology studies. The VHRR had one infrared channel (10.5 to 12.5 microns) and one visible channel (0.55 to 0.75 microns). The instantaneous field-of-view was 0.3 milliradian for the infrared channel (10.8-km resolution at subsatellite point) and 0.15 milliradians for the visible channel (5.4-km resolution at subsatellite point). The dynamic range for the infrared channel was from 0 to 240° k and 1 to 100% albedo for the visible channel. The infrared channel had a noise equivalent temperature difference of 1.5° C at 200° k and 0.5° C at 300° k. Data from this experiment was used to determine surface temperatures and horizontal wind vectors based on cloud motions derived from sequential images formed by both channels of the VHRR.

HERITAGE/DERIVATION: ITOS-D

DATA

DATA PRODUCTS:

Data Set Name: Black and white visual images on film.
Black and white infrared images on film.
Experimenter History Tape (EHT) Very High Resolution Radiometer (VHRR), on tape.

Film: 70-mm film, each frame corresponds to a full-dist Earth image (750 frames).
750 frames of 70-mm film from the infrared channel (10.5 to 12.5 micrometers).

Tape: 1176 reels of magnetic tape. 9-track 1600 BPI. Contain calibrated VHRR infrared picture information in one to four files.

PERIOD OF OPERATION: May 1974 - August 1974. Instrument failed after two months in orbit. Several hundred images were successfully taken.

VERY HIGH RESOLUTION RADIOMETER (VHRR)

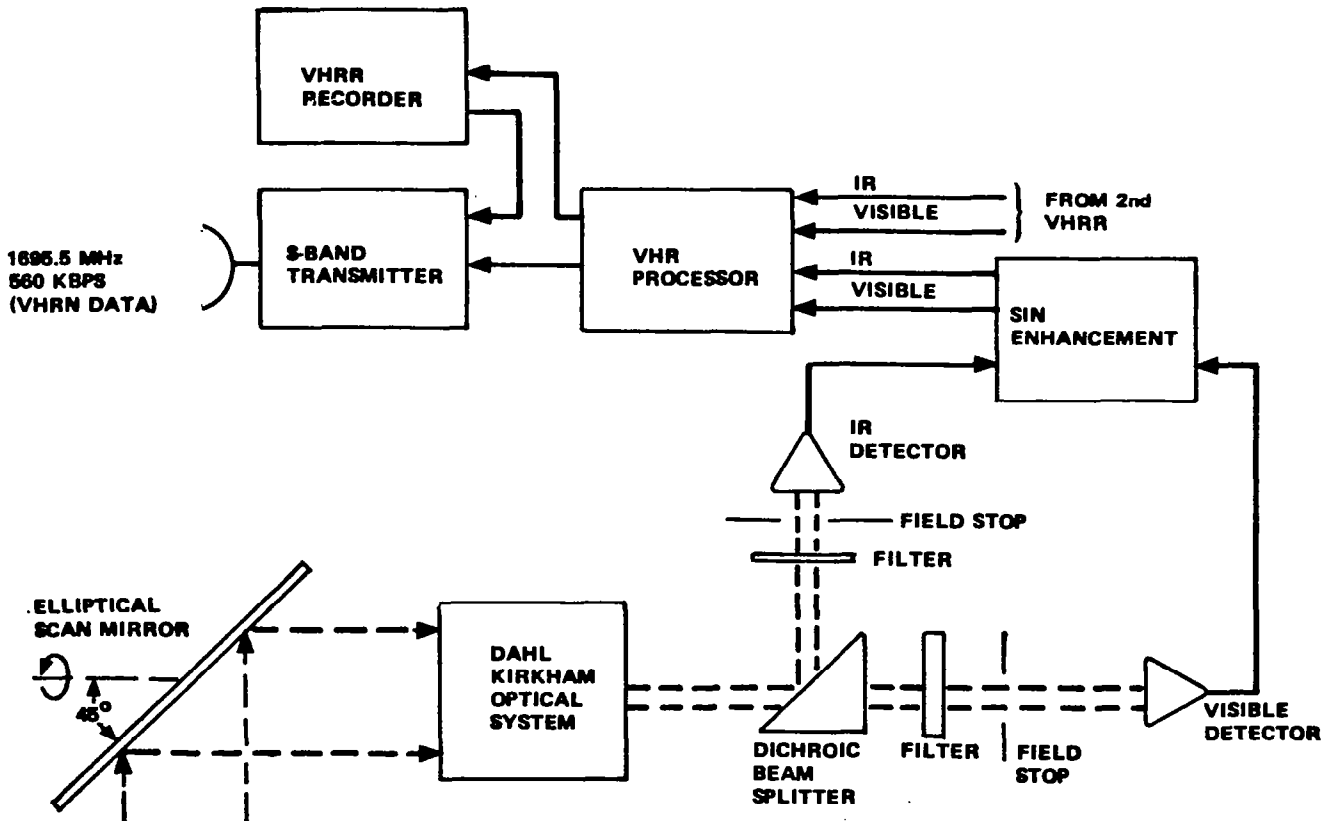
REFERENCES

1. Goldberg, I. L., A Very High Resolution Radiometric Experiment for ATS-F & G, January, 1968.
2. IEEE Trans. on Aerospace and Elec. Systems A&S-11, No. 6, November, 1975.
3. National Space Sciences Data Center computer printout 1980.

SYSTEM CHARACTERISTICS

Weight: 75 lbs.
Volume: 1.43 cu. ft.
Avg. Power: 20 Watts
Peak Power: 25 Watts
MTBF: 3 year
Components: Radiometer, Cassegrainian telescope, detector, electronics
Data Recovery: Realtime telemetry
Frequency of Observations: Every 24 minutes
Precision and Accuracy: 1.5 K at 200 K, 1200 lines/picture frame.

FUNCTIONAL DIAGRAM



Very High Resolution Radiometer Block Diagram

VERY HIGH RESOLUTION RADIOMETER (VHRR)

MEASUREMENTS

Measure visible and IR radiant energy.

Sensitivity:	<u>Scene Temp.</u>	<u>NE T</u>
	200K	1.5°C
	300K	0.5°C

Spectral Response: 10.5 - 12.5 microns
0.55 - 0.75 microns

Dynamic Range: 110 K to 340 vis. albedo 1 to 100%

Resolution: IFOV 0.3 mr (6 nm, 11 km) IR
IFOV 0.15 mr (3 nm, 5.5 km) visible

POTENTIAL DERIVED PARAMETERS

1. Cloud statistics, etc.
2. Earth surface temperature (nighttime, cloud free areas)
3. Cloud temperature measurements
4. Derived cloud height measurements
5. Earth albedo
6. Wind speed derived from cloud movement
7. Severe storm monitoring.

VERY HIGH RESOLUTION RADIOMETER (Sun Synchronous Orbit)

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: Jack O'Brian
LOCATION: NASA/Goddard Space Flight Center

ACRONYM: VHRR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: NOAA-2 -5
CONTRACTOR: RCA
P.I.: NOAA/NESS Staff

OBJECTIVES

1. To continuously measure surface temperatures of the Earth, sea, and cloud tops in daylight and night.
2. To transmit the temperature data in real time to command and data acquisition (CDA) stations throughout the world for use in local weather forecasting.

DESCRIPTION

SUMMARY: The Very High Resolution Radiometer (VHRR) included two scanning radiometers, a magnetic tape recorder, and associated electronics. The VHRR operated similarly to the scanning radiometer (SR) but with much greater resolution (0.9 km compared to 4 km for the SR at Nadir). One VHRR channel measured reflected visual radiation from cloud tops in the limited spectral range of 0.6 to 0.7 micron. This provided more contrast between the Earth and clouds than the SR by reducing the effect of haze. The second channel measured infrared radiation emitted from the Earth, sea, and cloud tops in the 10.5- to 12.5-micron region. This spectral region permitted both daytime and nighttime radiance measurements. The VHRR formed an image by using a scanning mirror technique similar to the SR except that both radiometers operated simultaneously. As the satellite proceeded in its orbit, the 400-rpm revolving mirrors scanned the Earth's surface 180; out of phase (one mirror at a time) and perpendicular to the orbit path. The visible and infrared data were time-multiplexed so that the scan of the infrared channel transmitted first, followed by the Earth scan portion of the visible channel. This process was repeated 400 times per minute (equivalent to the scan rate). If one of the radiometers failed, the system was still capable of measuring both visible and infrared radiation using only the remaining radiometer.

DATA

DATA PRODUCTS:

Data Sets:

1. Pictorial and Tabular Index to VHRR Imagery - 'Environmental Satellite Imagery'.
2. Prints (10 x 10 B&W) of VHRR Imagery.

Paper:

1. Digital Indexes; Booklets containing; Pictorial and tabular Data.

Film:

10 x 10 B&W prints.

VERY HIGH RESOLUTION RADIOMETER (VHRR)

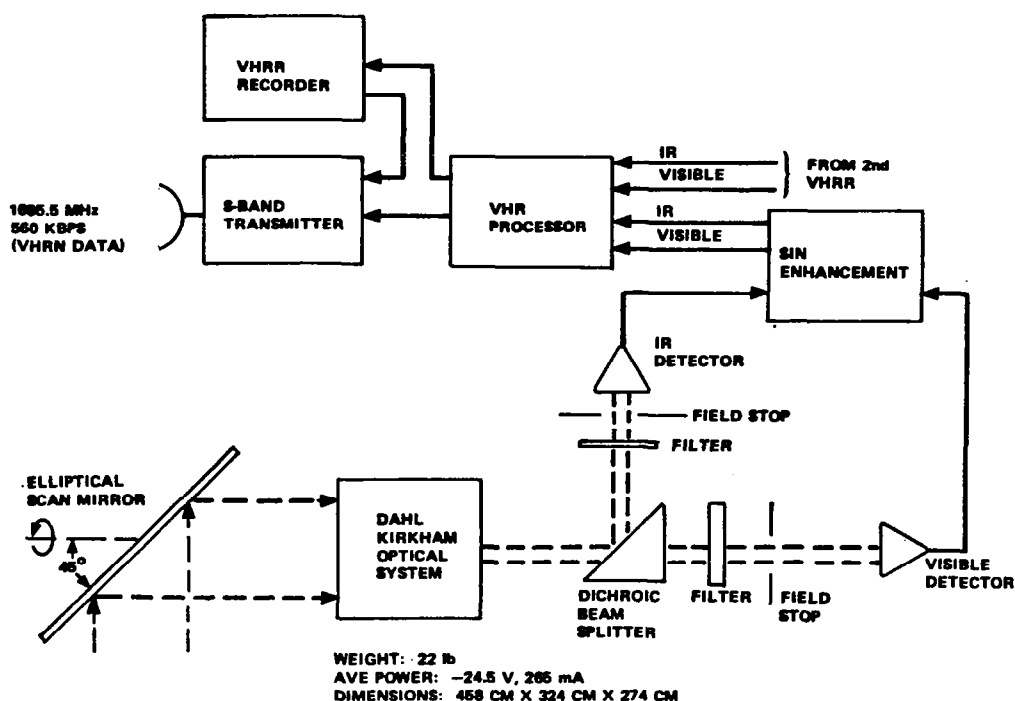
DATA ARCHIVES LOCATION: NOAA/NESS, Suitland, Maryland.

PERIOD OF OPERATION: October 1972 to January 1975
 November 1973 to August 1976
 November 1974 to November 1978
 July 1976 to July 1979

REFERENCES

1. National Space Science Data Center computer printout 1980.
2. Satellite Data User's Bulletin, August 1979.

FUNCTIONAL DIAGRAM



Very High Resolution Radiometer Block Diagram

MEASUREMENTS

Measure reflected visual radiation, IR radiation and surface temperatures.

Number of Channels: 4

Spectral Range: Channel 1 - 0.5 - 0.7 microns (visible)
 Channel 2 - 0.75 - 1.0 microns (near IR)
 Channel 3 - 10.5 to 12.5 microns (IR window)
 Channel 4 - 6.5 to 7.0 microns (water vapor)

Ground Resolution: 1 km (VIS,IR) 4 km (water vapor)

VERY HIGH RESOLUTION RADIOMETER (VHRR)

POTENTIAL DERIVED PARAMETERS

1. Daytime/nighttime cloud cover pictures
2. Cloud motions
3. Storm life cycles
4. Mesoscale phenomena
5. Cloud climatology.

VIDICON CAMERA SYSTEM

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. Garbacz
LOCATION: NASA Headquarters

ACRONYM: VCS
INSTRUMENT TYPE: Camera
SPACECRAFT: TIROS-1-10, ESSA-1
CONTRACTOR: RCA
P.I.: W.G. Stroud, GSFC

OBJECTIVES

1. To obtain data for operational meteorological use.
2. To further research in obtaining and using cloud cover pictures from satellites.

DESCRIPTION

SUMMARY: The TIROS-1-8 TV system was designed to obtain data for operational meteorological use and to further research in obtaining and using TV cloud cover pictures from satellites. The experiment consisted of two independent pairs of TV cameras, magnetic tape recorders, and TV transmitters. The two sensor units were capable of concurrent or independent operation. The cameras, one wide angle (104 degrees) and one medium angle (80 degrees), were mounted on the baseplate of the spacecraft with their optical axes parallel to the spacecraft spin axis, which was in the orbital plane. The cameras were automatically triggered into action only when they came in view of the earth. The pictures were transmitted directly to either of two ground receiving stations or stored on magnetic tape for later playback, depending on whether the satellite was within or beyond the communication range of the station. The TV cameras used 500-scan-line, 1.27 cm vidicons. The recorders could store up to 32 frames of pictures. Transmission of the 32 frame sequence was accomplished in 100 seconds by a 3-Watt FM transmitter operating at a nominal frequency of 237 MHz. At nominal attitude and altitude (approximately 700 km), a picture taken by the wide-angle camera covered a 1200 by 1200 km square with a spatial resolution of 2.5 to 3.0 km at nadir. The medium-angle camera covered a 725 by 725 km square and had a resolution of 2 km.

The TIROS-9 TV system was designed to obtain data for operational meteorological use and to further research in obtaining and using TV cloud cover pictures from satellites on TIROS-9. The camera system was identical to that flown on all previous TIROS missions and ESSA-1, i.e., two wide-angle 104 degree TV cameras equipped with 1.27 cm vidicons. Unlike previous TIROS TV cameras, however, the cameras on TIROS-9 were mounted 180 degrees apart on the side of the spacecraft and canted 64 degrees from the spacecraft spin axis. The cameras were automatically triggered into action only when they came in view of the earth.

The TIROS-10 experiment consisted of two redundant pairs of TV cameras, magnetic tape recorders, and TV transmitters, the two sensor units were capable of concurrent or independent operation. The one wide-angle (104 degrees) and one narrow angle (12 degrees) vidicon cameras were mounted on the baseplate of the spacecraft with their optical axes parallel to the spacecraft spin axis. The ability of the magnetic attitude control system to vary the spacecraft spin axis allowed the cameras to view the earth at various angles from nadir. In this respect, the camera system was similar to that flown on the TIROS-9 "Cartwheel" satellite. The cameras were automatically triggered into action only when they came in view of the earth, depending on whether or not the satellite was within communication range of either of two ground receiving stations. The TV camera system could operate in either real-time or tape recorder mode. The TV cameras used 500-scan-line, 1.27-cm vidicons. The recorder could store up to 32 frames of pictures. Transmission of the 32-frame sequence was accomplished in 100 sec by a 2 Watt FM transmitter operating at a nominal

VIDICON CAMERA SYSTEM (VCS)

DESCRIPTION (cont.)

frequency of 235 MHz. At nominal attitude and altitude (approximately 700 km), a picture covered a 1200 by 1200 km square with a spatial resolution of 2.5 to 3.0 km at nadir. From a near polar orbit, the camera system could provide complete pictorial coverage of the entire daylight portion of the globe.

DATA

DATA PRODUCTS:

TIROS-1, TIROS-2, TIROS-3

Data Set: 1. Index of meteorological satellite data - TIROS-1, 2, 3 television cloud photography
2. 35mm daytime TV cloud photography.

Paper

Film

Digital indexes of cloud pictures

35mm positive or negative film of wide-angle and narrow-angle cloud photography

TIROS-4, TIROS-5, TIROS-6

Data Set: 1. Global daily nephanalysis of satellite cloud observations
2. 35mm daytime TV cloud photography.

Paper

Film

Digital indexes of cloud pictures

35mm positive or negative film of wide-angle and medium-angle cloud photography

TIROS-7, TIROS-8

Data Set: 1. Global daily nephanalysis of satellite cloud observations
2. 35mm daytime TV cloud photography

Paper

Film

Digital indexes of cloud pictures by geographic areas

35mm positive or negative film of wide-angle cloud photography

TIROS-9

Data Set: 1. Global daily nephanalysis of satellite cloud observations
2. 35mm daytime TV cloud photography

Paper

Film

Published indexes to the available cloud pictures

35mm positive or negative film of wide-angle cloud photography

VIDICON CAMERA SYSTEM (VCS)

TIROS-10

Data Set: 1. Global daily nephanalysis of satellite cloud observations on microfiche

Paper

Published indexes to the available
cloud pictures

ESSA-1

Data set: 1. Global daily nephanalysis of satellite cloud observations
2. 35mm daytime TV photography.

Paper

Daily map indexes of areas
photographed, digital indexes
of cloud pictures listed by
orbit number and track

Film

35mm positive or negative film of
wide angle photography

DATA ARCHIVES LOCATION: National Climatic Center, Asheville, North Carolina
National Weather Records Center, Asheville, North Carolina

PERIOD OF OPERATION:

TIROS-1	April 1960 to June 1960
TIROS-2	November 1960 to February 1961
TIROS-3	July 1961 to October 1961
TIROS-4	February 1962 to June 1962
TIROS-5	June 1962 to May 1963
TIROS-6	September 1962 to October 1963
TIROS-7	August 1965 to February 1967
TIROS-8	December 1963 to January 1966
TIROS-9	January 1965 to January 1967
TIROS-10	July 1965 to July 1966
ESSA-1	February 1966 to June 1968

REFERENCES

1. Significant Achievements in Satellite Meteorology 1958-1964, NASA SP-96.
2. Golberg, E.A. and Landon V.D.: Key Equipment for TIROS-1, *Astronautics*, V.5, June 1960.
3. Mesner, M.H. and Staniszewski, J.: TV Cameras for Space Exploration, *Astronautics*, V.5, May 1960.
4. Instruments and Spacecraft, NASA SP-3028, 1966.
5. National Space Science Data Center, *Satellite Users Bulletin* - Volume 1, #2, August 1979.
6. National Space Science Data Center computer printout 1980.

VIDICON CAMERA SYSTEM (VCS)

SYSTEM CHARACTERISTICS

Peak Power: 9 Watts

Components: TV camera, transmitter, tape recorder

Data recovery: delayed or realtime

Avg. power: 9 Watts

Peak power: 9 Watts

MEASUREMENTS

Obtain daytime wide and narrow angle pictures of cloud cover.

Measurement range: 5 levels of gray

Spectral range: 0.4 to 0.65 microns

Field-of-view: 10.0 by 10.0 degrees

Spatial resolution: 1.5 nm per TV line from orbital altitude

Weight: 7 lbs.

POTENTIAL DERIVED PARAMETERS

1. Cloud cover over the earth's surface
2. Broad synoptic viewing of cloud cover patterns
3. More valuable data for weather-analysis than from medium or narrow angle cameras.

VISIBLE-INFRARED SPIN-SCAN RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: M. L. Garbacz
LOCATION: NASA Headquarters

ACRONYM: VISSR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: SMS-1, 2; GOES-1, 2, 3
CONTRACTOR: Santa Barbara Research Center
P.I.: D. V. Fordyce, GSFC
M. B. Weinreb, GSFC

OBJECTIVES

1. To provide day/night observations of cloud cover and earth/cloud radiance temperature measurements from a synchronous spin-stabilized geostationary satellite for use in operational weather analysis and forecasting.

DESCRIPTION

SUMMARY: The Visible-Infrared Spin-Scan Radiometer (VISSR), a two-channel instrument, was able to take both full and partial pictures of the Earth's disk. The infrared channel (10.5 to 12.6 micrometers) and the visible channel (0.55 to 0.70 micrometer) used a common optics system. Incoming radiation was received by an elliptically-shaped scan mirror and collected by a Ritchey-Chretien optical system. The scan mirror was set at a nominal angle of 45° to the VISSR optical axis, which was aligned parallel to the spin axis of the spacecraft. The spinning motion of the spacecraft (approximately 100 rpm) provided a west-to-east scan motion when the spin axis of the spacecraft is oriented parallel with the Earth's axis. The altitudinal scan was accomplished by sequentially tilting the scanning mirror north to south at the completion of each spin. A full picture took 18.2 minutes to complete and about 2 minutes to retrace. During each scan, the field-of-view on the Earth was swept by a linear array of eight visible-spectrum detectors, each with a ground resolution of 0.9 km at zero nadir angle. A mercury-cadmium telluride detector sensed the infrared portion of the spectrum with a horizontal resolution of approximately 8 km at zero nadir angle. The infrared portion of the detector measured radiance temperatures between 180 and 315° K with a proposed sensitivity between 0.4 and 1.4° K. The VISSR output was digitized and transmitted to the National Oceanographic and Atmospheric Administration (NOAA) Command Data Acquisition Station (CDA), Wallops Island, Virginia. There the signal was fed into a "line stretcher" where it was sorted and time-stretched for transmission back to the satellite at reduced bandwidth for re-broadcast to data utilization stations (DUS).

VISIBLE-INFRARED SPIN-SCAN RADIOMETER (VISSR)

DATA

DATA PRODUCTS:

SMS-1

- Data Set: Visible digital data on tape.
VISSR visible imagery on 70 mm film.
VISSR Infrared Imagery on 70 mm film.
AOIPS IR and visible imagery data on tape.
IDAMS Visible and IR image data on tape.
- Tape: 303 reels of magnetic tape containing digitized picture sections.
1266 reels of magnetic tape consisting of reduced data providing observed values of radiance temperature.
786 reels of magnetic tape consisting of reduced data providing observed values of radiance temperature.
- Film: 1286 frames containing a 33-level grayscale and title.
2863 frames containing a 33-level grayscale and title.

SMS-2

- Data Set: Visible Infrared Spin-Scan Radiometer (VISSR) data on magnetic tape.
VISSR visible imagery on 70 mm film.
VISSR infrared imagery on 70 mm film.
AOIPS IR and visible image data on tape.
IDAMS visible and IR image data on tape.
- Tape: 334 reels of magnetic tape containing digitized picture sections.
1102 reels of magnetic tape consisting of reduced data providing observed values of radiance temperature.
1630 reels of magnetic tape consisting of reduced data providing radiance temperature.
- Film: 1700 frames of 70 mm film containing a 33-level grayscale and title.
1675 frames of 70 mm film containing a 33-level grayscale and title.

GOES-1

- Data Set: Experimentor history tapes - VISSR data in digital format on magnetic tape.
Visible image pictures on 70 mm film.
AOIPS IR and visible imagery digital data tapes.
- Tape: 285 reels of magnetic tape containing digitized picture sections.
2050 reels of magnetic tape consisting of reduced data providing observed values of radiance temperature.
- Film: 1368 frames of 70 mm film containing VISSR IR imagery.

VISIBLE-INFRARED SPIN-SCAN RADIOMETER (VISSR)

DATA PRODUCTS (cont'd)

GOES-2

Data Set: AOIPS IR and visible data on tape.

Tape: 1140 reels magnetic tape.

GOES-3

Data Set: IR imagery on 70 mm film.
Visible Imaging on 70 mm film.
AOIPS IR and visible image data on tape.

DATA ARCHIVES LOCATION: National Oceanographic and Atmospheric Administration,
Environmental Data Service, Suitland, Maryland.

PERIOD OF OPERATION: GOES-1 - April 1976 to May 1977
GOES-2 - December 1977 to March 1978
SMS-1 - May 1974 to October 1975
SMS-2 - August 1974 to September 1979

REFERENCES

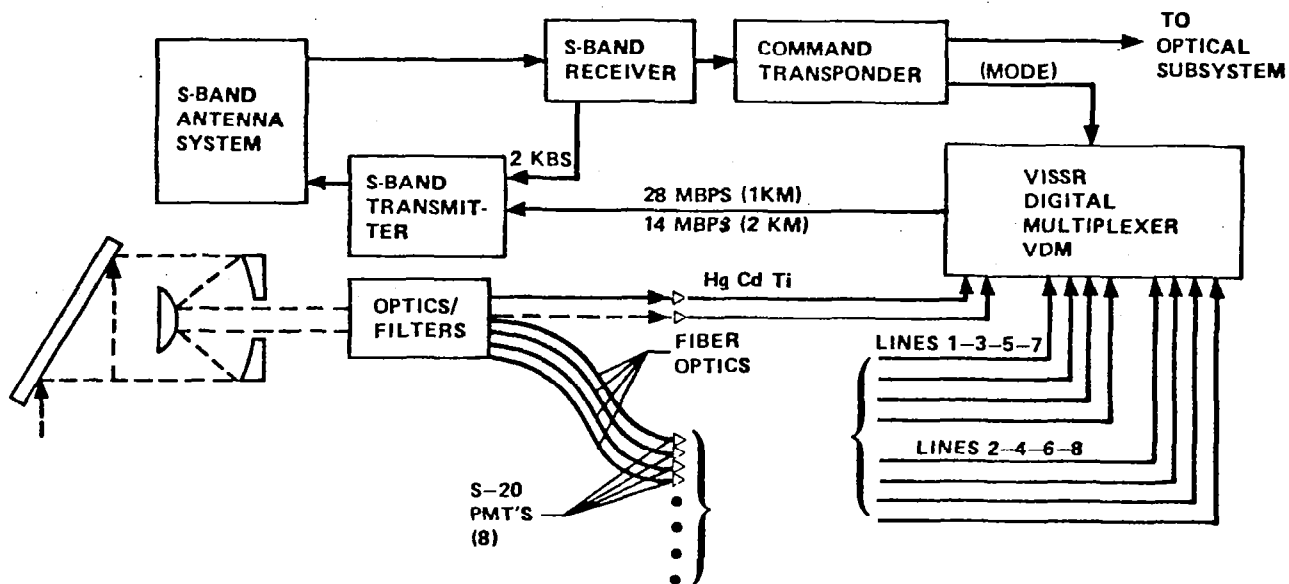
1. National Space Science Data Center computer printout, 1980.
2. Satellite Data Users Bulletin, Volume 1, #1, January 1979.

SYSTEM CHARACTERISTICS

Precision and Accuracy: Signal dynamic range 44 DB - visible; 27 DB IR
Components: Primary optics, fiber and relay optics, filters, detectors
Weight: 133 lb
Volume: 13.7 cu. ft.
Avg. Power: 23 Watts
Delayed Recovery: Delayed telemetry

VISIBLE-INFRARED SPIN-SCAN RADIOMETER (VISSR)

FUNCTIONAL DIAGRAM



Visible Infrared Spin Scan Radiometer Block Diagram

MEASUREMENTS

Measures reflected and thermal radiation from Earth's surface.

Spectral Range: 0.55 to 12.6 microns

Channels: 2

1. Visible: 0.55 - 0.70 micron

2. Infrared: 10.5 - 12.6 microns

Spatial Resolution: 0.5 nm visible bands; 5 nm thermal band

I FOV: (IR) 0.25 mrad

(Vis) 0.025 mrad

POTENTIAL DERIVED PARAMETERS

1. Day/night cloud cover observations
2. Cloud radiance temperatures.

VISIBLE/IR RADIOMETER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Future Flight Missions
NASA TECH. OFFICER: M. Garbacz
LOCATION: NASA Headquarters

ACRONYM: VIRR
INSTRUMENT TYPE: Radiometer
SPACECRAFT: SEASAT-1
CONTRACTOR: Santa Barbara Research Center
P.I.: Dr. P. McClain

OBJECTIVES

1. To measure emitted radiation from the Earth during day and night.
2. To measure reflected radiation from the Earth during the daytime.
3. Determination of the surface temperature of the ground, sea, or cloud tops that are viewed by the radiometer.

DESCRIPTION

SUMMARY: The SEASAT VIRR and the ITOS SR are identical instruments. The Scanning Radiometer (SR) Subsystem consisted of two scanning radiometers. A dual SR processor, and two SR recorders. The radiometer measured reflected radiation from the Earth-Atmosphere system in the 0.52- to 0.73-micron band during the day and emitted radiation from the Earth and its atmosphere in the 10.5- to 12.5-micron band during the day and night. Unlike a camera, the SR did not take a picture but instead formed an image using a continuously rotating mirror. The mirror scanned the Earth's surface perpendicular to the satellite's orbital path at a rate of 48 rpm. As the satellite progressed along its orbital path, each rotation of the mirror provided one scan line of picture. Radiation collected by the mirror was passed through a beam splitter and spectral filter to produce the desired spectral separation. Up to two full orbits of data (145 min) could be stored on magnetic tape for subsequent transmission (1697.5 MHz) to an acquisition station. The data could also be transmitted in real time to local APT stations. Once the signal was received by the ground station, a continuous picture was formed by using a facsimile recorder whose scan was in phase with the satellite's forward motion. At nominal spacecraft altitude (approximately 1450 km), the radiometer had a ground resolution of better than 4 km at nadir. The radiometer was capable of yielding radiance temperatures from 185 to 330° an accuracy of 4 and 1° K, respectively.

HERITAGE/DERIVATION: NOAA-1, ITOS-1

DATA

DATA PRODUCTS:

Magnetic Tape: 35 mm gridded, computer mapped
A limited number of CCTs containing Earth imagery located, time oriented, ocean radiance values will be available.

Film: Up to 40 (2 IR and 1 VIS) negatives per day, has a 9-km resolution.

DATA ARCHIVES LOCATION: National Oceanographic and Atmospheric Administration/NESS,
Suitland, Maryland

PERIOD OF OPERATION: July 7 through October 10, 1978

VISIBLE/IR RADIOMETER (VIRR)

REFERENCES

1. NASA, SEASAT-A Program Summary, August, 1974.
2. Satellite Data Users Bulletin, Volume 1, No. 1, January 1979.
3. National Space Science Data Center computer printout, 1980.

SYSTEM CHARACTERISTICS

Weight: 40 lbs.

Volume: 0.5 cu. ft.

Avg. Power: 14 W

Scan Rate: 48 rpm

I FOV (-6 dB Points)

Spectral Region (-6 db Points)

Information Bandwidth

Unfiltered

Filtered (Test)

NEI (over operating temperature range) for extended target source

NETD (at indicated target scene, over operating temperature range) for extended target scene

Output voltage range (nominal)

Maximum output voltage range over temperature for maximum calibrated target scene

DC restore level

Operating temperature

Visible Channel

2.8 ± 0.3 mr

0.47 ± 0.05 to
 0.94 ± 0.05 microns

1200 Hz

900 Hz

4.1×10^{-10} W/cm²

-5.9 to -0.3 Vdc

-1.0 to +0.1 Vdc
(100% albedo; 25°C
SR temperature
reference)

-5.9 ± 0.075 Vdc

-5°C to +45°C

Thermal Channel

$5.3^{+0.5}_{-1.1}$ mr

10.5 to 12.5 microns
(nominal)

600 Hz

455 Hz

4.2×10^{-10} W/cm²

1.0°K at 300°K
4°K at 185°K

-0.25 to -6.1 Vdc

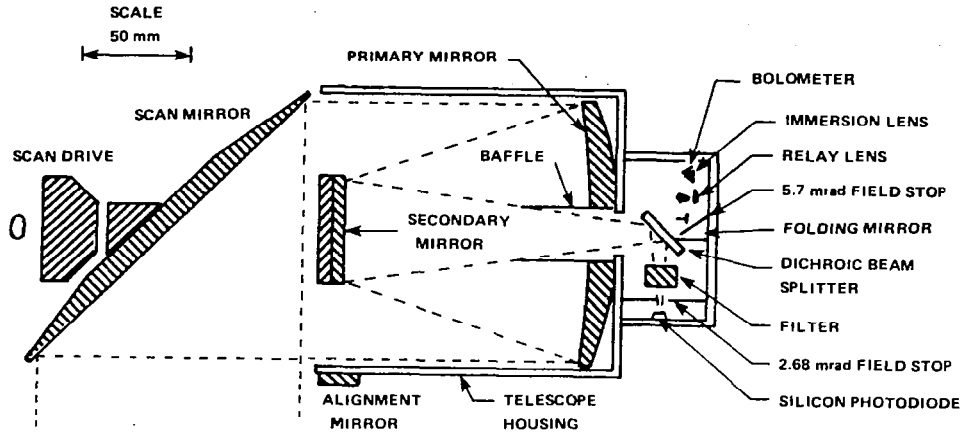
-6.1 to -5.0 Vdc
(320°K target)

0.25 ± 0.05 Vdc

-5°C to +40°C

VISIBLE/IR RADIOMETER (VIRR)

FUNCTIONAL DIAGRAM



Visible/IR Radiometer Schematic Diagram

MEASUREMENTS

Measure reflected radiation from the Earth-Atmosphere system.

Measurement Range: visible brightness - 50-100 ft. lamberts, IR temperature 180-300°K

Spectral Range: 0.47 to 12.5 microns

Channels:

1. Visible: 0.47-9.4 microns
2. Infrared: 10.5-12.5 microns

Components: 2 radiometers, electronics systems, processor, tape recorder

Precision and Accuracy: 1.0°K at 300°K, 4.0°K at 185°K

FOV: 150.0 DEG

Spatial Resolution: 2 nm visible 4 nm IR from 750 nm altitude

Frequency of Observation: nighttime/daytime

Feature Location Accuracy: 5 km

Ocean Surface Temperature Accuracy: to within $\pm 2^\circ\text{C}$

Scan Rate: 48 rpm

POTENTIAL DERIVED PARAMETERS

1. Energy in the infrared and visible region of the spectrum
2. Ocean surface temperatures.

VISSR ATMOSPHERIC SOUNDER

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: R. H. Pickard
LOCATION: NASA Goddard Space Flight Center

ACRONYM: VAS
INSTRUMENT TYPE: Scanning Imaging Passive
VIS/IR Spectro-radiometer
SPACECRAFT: GOES-4 and E-I
CONTRACTOR: SBRC
P.I.: W. Shenk, GSFC

OBJECTIVES

1. To provide high quality day/night cloud cover data.
2. To take radiance temperatures of the Earth/atmosphere system.
3. To determine atmospheric temperature and water content at various altitudes.

DESCRIPTION

SUMMARY: The visible-infrared spin-scan radiometer atmospheric sounder (VAS) operates in three distinct modes to provide parameter flexibility, spectral band selection, geographic location, and S/N ratio. The VISSR mode is the same as the VISSR system on board GOES-1, 2, 3. Both the IR channel (10.5 to 12.5 micrometers) and visible channel (0.55 to 0.75 micrometers) use common optics. Incoming radiation is collected by a Richey-Chretien optical system. The spinning motion of the spacecraft (100 rpm) provides a west to east (W to E) scan motion. Scan mission tilt after each spin provides a north to south (N to S) scan motion. A full picture takes 18.2 minutes to complete and 2 minutes to reset for next image. Eight visible-spectrum detectors (0.9 km horizontal resolution) sweep the Earth during each scan. The dwell-sounding mode uses up to 12 spectral filters in a wheel covering the range 678.7 per cm (14.74 micrometers) through 2535 per cm (3.94 micrometers) positioned into the optical train while the scanner is dwelling on a single N to S scan line. The filter wheel can be programmed so that each spectral band filter can dwell on a single scan line for from 0 to 255 spacecraft spins. Either the 6.9-km or 13.8-km resolution detectors can be selected for the seven filter positions operating in the spectral region 701.6 per cm (14.25 micrometers) through 1487 per cm (6.725 micrometers). For the remaining five spectral bands the 13.8-km resolution detectors are used. Selectable frame size, position and scan direction are also programmable via ground command. The VISSR output is digitized and transmitted to the NOAA Command Data Acquisition Station, Wallops Island, Virginia. There the signal is fed into a "line stretcher," where it is stored and time-stretched for transmission back to the satellite at reduced bandwidth for rebroadcast to apt user stations.

HERITAGE/DERIVATION: GOES-1, 2, 3 VISSR

DATA

DATA ARCHIVES LOCATION: National Climatic Center, Asheville, North Carolina.
PERIOD OF OPERATION: September 1980 to present.

REFERENCES

1. Santa Barbara Research Corporation, Conceptual Design Review.
2. Report on Active and Planned Spacecraft and Experiments National Space Sciences Data Center. August 1980.

VISSR ATMOSPHERIC SOUNDER (VAS)

SYSTEM CHARACTERISTICS

Power: 40 Watts

Size:

Scanner 1.5 x .65 m

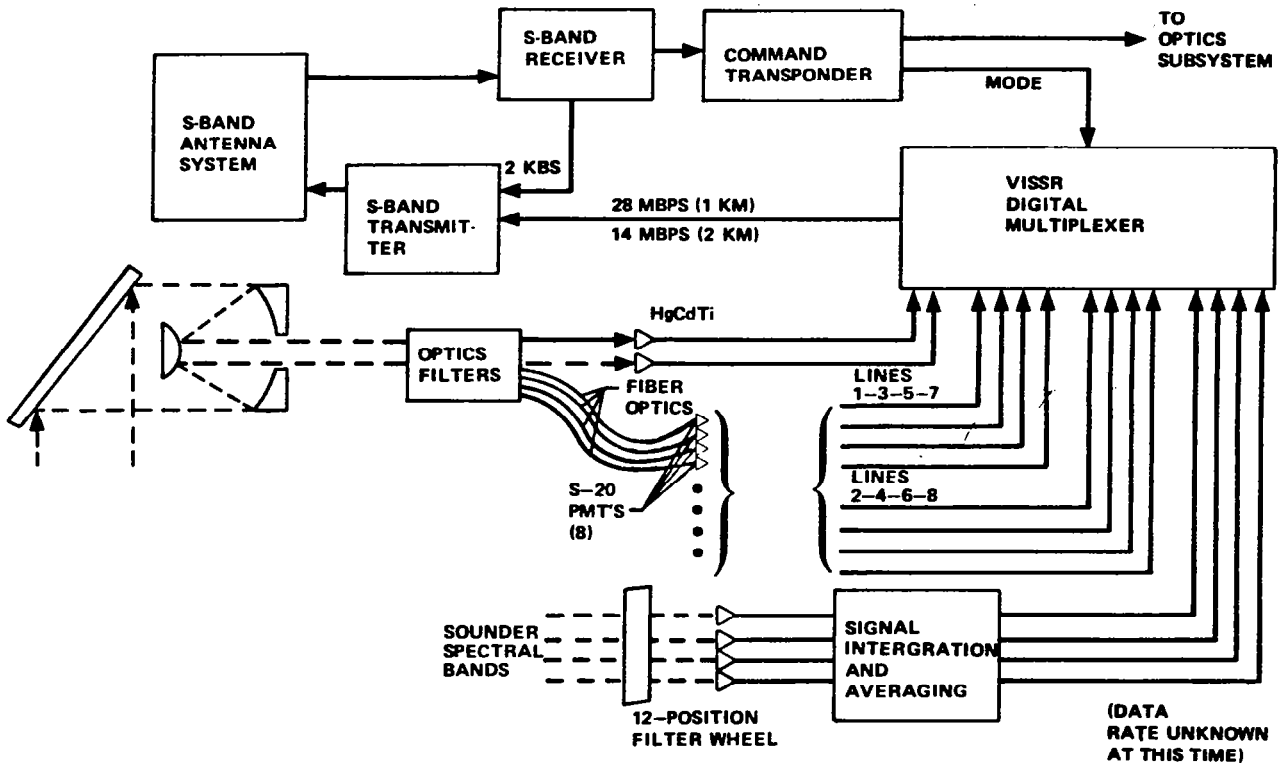
Electronics 30.5 x 18.8 x 28.0 cm

Weight:

Scanner 69.0 Kg

Electronics 9.5 Kg

FUNCTIONAL DIAGRAM



VISSR Atmospheric Sounder Block Diagram

VISSR ATMOSPHERIC SOUNDER (VAS)

MEASUREMENTS

Measure radiance in the 3.9 through 14.7 microns bands.

Soundings with a horizontal resolution of 30 km will be produced by averaging the 8 or 16 measurements. Accuracy is to within 13° of actual atmospheric temperature.

Spectral bands: 12

IR Channel Optical Range: 10.5 to 14.7 microns

Visible Channel Spectral Range: 0.39 to 0.75 micron

IR Resolution: 0.192 mradians

Visible Resolution: 0.21 x 0.25 mradians

Resolution of Sounding Channel: 16 km

Detector Field-of-View: 0.384 mrad

POTENTIAL DERIVED PARAMETERS

1. Day/night cloud movements
2. Surface temperature
3. Cloud water and temperature.

VISIBLE NITROGEN DIOXIDE

IDENTIFICATION

DISCIPLINE: Environmental Observations
STATUS: Flight Missions
NASA TECH. OFFICER: S. Tilford
LOCATION: NASA Headquarters

ACRONYM:
INSTRUMENT TYPE: Spectrometer
SPACECRAFT: Solar Mesosphere Explorer
CONTRACTOR: University of Colorado
P.I.: Charles A. Barth

OBJECTIVES

1. Observe NO₂ absorption lines.
2. Measure radiance in the 20-40 km limb region.

DESCRIPTION

SUMMARY: The Visible Nitrogen Dioxide is one of five instruments to be carried on the SME spacecraft which will measure the ozone density and altitude distribution, monitor the incoming solar radiation, and measure other atmospheric constituents which affect ozone. This instrument will have two channels operating from 3250 to 4500 Å and from 5200 to 7700 Å. It will measure the nitrogen dioxide distribution in the 20-40 km region.

HERITAGE/DERIVATION: Dual channel Ebert-Fastie spectrometer NASA, OSS, Jet Propulsion Laboratory.

DATA

DATA ARCHIVES LOCATION: NASA, National Center for Atmospheric Research, Jet Propulsion Laboratory, LASP.

REFERENCES

1. Project Plan for Solar Mesosphere Explorer 1981 Mission, Jet Propulsion Laboratory, September 1978.

SYSTEM CHARACTERISTICS

Physical size: 0.35 x 0.13 x 0.10 m
Mass: 2.72 kg
Power requirement: 5 We
Data rate: 64.0 kbps

MEASUREMENTS

1. Number of channels: 2
2. Spectral range: 3250 to 4500 Å
5200 to 7700 Å

POTENTIAL DERIVED PARAMETERS

1. Nitrogen Dioxide Concentration

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Legend: FM = Flight Missions
 FFM = Future Flight Missions
 DEV = Development

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DEV = Development

LIST OF REMOTE SENSOR ACRONYMS

ACRONYM	REMOTE SENSOR TITLE	PAGE NUMBER
ACR	Active Cavity Radiometer	1
AGCE	Atmosphere General Circulation Experiment	26
ALS	Advanced Limb Scanner	3
ALT	Altimeter	23
ALT	Radar Altimeter (SEASAT)	211
AMMS	Advanced Microwave Moisture Sensor	10
AMSU	Advanced Microwave Sounding Unit	11
AMTS	Advanced Meteorological Temperature Sounder	7
ATMOS	Atmospheric Trace Molecules Observed by Spectroscopy	27
AVHRR	Advanced Very High Resolution Radiometer	13
AVCS	Advanced Vidicon Camera System	16, 18, 20
AXIS	Atmospheric X-Ray Imaging Spectrometer	29
BLLS	Boundary Layer Lidar System	34
BUV	Backscatter Ultraviolet Spectrometer	31
CLAES	Cryogenic Limb Array Etalon Spectrometer	43
CLS	Cloud Lidar System	35
CLSIR	Cryogenic Limb Scanning Interferometer Radiometer	46
CTS	Cloud Top Scanner	36
CULER	Cryogenic Upper Atmosphere Limb Emission Radiometer	48
CZCS	Coastal Zone Color Scanner	37
CZCS/2	Coastal Zone Color Scanner/2	40
DCR	Differential Correlation Radiometer	54
DNCS	Day/Night Camera System	52
ERB	Earth Radiation Budget	55
ERBE	Earth Radiation Budget Experiment	58
ESMR	Electrically Scanning Microwave Radiometer	64, 67
ETC	Earth Terrain Camera	62
FILE	Feature Identification and Location Experiment	69
FMAG	Fluxgate Magnetometer	76
FPR	Flat Plate Radiometer	74
FWS	Filter Wedge Spectrometer	71
	Four-Channel Infrared Radiometer	78
GLIMPSE	High Resolution Global Measurement of Atmospheric Ozone GLIMPSE: Global Limb Photometric Scanning Experiment	91
HALOE	Halogen Occultation Experiment	80
HCMR	Heat Capacity Mapping Radiometer	83
HEPS	High Energy Particle Spectrometer	86
HIRS	High Resolution Infrared Radiation Sounder	100
HIRS-2	High Resolution Infrared Radiation Sounder-2	103
HRDI	High Resolution Doppler Imager	88
HRIR	High Resolution Infrared Radiometer	95, 98

LIST OF REMOTE SENSOR ACRONYMS

ACRONYM	REMOTE SENSOR TITLE	PAGE NUMBER
ICE	Ion Convection Electrodynamics	127
IDCS	Image Dissector Camera System	106
IR	Infrared Spectrometer	123
IRIS	Infrared Interferometer/Spectrometer	114, 117
ISAMS	Improved Stratospheric and Mesospheric Sounder	111
ISO	Imaging Spectrometric Observatory	109
ITPR	Infrared Temperature Profile Radiometer	123
LAMMR	Large Antenna Multifrequency Microwave Radiometer	130
LBR	L-Band Radiometer	132
LIMS	Limb Infrared Monitor of the Stratosphere	137
LRIR	Limb Radiance Inversion Radiometer	140
LRNR	Low Resolution Non-Scanning Radiometer	142
LROR	Low Resolution Omnidirectional Radiometer LIDAR System for OH and O ₃	144 135
MAG	Magnetometer	146
MAPS	Measurement of Air Pollution from Shuttle	149
MCR	Multispectral Cloud Radiometer	166
MEPS	Medium Energy Particle Spectrometer	151
MLA	Multispectral Linear Array	167
MLS	Microwave Limb Sounder	156
MPF	Multispectral Photographic Facility	169
MPS	Microwave Pressure Sounder	159
MRIR	Medium Resolution Infrared Radiometer	153
MRSA	Microwave Radiometer/Scatterometer/ and Altimeter	161
MSS	Multispectral Scanner	172
MUSE	Monitor of Ultraviolet Solar Energy	164
NEMS	NIMBUS-E Microwave Spectrometer	177
NOSL	Nighttime/Daytime Optical Survey of Lightning	175
OCE	Ocean Color Experiment	180
	1.27 Micron Airglow	182
PMR	Pressure Modulated Radiometer	183
RBVC	Return Beam Vidicon Camera System	190
SAGE	Stratospheric Aerosol and Gas Experiment	239
SAGE-II	Stratospheric Aerosol and Gas Experiment-II	242
SAM-II	Stratospheric Aerosol Measurement	245
SAMS	Stratospheric and Mesospheric Sounder	248
SAR	Synthetic Aperture Radar	254
SASS	SEASAT-A Satellite Scatterometer	211
SBUV	Solar and Backscatter Ultraviolet Spectrometer	225
SBUV/TOMS	Solar Backscatter Ultraviolet/Total Ozone Mapping Spectrometer	227
SCAMS	Scanning Microwave Spectrometer	198
SCMR	Surface Composition Mapping Radiometer	251
SCR	Selective Chopper Radiometer	213
SCV	Solar Constant Variations	230
SIR	Shuttle Imaging Radar	216
SIR-A	Shuttle Imaging Radar-A	220

LIST OF REMOTE SENSOR ACRONYMS

ACRONYM	REMOTE SENSOR TITLE	PAGE NUMBER
SIRS	Satellite Infrared Spectrometer	193
SMIRR	Shuttle Multispectral Infrared Radiometer	223
SMMR	Scanning Multichannel Microwave Radiometer	201
SR	Scanning Radiometer	205, 208
SSCC	Spin-Scan Cloud Cover Camera	235, 236
SUM	Solar Ultraviolet Monitor	231
SUSIM	Solar Ultraviolet Spectral Irradiance Monitor	232
	Scaler Magnetometer	196
TBMS	13-Band Multispectral Scanner	266
THIR	Temperature Humidity Infrared Radiometer	259
TM	Thematic Mapper	263
TOVS	TIROS Operational Vertical Sounder	269
	Two Channel Microwave Radiometer	273
	Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere	257
UOS	Ultraviolet Ozone Spectrometer	275
USIS	Ultraviolet Stratospheric Imaging Spectrometer	281
	Ultraviolet Solar Spectrometer	278
VAS	VISSR for Atmospheric Sounder	307
VCS	Vidicon Camera System	296
VHRR	Very High Resolution Radiometer (Geostationary Orbit)	290
VHRR	Very High Resolution Radiometer (Sun Synchronous Orbit)	293
VIRR	Visible/IR Radiometer	304
VISSR	Visible Infrared Spin-Scan Radiometer	300
VTPR	Vertical Temperature Profile Radiometer	287
	Vector Magnetometer	284
	Visible Nitrogen Dioxide	310

LIST OF SPACECRAFT ACRONYMS

ACRONYM	SPACECRAFT NAME
AEM	Atmospheric Explorer Mission
ATS	Applications Technology Satellite
ERBS	Earth Radiation Budget Satellite
GOES	Geosynchronous Operational Environmental Satellite
ITOS	Improved TIROS Operational Satellite
MAGSAT	Magnetic Field Satellite
SME	Solar Mesosphere Explorer
TIROS	Television and Infrared Observations Satellite
UARS	Upper Atmosphere Research Satellite

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16. Abstract This handbook is a compendium of information on Space and Terrestrial Applications remote sensor systems. The sensor systems presented in this book range from those experimental systems flown on early flights to those highly sophisticated sensors currently under development or planned for future missions. Each sensor is presented separately. Information is included on its objectives, description, technical characteristics, data products obtained when appropriate, data archives location, period of operation, measurement parameters and potential derived parameters. Not all sensors have the same degree of information dependent upon the current state of development and the inability to obtain complete information for all sensors. Following the alphabetical listing given in the Table of Contents, each sensor in this book has been cross indexed in each of the following indices: 1) Index of Remote Sensors by Status and Spacecraft, i.e., Flight, Future Flight, and Development 2) Index of Remote Sensors by Alphabetical Order and Major Derived Parameters, e.g., atmospheric trace constituents, solar constant, and earth resources phenomena. 3) List of Remote Sensors by Instrument Type, e.g., radiometers, spectrometers, and radars.					
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