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Compendium of Meteorological Space Programs, Satellites, and Experiments

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COMPENDIUM OF METEOROLOGICAL SPACE PROGRAMS, SATELLITES, AND EXPERIMENTS

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PREFACE

This volume includes plans and events known to the authors through January 1987. Compilation of the information began in 1967, concurrent with a period of major expansion of facilities and personnel at the National Space Science Data Center (NSSDC). As noted in the acknowledgments, there have been ten primary contributors. The satellite information is recorded in an Automated Information Management (AIM) system, which was initiated at NSSDC in 1967. It is a tool that has proved extremely useful for maintaining, revising, and reproducing this satellite and experiment information. A large portion of this volume consists of selected extracts from this AIM file.

This revision of the compendium includes new and updated material on satellites and experiments, a rearrangement of materials, pagination, and indexing which is more amenable to updating, and a different approach to preparation of the bibliography. It includes summary information on programs of all nations sponsoring meteorological experiments. Punching for a standard three-ring notebook has been provided to simplify the addition of material to keep the information up to date.

ACKNOWLEDGMENTS

Many persons have contributed significantly to the preparation of this volume. We wish to recognize primary authorship of the text by the following:

Boyington, Gerald D.
Diesen, Bernard C.
Hankins, Russell A.
Havanac, Peter J.
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Except for the coauthors and Y. P. Sheu, all contributing authors were on assignment to NSSDC from USAF-MAC-AWS between 1967 and 1978.

Special credit is given here to N. W. Stoldt and P. J. Havanac, who prepared the first edition of this compendium in 1973. We also wish to acknowledge the leadership and support of NSSDC and the Goddard Laboratory for Atmospheres management, Dr. J. King, Dr. J. I. Vette, Dr. J. L. Green, and Dr. J. Simpson who provided encouragement and resources for the completion of this revised compendium.

The entire staff of the National Space Science Data Center (NSSDC), both federal and contract employees, and its computer facilities have been instrumental in maintaining the files used to produce this volume. Clerical support was also provided by Ms. C. Sawyer of the GSFC Severe Storms Branch. We are also indebted to a long list of individuals and information sources too numerous to name, without which this volume would not have been possible. Especially noteworthy have been the chief editor, Ms. B. Goldberg; Ms. J. Riddle of the NASA/GSFC Library; Ms. M. Pavlovich of the Smithsonian Air and Space Museum Library; the NSSDC Technical Reference System; the Radio Astronomy Explorer (King-Hele et al.) literature on orbital information; and NORAD releases of launch information. Not to be forgotten are the many NOAA, NASA, and ESA experimenters and other contacts from whom information has been obtained.

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I. INTRODUCTION

Explanatory Notes

This publication evolved from work accomplished primarily by the authors and meteorologists noted in Acknowledgments while assigned to the National Space Science Data Center (NSSDC), located at NASA/Goddard Space Fight Center (GSFC), Greenbelt, Maryland. This document is intended to serve two purposes:

- As a historical record of all satellites and instrumentation that has been useful for meteorological research or operational uses

- As a working document to be used to assist meteorologists in identifying meteorological satellites, locating data from these satellites, and understanding experiment operation which is related to satellite data that may be of interest to them

The material presented in this document was compiled from documents by, and from personal interviews with, those directly involved with the various meteorological satellite programs. Frequently, source material pertaining to spacecraft included in this document was obtained from a wide variety of publications that were sometimes vague or conflicting. Some judgment was required to evaluate these sources in order to be technically consistent. It is felt that the information appearing here represents the most accurate and comprehensive unclassified collection of information about meteorological satellite experiments available at this time. Every effort was made to ensure the accuracy and completeness of all information presented; nevertheless, corrections to, and suggestions for, improvements in this document are solicited.

Summary information of all known launched satellites for all countries and their experiments, which were concerned with meteorological operations or research, are included. On reviewing the numbers of satellites and experiments noted in Table 1, bear in mind that experiment definition is often somewhat ambiguous. This is because several sensors may constitute one instrument, an instrument may be operated in any of several modes to obtain different kinds of data, the instrument function may be operational or truly experimental--or a combination of operational and experimental--and it is possible for several instruments to be involved in one experiment. In spite of these complications, the experiments (or instruments) counted in Table 1 are intended to be analogous to those experiments described in the text. For these reasons, it is not advisable to compare these numbers with similar experiment enumerations in other references without first understanding and accounting for differences in the definition of an experiment.

TABLE 1

SUMMARY OF METEOROLOGICAL SPACE PROGRAMS, SATELLITES, AND EXPERIMENTS

PROGRAM	SATELLITES*	EXPERIMENTS†	COUNTRY
AEM	2	2 (2)	U.S.
Apollo	14	10 (22)	U.S.
ATS	5	6 (6)	U.S.
Bhaskara	2	2 (4)	India
Cosmos§	55	- ---	U.S.S.R.
Discoverer	6	3 (6)	U.S.
DMSP	23	9 (42)	U.S.
DOD (other)	5	2 (5)	U.S.
DODGE	1	1 (1)	U.S.
EOLE	2	1 (2)	France/U.S.
ERBE	3	2 (4)	U.S.
ESSA	9	6 (13)	U.S.
Explorer	2	2 (2)	U.S.
Gemini	10	4 (23)	U.S.
GMS	3	1 (3)	Japan
GOES/SMS	9	2 (9)	U.S.
INSAT	3	1 (3)	India
IRS	1	1 (1)	India
Landsat	5	3 (10)	U.S.
Mercury	6	1 (6)	U.S.
Meteor 1	31	5 (119)	U.S.S.R.
Meteor 2§	15	- ---	U.S.S.R.
Meteosat	3	2 (6)	ESA
Molniya	8	1 (8)	U.S.S.R.
MOS	1	4 (4)	Japan
Nimbus	7	27 (42)	U.S.
NOAA (1-5)/ITOS	6	6 (20)	U.S.
NOAA (6, 7, D)/TIROS-N	4	2 (8)	U.S.
NOAA (8-10, H-J)/ATN	6	4 (18)	U.S.
Salyut	6	5 (7)	U.S.S.R.

* Satellites or other spacecraft carrying meteorology-related observing equipment.

† The number of different experiments for each program is shown followed by the total number of experiments in parentheses. This accounts for experiments which are duplicative or nearly duplicative, but on different spacecraft.

§ Lack of complete information.

TABLE 1

SUMMARY OF METEOROLOGICAL SATELLITE PROGRAMS, SATELLITES, AND EXPERIMENTS (concluded)

PROGRAM	SATELLITES*	EXPERIMENTS†	COUNTR.
Seasat	1	5 (5)	U.S.
Shuttle I	6	5 (10)	U.S.
Shuttle II: Spacelab	1	2 (2)	U.S.
Skylab	1	5 (5)	U.S.
Soyuz	19	1 (19)	U.S.S.R.
TIROS	10	5 (20)	U.S.
TOPEX	1	1 (1)	U.S.
Vanguard	1	1 (1)	U.S.
Voskhod	2	1 (2)	U.S.S.R.
Vostok	5	1 (5)	U.S.S.R.
Zond	4	1 (4)	U.S.S.R.
Total 41	304	>143(>470)	>6

Note that the words "experiment" and "instrument" are used interchangeably in the following text. Also note that there are experiment descriptions that are more closely related to aeronomy. Some of the aeronomy experiments included observed atmospheric aerosols, sun and earth radiation, and other parameters designed for climate studies. Such experiments are included in the primary text only if they have readily apparent applications to meteorological forecasting and research related to understanding the atmospheric circulations on time scales shorter than a few weeks.

The major portion of this volume consists of the space program, satellite, and experiment descriptions in Section II. This section is arranged alphabetically by program common name and paginated only within each program. It is hoped that this scheme will provide a simple means of indexing, while also allowing the addition of updating material without disturbing the fundamental organization of the material.

At the beginning of each program in Section II, there is a brief program description intended to highlight the similarities and differences between satellites and experiments in that program. It is also intended to provide some perspective on the nonmeteorological aspects (if any) of that program, and on interrelations with other programs. Following each program description are the satellite and experiment descriptions. Within each program, satellites are arranged in order of their chronology of launch date (or planned launch date); experiments follow the appropriate satellite and are ordered alphabetically by the principal experimenter's last name.

Some of the experiment and satellite descriptions are quite duplicative, especially in the case of operational satellites in the same program, because there often is considerable duplication in the satellite and experiment design. In several programs, there is very little information available about the specific equipment, or differences in equipment, on different satellites in the program. In both instances, we have often replaced duplicative experiment and/or satellite descriptions with tabular listings and included at least a sample of the known descriptive information in the program description. This occurs primarily with some U.S.S.R. programs, with operational programs, and with the manned programs.

Appendix A in Section III lists all known proposed and planned satellites that are directly related to or have some application to meteorology. Due to lack of information and/or human resources, no intensive effort was made to provide descriptions of these future launches. Certain words, phrases, and acronyms used in this volume are defined in Appendixes B and C, respectively. For convenient access to records of interest, three sets of indexes are included in Appendix D.

All satellites have been known by more than one identification. A common scheme is to use a name and a letter (e.g., TIROS-A) for a prelaunch identifier, and the same name and a number for the postlaunch identifier (e.g., TIROS 1). For a variety of reasons, the letters and numbers often do not correspond (e.g., ITOS-B became NOAA 1). We have selected what we believe are the most commonly used identifiers for the satellites and satellite programs for primary indexing use here. Other known identifiers are listed in the indexes to provide some cross-reference.

There are only two standard and complete satellite identifiers (each including all satellites) in use, but unfortunately they have not proved very popular. This is due in part to the fact that they are not assigned until after the successful launch. The most used identifier is one established by the Committee for Space Research (COSPAR), a subordinate unit of the International Council of Scientific Unions (ICSU). Used in all NSSDC records, this identifier consists of the year of launch, the serially assigned number of the launch during that year, and a letter designating the various spacecraft resulting from that launch. Thus, 1967-008B designated the second satellite (B) resulting from the eighth successful launch during 1967. The NSSDC standard identifier used for their records is a modification of the COSPAR identifier. The leading 19 is omitted, and a serial experiment number and data set letter are appended (e.g., 66-008B-03F) as needed. Note that prior to 1963 a Greek letter was used instead of the launch serial number, followed by a number. NSSDC has renumbered these early satellites in accordance with the standard identifier. This NSSDC identifier is used in all indexes and references to spacecraft throughout the volume.

The other identifier, the "NORAD object number" (or more commonly known as just "object number") is a 5-digit serial number assignment made by the North American Defense (NORAD) satellite tracking facility. These are assigned when, and in the order of when, the tracking facility first identifies the satellite. These numbers are in common use primarily for Department of Defense (DOD) satellites that are initially classified, and then subsequently have unclassified or declassified results published in the literature. Some "object numbers" are included in the spacecraft brief descriptions.

Orbital parameters provided are approximate, with epoch date usually a few days after launch. The parameters given here are intended only to provide a crude description of the satellite path. They show considerable variation with time as expected, and also with resource of information. Two primary sources are the NORAD and the NASA tracking facilities.

Bibliography

For many reasons, no bibliography is included here. The primary reasons are that it would be very lengthy, would soon be out-of-date, and would require considerable additional effort, resulting in further delay of this publication. It is suggested that library machine listings, such as the NASA Scientific and Technical Information Facility (STIF) and the NSSDC Technical Reference File (TRF), be used to search for desired material. Combinations of satellite program name and any of several words related to meteorology need to be used to reduce the bibliography listings to manageable size. When listings of reasonable size cannot be obtained in this way, a manual scan of titles will usually eliminate items unlikely to be of use.

Historical Notes

The ability to obtain images of the earth from artificial earth satellites is the culmination of many years of various attempts by man to increase his perspective of the world in which he lives. The first high-level photography (beyond that of climbing high towers or mountains) was accomplished by a noted French photographer, Gaspard F. Tournachon, who began photographic balloon ascents over Paris in 1858. The value of the increased visual coverage was quickly realized, and several countries used balloons for military reconnaissance during the remaining years of the nineteenth century.

The first few years of the twentieth century saw balloons equipped with panoramic cameras ascending to heights of several thousand feet. Balloons were soon followed by rockets and airplanes that served as platforms for high-altitude photography. In 1905 Alfred Maul (Germany) began firing solid-propellant rockets equipped with cameras, and by 1912 photographs were being obtained from heights of 0.8 km.

The outbreak of World War I and the rising popularity of the airplane as a reconnaissance platform, in addition to its use as a combat vehicle, caused the work with rockets to slow down considerably. Balloons, however, continued to be used as reconnaissance platforms.

In the years following World War I, balloons were designed to attain even greater heights. In 1935 Albert Stevens took the first photograph showing the curvature of the earth from the National Geographic Society Explorer 2 balloon at an altitude of 22 km. The onset of World War II, however, brought the use of high-altitude balloon flights to a virtual standstill.

During World War II, a German group working at Peenemunde applied the pioneering work of Konstantin Tsiolkovsky, Hermann Oberth, and Robert H. Goddard to produce the V-2 rocket. This event revolutionized the technology of high-altitude probes and, in the post-war years, greatly extended the heights from which photographs could be obtained.

The study of the atmosphere and its weather systems from high altitudes began in earnest after World War II. During the late 1940's and early 1950's, many modified versions of captured German V-2 rockets equipped with cameras were launched from White Sands, New Mexico. In 1947 the first successful photographs of a large expanse of cloud cover were taken from a V-2 rocket at altitudes between 110 and 165 km. Many additional photographs were soon obtained from outside the atmosphere by V-2's, Viking rockets, Aerobee rockets, and various military ballistic missiles equipped with cameras. (See Table 2.)

Such flights demonstrated the feasibility and value of high-altitude photography for making synoptic observations of cloud systems and storms that would not have been detected by conventional ground-based observing networks. The desire for increased coverage established the need for a more permanent high-altitude monitoring platform, i.e., the meteorological satellite. The initial research-and-development satellites very quickly paved the way for the low-altitude, sun-synchronous[1] satellites. Continued development of technology paved the way for the earth-synchronous[2] satellites. They now provide high-resolution imagery for many purposes from an altitude of about 36,000 km above the equator. At present, both low- and high-altitude satellites work together on a global basis to provide useful information to the weather services of many nations.

The 1981 launch of NASA's first Space Transportation System, more commonly known as the Space Shuttle, marked a new era of manned space exploration. The Shuttle and the Spacelab (a joint venture with European countries) have contributed significantly to meteorological research. Instruments to be flown on operational weather satellites have been calibrated, and these earth

1 Sun-synchronous: With satellite orbit inclinations between 105 deg and 180 deg and an appropriate altitude between 185 km and 5900 km, a satellite orbit will move in the same direction and rate as the earth's rotation, i.e., 15 deg longitude per hour. For such an orbit, observations of the earth during each half orbit will be at the same solar time, since the position of the satellite (for any given latitude) will appear, to an earth observer, fixed relative to the sun.

2 Earth-synchronous: With satellite altitudes near 37,000 km, the satellite orbit will move in the same direction and rate as the earth's revolution about the sun, i.e., 360 deg per year. For such an orbit, observations of the earth are continuous over the same general longitudinal region of the earth. In the case with orbit inclination of zero, the satellite will appear to hover over a fixed equatorial longitude.

TABLE 2

EARTH PHOTOGRAPHY FROM EARLY ROCKETS

ROCKET FLIGHTS	ROCKET TYPE	LAUNCH SITE †	SPONSORING AGENCY†
NSSDC Rocket ID (RYYMM-DDSS)*			
R4610-2401	V-2	WSMR	APL
R4612-0501	V-2	WSMR	NRL
R4702-2001	V-2	WSMR	ARDC
R4703-0701	V-2	WSMR	NRL
R4704-0101	V-2	WSMR	APL
R4704-0901	V-2	WSMR	APL
R4705-1501	V-2	WSMR	NRL
R4707-2901	V-2	WSMR	APL
R4712-0801	V-2	WSMR	ARDC
R4805-2701	V-2	WSMR	APL
R4807-2601	Aerobee	WSMR	APL
R4807-2602	V-2	WSMR	APL
R4808-0501	V-2	WSMR	NRL
R4901-2801	V-2	WSMR	NRL
R4902-1701	V-2	WSMR	APL
R4903-2204	V-2	WSMR	ARDC
R4905-0301	Viking	WSMR	NRL
R4906-1402	V-2	WSMR	ARDC
R4909-0601	V-2	WSMR	NRL
R4912-0201	Aerobee	WSMR	ARDC
R5002-0901	Viking	WSMR	NRL
R5010-1201	Aerobee	WSMR	ARDC
R5011-2101	Viking	WSMR	NRL
R5102-0601	Aerobee	WSMR	APL
R5107-2501	Aerobee	WSMR	ARDC
R5205-2001	V-2	WSMR	SCEL
R5212-1501	Viking	WSMR	NRL
R5405-2401	Viking 11	WSMR	NRL
R5502-0401	Viking 12	WSMR	NRL
R6010-0521	Unknown	Ft. Churchill	GSFC
R6012-1901	Mercury Atlas	CPKF	NASA/MSC
R6105-0502	Mercury Atlas	CPKF	NASA/MSC

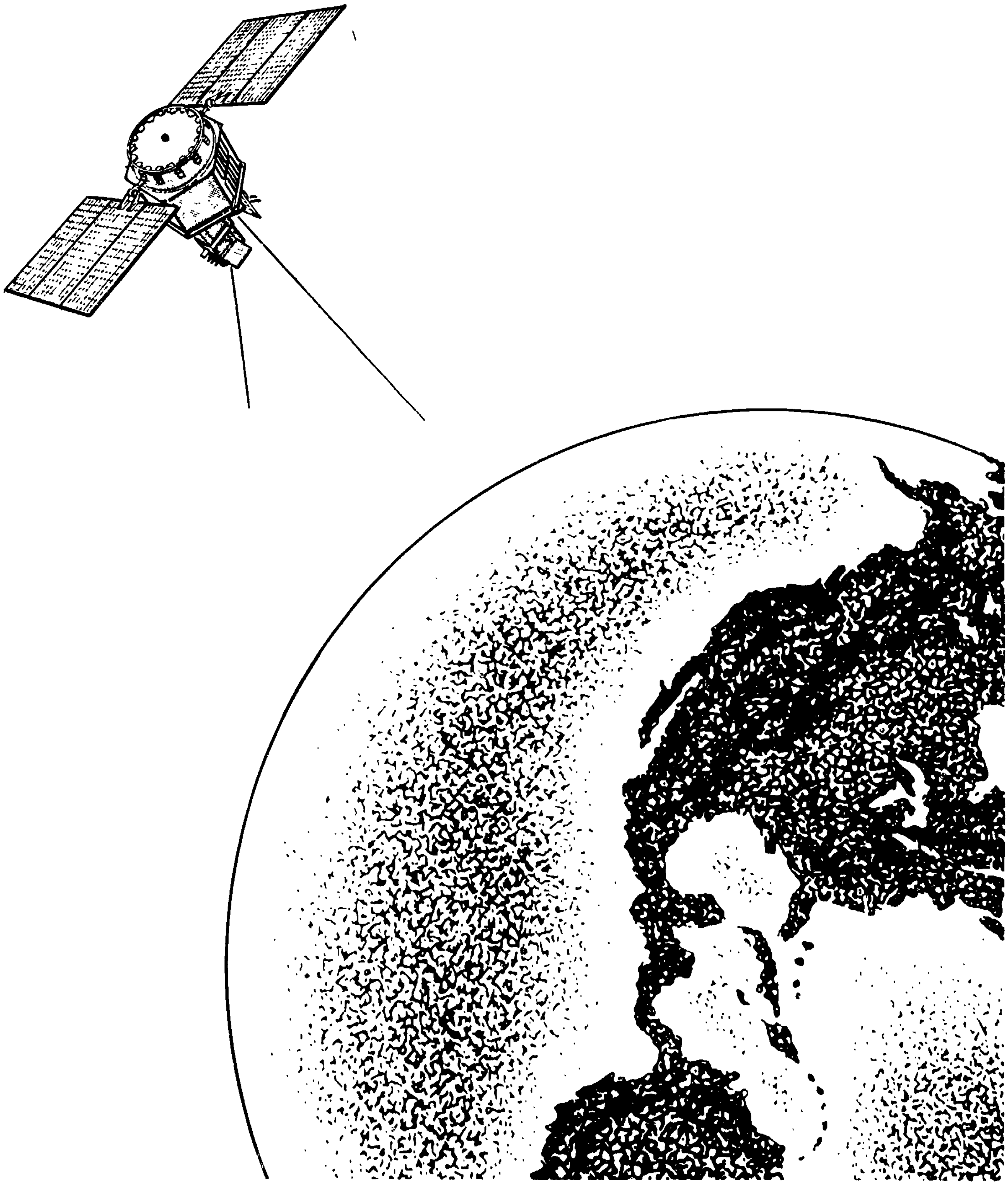
* R = Rocket file designator
YY = year of launch
MM = month of launch
DD = day of launch
SS = sequence number

† See Appendix B: Abbreviations and Acronyms

observation capabilities will be expanded when NASA and the National Oceanic and Atmospheric Administration (NOAA) collaborate on the Space Station polar platform activities during the 1990's. Observations will be made in high-altitude, sun-synchronous polar orbits to view the entire planet. Instruments such as medium-resolution imaging radiometer, infrared sounder, and microwave sounder are being planned for these programs.

II. METEOROLOGICAL SPACE PROGRAMS, SATELLITES, AND EXPERIMENTS

AEM



APPLICATIONS EXPLORER MISSION (AEM) PROGRAM

The Applications Explorer Mission (AEM) spacecraft were relatively low-cost spacecraft built to meet individual particular space observation needs regarding the earth and its atmosphere. Three satellites have been launched since April 1978: (1) AEM-A, the Heat Capacity Mapping Mission (HCMM); (2) AEM-B, the Stratospheric Aerosol Gas Experiment (SAGE); and (3) AEM-C, the Magnetic Field Satellite (Magsat). A fourth satellite, the Earth Radiation Budget Satellite (ERBS), was originally designated as AEM-D but is no longer part of the program. Each of the three launched spacecraft carried only one instrument. Although each was designed for 1 year of life, HCMM operated between April 1978 and September 1980, and SAGE remained in operation for 2 1/2 years, from May 1979 to November 1981. Since Magsat did not produce any meteorological data, it is not discussed here.

The primary purpose of the HCMM mission was to estimate the thermal inertia of the earth's surface at the time of daily maximum and minimum temperatures. The spacecraft was launched into a 620-km circular, sun-synchronous orbit, covering the areas between 85 deg N and 85 deg S. The instrument, the Heat Capacity Mapping Radiometer (HCMR), operated in visible to (0.5 to 6.micrometers) and IR (10.5 to 12.5 micrometers) channels. The radiometer had a scan angle of 60 deg to produce a swath width of 720 km with a ground resolution of 500 m for the reflectance channel, and of 600 m for the IR channel.

It acquired data from both channels during the day and only thermal infrared data during the night. Although the HCMM mission was designed for earth resource studies, the derived apparent albedos, earth surface temperatures, and snow cover can be used for meteorological studies. The disadvantage of the HCMM data was that the spacecraft did not possess an onboard tape recorder system. Only data within the receiving range of ground stations were collected, mainly in North America (including Alaska), Europe, and eastern Australia.

The main objective of SAGE was to determine the global distribution of stratospheric aerosols and ozone from 79 deg S to 79 deg N. The spacecraft was launched into a 55-deg-inclined, 600-km circular orbit. The onboard SAGE experiment measured the extinction coefficients of the solar wavelengths (0.38, 0.45, 0.6, and 1.0 micrometer) through the earth's atmosphere during spacecraft sunset and sunrise. Earlier models of the sensor were flown on the Apollo/Soyuz Test Project in 1975 and the Nimbus 7 in 1978. The data are used toward a better understanding of the role of aerosols and ozone in the radiation balance of the earth's environment on a global scale.

Both HCMM and SAGE suffered power problems because of early deterioration of the batteries. Data are available from NSSDC.

**************************** HCMM ****************************

SPACECRAFT COMMON NAME- HCMM
ALTERNATE NAMES- SATS, APPL EXPL MISSION A
HEAT CAPACITY MAP MSN, AEM-A
10818

NSSDC ID- 78-041A

LAUNCH DATE- 04/26/78 WEIGHT- 117. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- SCOUT-F

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSTA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 04/27/78
ORBIT PERIOD- 96.7 MIN INCLINATION- 97.6 DEG
PERIAPSIS- 558. KM ALT APOAPSIS- 646. KM ALT

PERSONNEL
PM - C.M. MACKENZIE NASA-GSFC
PS - R.E. MURPHY NASA-GSFC
PS - J.C. PRICE(NLA) NASA-GSFC

BRIEF DESCRIPTION

The Heat Capacity Mapping Mission (HCMM) spacecraft was the first of a series of Applications Explorer Missions (AEM). The objective of the HCMM was to provide comprehensive, accurate, high-spatial-resolution thermal surveys of the surface of the earth. The HCMM spacecraft was made of two distinct modules: (1) an instrument module, containing the heat capacity mapping radiometer and its supporting gear, and (2) a base module, containing the data handling, power, communications, command, and attitude control subsystems required to support the instrument module. The spacecraft was spin stabilized at a rate of 14 rpm. The HCMM circular sun-synchronous orbit allowed the spacecraft to sense surface temperatures near the maximum and minimum of the diurnal cycle. The orbit had a daylight ascending node with nominal equatorial crossing time of 2:00 p.m. Since there was no inclination adjustment capacity, the spacecraft drifted from this crossing time by about 1 hour earlier per year. There was no on-board data storage capability, so only real-time data were transmitted when the satellite came within reception range of seven ground stations. The repeat cycle of the spacecraft was 16 days. Day/night coverage over a given area between the latitudes of 85 deg N and 85 deg S occurred at intervals ranging from 12 to 36 h (once every 16 days). During February 21-23, 1980, the HCMM orbital altitude was lowered from 620 km to 540 km to stop the drift of the orbit plane to unfavorable sun angles which in turn reduced the power collection capability of the solar panels. The operations of the spacecraft were terminated on September 30, 1980. More detailed information can be found in the "Heat Capacity Mapping Mission Users' Guide" (TRF B30282), available from NSSDC.

------- HCMM, BARNES ---

INVESTIGATION NAME- HEAT CAPACITY MAPPING RADIOMETER

NSSDC ID- 78-041A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY
METEOROLOGY

PERSONNEL
PI - W.L. BARNES NASA-GSFC

BRIEF DESCRIPTION

The objectives of the Heat Capacity Mapping Radiometer (HCMR) were (1) to produce thermal maps at the optimum times for making thermal-inertia studies for discrimination of rock types and mineral resources location, (2) to measure plant-canopy temperatures at frequent intervals to determine the transpiration of water and plant life, (3) to measure soil-moisture effects by observing the temperature cycle of soils, (4) to map thermal effluents, both natural and man-made, (5) to investigate the feasibility of geothermal source location by remote sensing, and (6) to provide frequent coverage of snow fields for water runoff prediction. The HCMR transmitted analog data in real time to selected receiving stations. The radiometer was similar to the surface composition mapping radiometer (SCMR) of Nimbus 5 (72-097A). The HCMR had a small instantaneous geometric field of view of 0.83 mrad, high radiometric accuracy, and a wide 716-km swath coverage on the ground so that selected areas were covered within the 12-h period corresponding to the maximum and minimum of temperature observed. The instrument operated in two channels, 10.5 to 12.5 micrometers (IR) and 0.55 to 1.1 micrometers (visible). The spatial resolution was approximately 600 m at nadir for the IR channel, and 500 m for the visible channel. The instrument utilized a radiation cooler to cool the two Hg-Cd-Te detectors to 115 K. The experiment included an analog multiplexer that accepted the analog outputs of the detectors and multiplexed them in a form suitable for transmission by the spacecraft S-band transmitter. The instrument performed satisfactorily until the spacecraft operations terminated on September 30, 1980. More detailed information can be found in the "Heat Capacity Mapping Mission Users' Guide" (TRF B30282), available from NSSDC. Data are available from NSSDC and Earthnet Users Services, via Galileo Galilei, C.P. 64, 00044 Frascati, Italy.

**************************** SAGE ****************************

SPACECRAFT COMMON NAME- SAGE
ALTERNATE NAMES- AEM-B, STRAT AERO AND GAS EXP
APPL EXPL MISSION B, 11270

NSSDC ID- 79-013A

LAUNCH DATE- 02/18/79 WEIGHT- 148.7 KG
LAUNCH SITE- WALLOPS FLIGHT CENTER, UNITED STATES
LAUNCH VEHICLE- SCOUT-F

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSTA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 02/19/79
ORBIT PERIOD- 96.8 MIN INCLINATION- 54.9 DEG
PERIAPSIS- 547.5 KM ALT APOAPSIS- 660.2 KM ALT

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BRIEF DESCRIPTION

The Stratospheric Aerosol and Gas Experiment (SAGE) spacecraft was the second of the Applications Explorer Missions (AEM). The small, versatile, low-cost spacecraft was made of two distinct parts: (1) the SAGE instrument module containing the detectors and the associated hardware, and (2) the base module containing the necessary data handling, power, communications, command, and attitude control subsystem to support the instrument mode. The objective of the SAGE mission was to obtain stratospheric aerosol and ozone data on a global scale for a better understanding of the earth's environmental quality and radiation budget. The spacecraft was designed for a 1-year life in orbit. The spacecraft experienced power problems after May 15, 1979. Spacecraft operations continued until November 19, 1981. The signal from the spacecraft was last received on January 7, 1982, when the battery failed. For more detailed information, see "Satellite studies of the stratospheric aerosol" by M. P. McCormick, et al., Bull. Am. Meteorol. Soc., v. 60, pp. 1038-1046, 1979.

------- SAGE, MCCORMICK ---

INVESTIGATION NAME- STRATOSPHERIC AEROSOL AND GAS EXPERIMENT
(SAGE)

NSSDC ID- 79-013A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
UPPER ATMOSPHERE RESEARCH
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OI - P.B. RUSSELL SRI INTERNATIONAL

BRIEF DESCRIPTION

The objectives of the Stratospheric Aerosol and Gas Experiment (SAGE) were to determine the spatial distribution of stratospheric aerosols and ozone on a global scale. Specific objectives were (1) to develop a satellite-based remote-sensing technique for stratospheric aerosols and ozone measurements, (2) to map aerosol and ozone concentrations on a time scale shorter than major stratospheric changes, (3) to locate stratospheric aerosol and ozone sources and sinks, (4) to monitor circulation and transfer phenomena, (5) to observe hemisphere differences, and (6) to investigate the optical properties of aerosols and assess their effects on global climate. The SAGE instrument was a radiometer consisting of a Gregorian telescope and a detector subassembly which measured the attenuation of solar radiation at four wavelengths (0.385, 0.45, 0.6, and 1.0 micrometer) during solar occultation. As the spacecraft emerged from the earth's shadow, the sensor scanned the earth's atmosphere from the horizon up, and measured the attenuation of solar radiation by different atmospheric layers. This procedure was repeated during spacecraft sunset. Two vertical scannings were obtained during each orbit, with each scan requiring approximately 1 min of time to cover the atmosphere above the troposphere. The instrument had a field of view of approximately 0.15 mrad which resulted in a vertical resolution of about 1 km. Spatial coverage extended from about 79 deg N to 79 deg S latitude and thus complemented the coverage (64 deg N to 80 deg N and 64 deg S to 80 deg S) of the SAM II on Nimbus 7. The instrument performed satisfactorily. Because of power problems, the data collection was limited to sunset events after June 1979, and was eventually terminated on November 18, 1981. Both NSSDC and the World Ozone Data Center, Atmospheric Environmental Services, 4905 Duffins St., Downsview, Ontario, M3H 5T4 Canada, [illegible] data.

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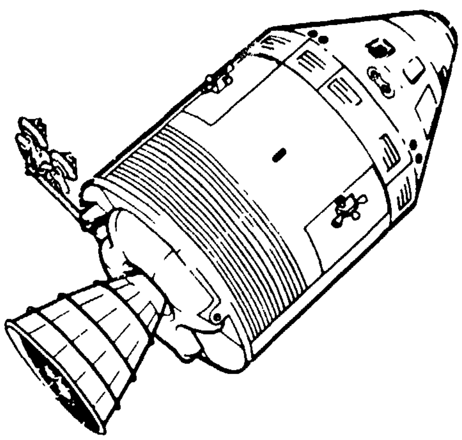
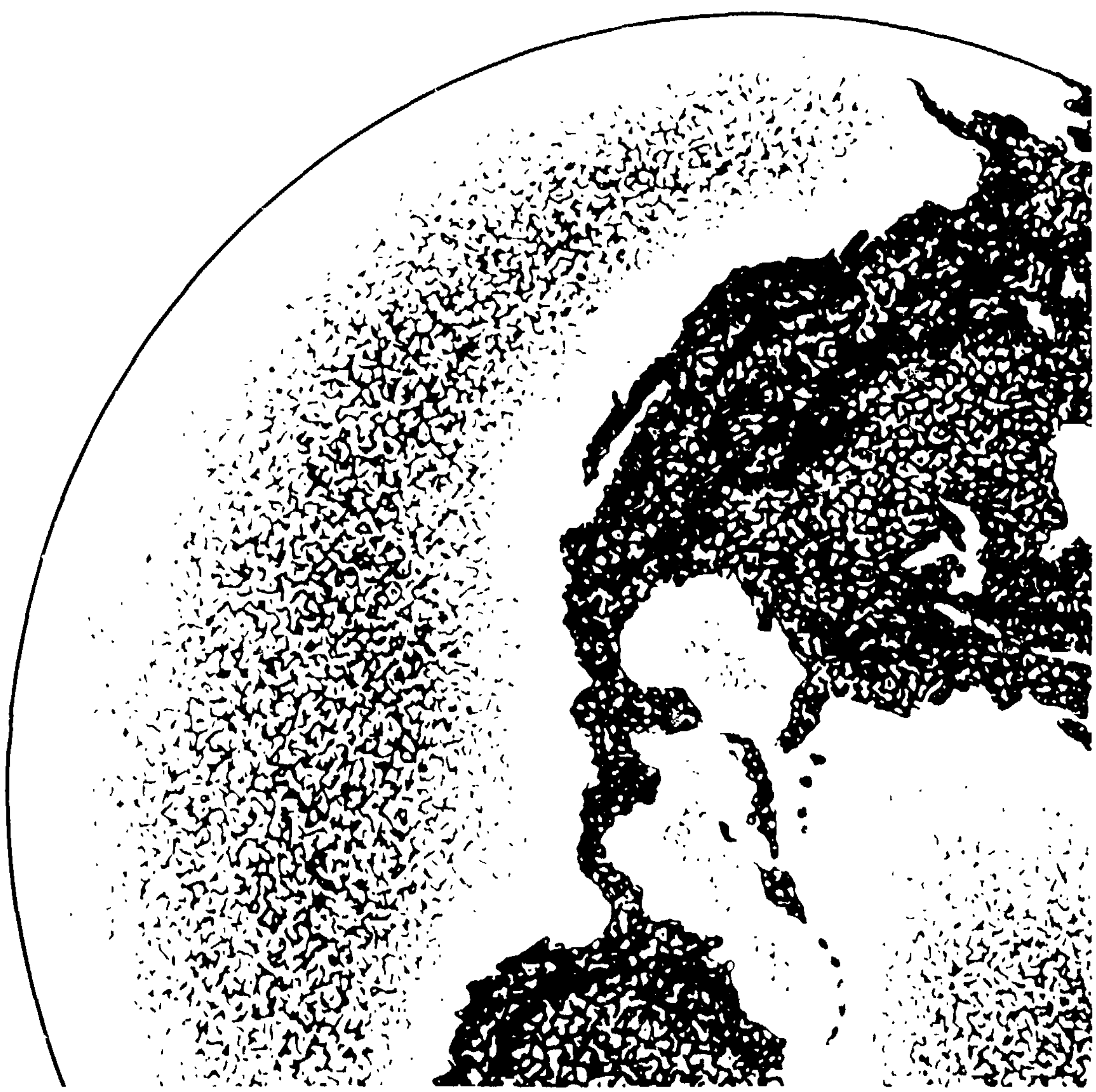
APOLLO





APOLLO PROJECT

Apollo 1-7, 9, and 18* were placed in earth orbit (1-3 were suborbital), and of these only the last three (7, 9, and 18) were manned. All of them were launched by the Saturn 1B configuration, with the exception of Apollo 4 and 6, for which the Saturn 5 was used. All of these flights were primarily to test and evaluate equipment to be used for the lunar flights, except for the scientific-political flight of Apollo 18. Apollo 10-17 were all manned lunar flights. Apollo 8 and 10 were test flights with a test of the lunar module. Apollo 11-17 were planned lunar landing missions. Of these seven landers, only Apollo 13 failed to land due to an inflight explosion; however, the flight path circumnavigating the moon and returning to earth was successfully accomplished. An earth photography experiment was included on Apollo 6-18. All photographs were taken by means of hand-held Hasselblad 70-mm and Maurer 16-mm cameras with the exception of the unmanned Apollo 6, on which a fixed mount, sequencing camera was used. The Apollo pictures were used for a variety of purposes including: initial development of stereo techniques from satellite photography, storm case studies, and optimizing techniques, altitudes, and observing equipment for meteorological imaging experiments and operational sensors. An excellent, somewhat detailed summary of all Apollo photographic instrumentation may be found in NSSDC Publication 77-2 (p. 5, pp. 54-89). All Apollo earth photographs are available through the EROS Data Center. Table 3 is a listing of all Apollo launches with the major characteristics of each flight noted.

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* Apollo 18 and Soyuz 19 (1975-065A and 1975-066A), more frequently referred to as Apollo Soyuz, were launched independently and then docked in orbit. The crews jointly accomplished various observations and tests, undocked, and made their separate descents (also refer to the Soyuz Project).

TABLE 3
APOLLO PROGRAM

Apollo Vehicle Number	NSSDC ID	Launch Date (MMDD)	Launch Vehicle (1B=Saturn 1B, 5=Saturn 5)	Orbit (S=Suborbital, E=Earth, L=Lunar)	Module	Lunar Landing	Rover	Earth Photography	Crew/Remarks
1	(1966)	02-26	1B	S					LV and SC test
2	(1966)	07-05	1B	S					LV and SC test
3	(1966)	08-25	1B	S					LV and SC test
4	67-113A	11-09	5	E				X	LV and SC test
5	68-007A/B	01-22	1B	E					Hardware and Systems Test
6	68-025A	04-04	5	E				X	Hardware and Systems Demonstration
7	68-089A	10-11	1B	E				X	Schirra, Cunningham, Eisele
8	68-118A	12-21	5	L				X	Borman, Lovell, Anders
9	69-018A	03-03	5	E				X	McDivitt, Scott, Schweickert
10	69-043A	05-18	5	L	X			X	Stafford, Young, Cernan
11	69-059A/C	07-16	5	L	X	X		X	Armstrong, Aldrin, Collins
12	69-099A/C	11-14	5	L	X	X		X	Conrad, Bean, Gordon
13	70-029A/C	04-11	5	L	X			X	Lovell, Swigert, Haise
14	71-008A/C	01-31	5	L	X	X		X	Shepard, Mitchell, Roosa
15	71-063A/C/D	07-26	5	L	X	X	X	X	Scott, Irwin, Worden
16	72-031A/C/D	04-16	5	L	X	X	X	X	Young, Duke, Mattingly
17	72-096A/C	12-07	5	L	X	X	X	X	Cernan, Schmitt, Evans
18	75-066A	07-15	1B	E				X	Stafford, Slayton, Brand

**************************** APOLLO 8 ****************************

SPACECRAFT COMMON NAME- APOLLO 8
ALTERNATE NAMES- PL-684M, 03626

NSSDC ID- 68-118A

LAUNCH DATE- 12/21/68 WEIGHT- 9979. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN 5

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL

BRIEF DESCRIPTION

This spacecraft was the first of the Apollo series to successfully orbit the moon. The mission achieved operational experience and tested the Apollo command module systems. The crew photographed the lunar surface, both farside and nearside, obtaining information on topography and landmarks as well as other scientific information necessary for future Apollo landings. The spacecraft was launched on December 21, 1968, and was placed in an elliptical lunar orbit at 69 h 8 min ground elapsed time for two orbits. It was later placed in a near-circular lunar orbit of 110.4 by 112.3 km for eight orbits. The mission was considered nominal and was completed on December 27, 1968, at 147 h after launch.

------- APOLLO 8, ALLENBY, JR.-------------------------------

INVESTIGATION NAME- APOLLO 8 PHOTOGRAPHIC STUDIES

NSSDC ID- 68-118A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - R.J. ALLENBY, JR. NASA HEADQUARTERS

BRIEF DESCRIPTION

The Apollo 8 mission utilized two 70-mm Hasselblad cameras with two 80-mm lenses, a 250-mm lens, and associated equipment such as filters, ringsight, spotmeter, and an intervalometer for stereo strip photography. It also carried a 16-mm Maurer camera with 200-, 75-, 18-, and 5-mm lenses, a right-angle mirror, and a boresight bracket. The purpose of this photographic equipment was (1) to acquire vertical and oblique overlapping photographs of the lunar farside, (2) to photograph "targets of opportunity," and (3) to record operational activities. Seven magazines of 70-mm film and five magazines of 16-mm film were used for lunar photography. A complete description of the experiment can be found in a Data Announcement Bulletin, NSSDC 69-06, available at NSSDC by request.

**************************** APOLLO 9 ****************************

SPACECRAFT COMMON NAME- APOLLO 9
ALTERNATE NAMES- PL-691M, SA-504
03769

NSSDC ID- 69-018A

LAUNCH DATE- 03/03/69 WEIGHT- 11205. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 03/04/69
ORBIT PERIOD- 88.64 MIN	INCLINATION- 32.57 DEG
PERIAPSIS- 203. KM ALT	APOAPSIS- 229. KM ALT

PERSONNEL
PM - W.C. SCHNEIDER(RETIRED) NASA HEADQUARTERS
PM - C.W. MATHEWS(RETIRED) NASA HEADQUARTERS

BRIEF DESCRIPTION

Apollo 9, which was composed of a command module (CM), a command service module (CSM), a lunar module (LM), and an instrument unit (IU), was launched by a Saturn V rocket on March 3, 1969, from Cape Kennedy into a nominal orbit of 102.3 by 103.9 n.m. (166 by 166 km). The crew were commander J.R. McDivitt, CM pilot D.R. Scott, and LM pilot R.L. Schweickart. The vehicle rocket had three stages, S-IC, S-II, and S-IVB. The CM, a cone-shaped craft about 390 CM in diameter at the large end, served as a command, control, and communications center. Supplemented by the SM, it provided all life support elements for the three crewmen. The CM was capable of attitude control about three axes and some lateral lift translation. It permitted LM attachment and CM/LM ingress and egress and served as a buoyant vessel at sea. The CMS provided the main propulsion and maneuvering capability. It was jettisoned just before CM reentry. The CSM was a cylinder 390 cm in diameter. The LM was a two-stage vehicle that accommodated two men and could transport them to the lunar surface. On Apollo 9 the CM and LM were separated and some maneuvers, including docking, were completed, but the LM did not land because this was an earth-circling mission. The LM had its own propulsion, communication, and life support systems. All systems worked nearly normally.

------- APOLLO 9, ALLENBY, JR.-------------------------------

INVESTIGATION NAME- 70-MM HASSELBLAD SPECTRAL TERRAIN PHOTOGRAPHS

NSSDC ID- 69-018A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - R.J. ALLENBY, JR. NASA-GSFC

BRIEF DESCRIPTION

The S065 multispectral terrain photography experiment was designed (1) to obtain multispectral photographs from space over selected land and ocean areas, (2) to determine the usefulness of this type of photography for earth resources, and (3) to define future multispectral photographic systems. A total of 584 pictures were obtained by four electrically driven, model 500-El Hasselblad cameras, each with different film-filter combinations and fitted with Zeiss f/2.8 80-mm planar lenses. The cameras were operated simultaneously, and a manual intervalometer was used to obtain systematic overlapping (stereo) photographs. The cameras were mounted coaxially on a metal bracket designed to fit the circular command module hatch window. The cameras were preset, and thus no adjustments were made by the crew. The shutters were triggered simultaneously at predetermined intervals (between 5 and 10 sec) by a manual electric switch controlled by an astronaut. Film-filter combinations (and number of photos obtained) were as follows - (1) infrared Ektachrome type SO-180 color IR film - Photar 15 filter sensitive to 510 to 900 mu (139), (2) Panatomic-X type 3400 black and white panchromatic film - Photar 58 filter sensitive to 460 to 610 mu (159), (3) infrared aerographic type SO-246 black and white infrared film - Photar 89b filter sensitive to 700 to 900 mu (127), and (4) Panatomic-X type 3400 black and white panchromatic film - Photar 25A filter sensitive to 580 mu into the IR region (159). The regions photographed included the Southwestern United States (south of 34 deg N lat), Northwestern Mexico, the South Central and Southeastern United States, Southern Mexico, and the Caribbean-Atlantic region. The handheld photography was obtained simultaneously with the four-camera multispectral photography. The experiment was very successful as to quantity and quality of photographs obtained. A more complete description of this experiment is available in "Apollo 9 multispectral photographic information," NASA TM X-1957, April 1970.

**************************** APOLLO 10 ****************************

SPACECRAFT COMMON NAME- APOLLO 10
ALTERNATE NAMES- PL-692F, 03941

NSSDC ID- 69-043A

LAUNCH DATE- 05/18/69 WEIGHT- 9979. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL
PM - S.C. PHILLIPS NASA HEADQUARTERS

BRIEF DESCRIPTION

This spacecraft was the second Apollo mission to orbit the moon, check out the Apollo systems in the vicinity of the moon, and obtain numerous photographs of the lunar surface. Apollo 10 accomplished lunar orbit 4 days after the May 18, 1969 launch. Both the command service module (CSM) and the lunar module (LM), which undocked and came within 50,000 ft (15,400 m) of the lunar surface, performed successfully. The command module (CM) and crew returned to earth on May 26, 1969.

------- APOLLO 10, ALLENBY, JR.-------------------------------

INVESTIGATION NAME- APOLLO 10 PHOTOGRAPHIC STUDIES

NSSDC ID- 69-043A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - R.J. ALLENBY, JR NASA HEADQUARTERS
OI - J.H. SASSER NASA-JSC

BRIEF DESCRIPTION

Apollo 10 carried photographic equipment and materials to (1) obtain photographs of the transposition, docking, lunar module ejection maneuver, and LM rendezvous sequence from both the command and lunar modules, (2) obtain photos of the lunar ground track and of landing site no. 2 from the low point of the LM flight path, (3) record operational activities of the crew, and (4) obtain long-distance earth and lunar terrain photographs. Camera equipment carried aboard Apollo 10

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consisted of two 70-mm Hasselblad cameras, each fitted with 80-mm f/2.8 Zeiss planar lenses, a 250-mm telephoto lens stowed aboard the command module, and associated equipment (filters, ringsight, spotmeter, and an intervalometer for stereo strip photography). For motion pictures, two 16-mm Maurer data acquisition cameras (one in the CSM and one in the LM), with variable frame speed selection, were used. Motion picture camera accessories included bayonet-mounted lenses of 75-, 18-, and 5-mm focal lengths, a right-angle mirror, a command module boresight bracket, a power cable, and an adapter for shooting through the sextant. A Data Announcement Bulletin presenting the photographic coverage and format of available data can be obtained from NSSDC by requesting NSSDC Publication 69-14.

************************** APOLLO 11 CSM********************

SPACECRAFT COMMON NAME- APOLLO 11 CSM
ALTERNATE NAMES- PL-693H, SA-506
04039

NSSDC ID- 69-059A

LAUNCH DATE- 07/16/69 WEIGHT- 28860. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL
PM - S.C. PHILLIPS NASA HEADQUARTERS

BRIEF DESCRIPTION
The Apollo 11 spacecraft was part of the first mission in which men landed on the lunar surface and returned to earth. The spacecraft consisted of three modules -- a command module (CM), a lunar module (LM), and a command service module (CSM). After the spacecraft orbited the moon, the LM and CSM separated. Two astronauts in the LM landed on the lunar surface at the sea of tranquility (0.67 deg N latitude and 23.49 deg E longitude), while one remained in lunar orbit in the command module. Scientific studies were performed, and soil and rock samples were acquired by the astronauts during a moonwalk. The men returned to the LM, docked the LM and the CSM, and returned to earth. The Apollo 11 spacecraft was launched on July 16, 1969 and was injected into lunar orbit on July 19. The LM (69-059C) landed on the moon on July 20, 1969 and returned to the command module on July 21. The command module left lunar orbit on July 22 and returned to earth on July 24, 1969. A laser ranging retroreflector and a passive seismograph experiment were left on the moon. The performance of the spacecraft was excellent throughout the mission.

------- APOLLO 11 CSM, MAPPING SCIENCES LAB-------------------

INVESTIGATION NAME- APOLLO 11 PHOTOGRAPHIC STUDIES

NSSDC ID- 69-059A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - MAPPING SCIENCES LAB NASA-JSC

BRIEF DESCRIPTION
Apollo 11 carried photographic equipment and materials to (1) obtain photographs of the transposition, docking, lunar module ejection maneuver, and the LM rendezvous sequence from both the command and lunar modules, (2) obtain photos of the lunar ground track and of the landing site from the low point of the LM's flight path, (3) record the operational activities of the crew, (4) obtain long-distance earth and lunar terrain photographs with 70-mm still cameras, and (5) obtain photographs of lunar surface features and of the activities of the two astronauts who landed on the moon. The camera equipment carried by Apollo 11 consisted of one 70-mm Hasselblad electric camera, two Hasselblad 70-mm lunar surface superwide-angle cameras, one Hasselblad El data camera, two 16-mm Maurer data acquisition cameras, and one 35-mm lunar surface stereoscopic closeup camera. Various lenses were used with these cameras for specific types of photography. The photographs taken included 1359 frames of 70-mm format, 58,134 frames of 16-mm photography, and 17 stereoscopic pairs. A users' package that contains detailed information about the photographic equipment and coverage, availability of and ordering procedures for photography and proof prints for the Apollo 11 photography is available from NSSDC. Requesters should ask for NSSDC 70-06.

************************** APOLLO 12 CSM********************

SPACECRAFT COMMON NAME- APOLLO 12 CSM
ALTERNATE NAMES- PL-6931, SA-507
04225

NSSDC ID- 69-099A

LAUNCH DATE- 11/14/69 WEIGHT- 28850. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS
PS - M.W. MOLLOY NASA HEADQUARTERS

BRIEF DESCRIPTION
The Apollo 12 spacecraft was part of the second mission in which men landed on the moon and returned to earth. The spacecraft consisted of three modules -- a command module (CM), a command service module (CSM), and a lunar module (LM). The lunar module landed two men on the surface of the moon in the vicinity of Surveyor 3, while the piloted command module continued in orbit. An Apollo lunar surface experiments package (ALSEP) was placed on the lunar surface, samples of the lunar terrain were acquired, and various photographs of 16-, 35-, and 70-mm film sizes were exposed from the lunar and command modules and by the astronauts during lunar surface activities. The Apollo 12 spacecraft was launched on November 14, 1969, and was injected into lunar orbit on November 18. The LM (69-099C) landed on the moon on November 19 and returned to the command module on November 20. The command module left lunar orbit on November 22 and returned to earth on November 24, 1969. Performance was very good for all aspects of the mission.

------- APOLLO 12 CSM, GOETZ-----------------------------------

INVESTIGATION NAME- MULTISPECTRAL PHOTOS

NSSDC ID- 69-099A-09 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - A.F.H.GOETZ NASA-JPL

BRIEF DESCRIPTION
The S-158 multispectral experiment camera group consisted of four Hasselblad cameras, side-by-side on a common mount, each fitted with a different filter and type of film. The objective of the experiment was to obtain photographs showing lunar surface color variations for use in geologic mapping and correlation with surface samples from spectral reflectance.

------- APOLLO 12 CSM, MAPPING SCIENCES LAB-------------------

INVESTIGATION NAME- APOLLO 12 PHOTOGRAPHIC STUDIES

NSSDC ID- 69-099A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - MAPPING SCIENCES LAB NASA-JSC

BRIEF DESCRIPTION
Apollo 12 carried photographic equipment and materials to (1) obtain photographs of the transposition, docking, lunar module ejection maneuver, and the LM rendezvous sequence from both the command and lunar modules, (2) obtain photos of the lunar ground track and of the landing site from the low point of the LM's flight path, (3) record the operational activities of the crew, (4) obtain long-distance earth and lunar terrain photographs with 70-mm still cameras, and (5) obtain photos of lunar surface features and of the activities of the astronauts who landed on the moon. The camera equipment carried by Apollo 12 consisted of one 70-mm Hasselblad electric camera, two Hasselblad data cameras, two 16-mm Maurer data acquisition cameras, one 35-mm lunar surface stereoscopic closeup camera, and a four-camera, multispectral, S-158 experiment. Various lenses were used with these cameras for specific types of photography. The photographs included 1584 frames of 70-mm format, 69,519 frame, of 16-mm format, 15 stereoscopic pairs, and 552 frames of photography from the S-158 experiment. A user's package containing detailed information about the photographic equipment and coverage, availability of photographs, ordering procedures, and proof prints for the Apollo 12 photography is available from NSSDC. Requesters should ask for NSSDC 70-09.

************************** APOLLO 13 CSM********************

SPACECRAFT COMMON NAME- APOLLO 13 CSM
ALTERNATE NAMES- PL-7010, SA-508
04371

NSSDC ID- 70-029A

LAUNCH DATE- 04/11/70 WEIGHT- 9979. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS
PS - M.W. MOLLOY NASA HEADQUARTERS

BRIEF DESCRIPTION
Apollo 13 was launched on April 11, 1970, on a scheduled 10-day lunar landing mission. The purposes of the mission were (1) to explore the hilly upland Fra Mauro region of the moon, (2) to perform selenological inspection, survey, and sampling of material in the Fra Mauro formation, (3) to deploy and activate an Apollo lunar surface experiments package (ALSEP), (4) to further develop man's capability to work in the lunar environment, and (5) to obtain photographs of candidate lunar exploration sites. These goals were to be carried out from a near-circular lunar orbit and on the lunar surface at 3 deg S latitude, 17 deg W longitude. Because of a malfunction in the command service module, which made the command module (CM) unusable for the mission, the mission had to be aborted. The crew transferred to the lunar module and performed a free-return trajectory, returning to the CM only prior to entering the earth's atmosphere. Although the planned mission objectives were not realized, a limited amount of photographic data was obtained.

------- APOLLO 13 CSM, MAPPING SCIENCES LAB-------------------

INVESTIGATION NAME- APOLLO 13 PHOTOGRAPHIC STUDIES

NSSDC ID- 70-029A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - MAPPING SCIENCES LAB NASA-JSC

BRIEF DESCRIPTION
The photographic objectives of the Apollo 13 mission were (1) to photograph targets of opportunity (scientifically interesting sites and potential Apollo landing sites), (2) to obtain vertical and oblique stereo strips of nearside and farside regions of scientific interest, (3) to record mission operational activities, including the operations and maneuvers of the command service module, the command module, and lunar module, and (4) to obtain photos of lunar surface features, before and after landing, and long-distance earth photographs. The camera equipment carried onboard the spacecraft consisted of two 70-mm Hasselblad electric cameras, two 70-mm Hasselblad data cameras, two 16-mm Maurer data acquisition cameras, one 35-mm lunar surface stereoscopic closeup camera, and one Hycon topographic camera. Because the mission was aborted, only the two Hasselblad 70-mm electric cameras and the two Maurer data acquisition cameras were used, and photographic coverage included only a limited amount of lunar surface and photographs of mission operational activities. This photographic coverage, which is of good to fair quality, includes 584 frames of 70-mm photography and 22,073 frames of 16-mm photography.

*************************** APOLLO 14 CSM*********************

SPACECRAFT COMMON NAME- APOLLO 14 CSM
ALTERNATE NAMES- PL-704A, 04900

NSSDC ID- 71-008A

LAUNCH DATE- 01/31/71 WEIGHT- 29290. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS
I - UNKNOWN UNKNOWN

BRIEF DESCRIPTION
This spacecraft was the third Apollo mission to land men on the moon. On February 5, 1971, the lunar module (LM) landed two men in the hilly upland region 24 km north of the rim of Fra Mauro crater, while the piloted command module (CM) continued in a lunar equatorial orbit. The Apollo lunar surface experiments package (ALSEP) was placed on the surface of the moon, and samples of the lunar surface were acquired. Various frames of 16-mm, 35-mm, 70-mm, and 5-in. mapping film were exposed by the astronauts from the LM and CM and on the lunar surface. Performance was good for most aspects of the mission. The Apollo 14 spacecraft was launched on January 31, 1971, and was injected into lunar orbit on February 4. The LM (71-008C) landed on the moon on February 5 and returned to the command module on February 6. The command module left lunar orbit on February 7 and returned to earth on February 9, 1971.

------- APOLLO 14 CSM, EL-BAZ--------------------------------

INVESTIGATION NAME- ORBITAL AND SURFACE PHOTOGRAPHY

NSSDC ID- 71-008A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F. EL-BAZ SMITHSONIAN INST

BRIEF DESCRIPTION
Apollo 14 was equipped with photographic equipment and materials to (1) obtain photographs of the transposition, docking, lunar module (LM) ejection maneuver, and the LM rendezvous sequence from the command and lunar modules, (2) obtain mapping type photos of the lunar ground track and of potential landing sites from the low point of the LM's flight path, (3) record the operational activities of the crew, (4) obtain long-distance earth and lunar terrain photographs with 70-mm still cameras, and (5) obtain photos of lunar surface features and activities after landing. The camera equipment carried by Apollo 14 consisted of two 70-mm Hasselblad electric cameras, two Hasselblad data cameras, three 16-mm Maurer data acquisition cameras, one 35-mm lunar surface stereoscopic camera, and one Hycon topographic mapping camera. Various lenses were used with these cameras for specific types of photography. The performance for all the cameras was good except for the Hycon camera, which experienced a shutter problem that resulted in over-exposed film.

*************************** APOLLO 15 CSM*********************

SPACECRAFT COMMON NAME- APOLLO 15 CSM
ALTERNATE NAMES- 05351

NSSDC ID- 71-063A

LAUNCH DATE- 07/26/71 WEIGHT- 57760. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

ORBIT PARAMETERS
ORBIT TYPE- SELENOCENTRIC EPOCH DATE- 07/30/72
ORBIT PERIOD- 119.0 MIN INCLINATION- 26. DEG
PERIAPSIS- 90.0 KM ALT APOAPSIS- 115.0 KM ALT

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS

BRIEF DESCRIPTION
Apollo 15 was the fifth spacecraft (fourth accomplished) and the first of the J-series Apollo missions designed to land men on the moon. The lunar landing site for the 12-day scientific mission was the Hadley Rille-Apennine mountain region at 26 deg 06 min 54 sec N, 3 deg 39 min 30 sec E on the lunar surface. The lunar module (LM) carrying astronauts David Scott and James Irwin and the lunar roving vehicle (LRV) landed on the moon on July 31, 1971. The command module (CM) piloted by Alfred Worden remained in a slightly elliptical orbit at an altitude of 93 by 120 km with an inclination of 23 deg. The projects carried out on the surface included the deployment of the Apollo lunar surface experiments package (ALSEP), geological field exploration in three EVA excursions, documenting photography, and acquisition of samples of the lunar terrain. Photographs using 16- and 70-mm film were obtained from both the surface and from orbit, and 35-mm and two kinds of 5-in. film photographs were obtained from orbit. Special UV and dimlight photographic experiments were performed during orbit. Before leaving the lunar environment, a subsatellite with an experiments package was released from the command service module (CSM) on August 4, 1971, into an orbit 135 by 97 km. The LRV was used to explore regions within 5 km of the LM landing site. This was the first time a vehicle of this type had been used, and its performance on the lunar terrain was very successful. The CM and LM vehicles rejoined on August 2, 1971, performed further photographic experiments in orbit around the moon for 2 days. The LM was separated for lunar impact, and the CSM was placed in earthbound trajectory. The service module was separated enroute, and the CM returned to earth on August 7, 1971. More information on the LM may be found under spacecraft 71-063C.

------- APOLLO 15 CSM, DOYLE---------------------------------

INVESTIGATION NAME- HANDHELD PHOTOGRAPHY

NSSDC ID- 71-063A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The photographic equipment for Apollo 15 included Hasselblad and Maurer cameras that were used (1) to obtain photographs of the transposition, docking, lunar module ejection maneuver, and LM rendezvous sequence from both the command and lunar modules, (2) to obtain photographs of the lunar ground track and of future landing sites, (3) to record the operational activities of the crew, (4) to obtain long-distance earth and lunar photographs for areas of scientific interest, and (5) to obtain photos of lunar surface features and of the activities of the astronauts after their landing on the moon. The camera equipment consisted of one 70-mm Hasselblad electric camera, two Hasselblad data cameras, two 16-mm Maurer data acquisition cameras, and two TV cameras. Various lenses were used with these cameras for specific types of photography.

------- APOLLO 15 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- PANORAMIC PHOTOGRAPHY

NSSDC ID- 71-063A-02 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The scientific instrument module (SIM) Itek panoramic camera experiment was designed to obtain high-resolution panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface. The panoramic camera, which was housed in the command service module (CSM) and scanned the lunar surface from lunar orbit, also provided supporting photographic data for the other CSM cameras and experiments. The camera provided photographs of 1- to 2-m resolution from an orbital altitude of 111 km. The ranges for this camera were (1) focal length, 24 in., (2) field of view, 108 deg cross-track by 10.4 deg along the track scanned, (3) image coverage (from 111 km altitude), 337 km by 21.6 km, (4) image size, 45.24 in. by 4.5 in., and (5) film capacity, 6500 ft for 1600 frames. The panoramic camera had four main components: (1) a roll frame assembly that rotated continuously in the cross-track scan direction during camera operation (panoramic scanning), (2) a gimbal assembly that tilted fore and aft to provide stereo coverage as well as forward motion compensation, (3) the main frame, and (4) a gaseous nitrogen pressure vessel assembly required for certain film roller gas bearings. The pressure vessel assembly also was used by the Fairchild mapping camera experiment (Apollo 15A-03). The camera optics system, a camera/film drive and control system, and a film cassette completed the panoramic camera system. The film cassette was retrieved by a crewman during extravehicular activity (EVA) in the transearth portion of the mission. The panoramic camera was mounted on structural beams in the CSM SIM bay between the two SIM shelves. It was designed to operate in its SIM-installed position without the use of a deployment subsystem. The camera lens was stowed face-inward to the sim to protect it from CSM contamination sources. The camera automatically stowed its lens when off-nominal lens thermal conditions were experienced. Command module camera controls were available for the crew (1) to activate and deactivate camera heaters, (2) to supply or remove primary camera power, (3) to select an operate or standby operation mode, (4) to supply film roller torque to prevent film slack during the launch, translunar injection, and service propulsion system powered flight phases, (5) to activate the five-film frame advance cycle required daily (if camera was not operated in a 24-h period) to prevent film set after film loading, (6) to increase or decrease the width of the camera exposure slit, and (7) to select a stereoscopic or monoscopic mode of operation. A CM display of the barber pole/gray talkback type was provided to enable the crew to verify camera operational status. Over 1500 useful photographs were obtained.

------- APOLLO 15 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- METRIC PHOTOGRAPHY

NSSDC ID- 71-063A-03 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The Fairchild mapping camera experiment was designed to obtain high-quality metric photographs of the lunar surface and stellar photographs exposed simultaneously with the metric photographs. The metric photographs were obtained using a 3-in. (76 mm) cartographic lens, and photographs of the star field were obtained using a 35-mm stellar camera lens. The mapping camera also provided supporting photographic data for the scientific instrument module (SIM) panoramic camera and for other command service module (CSM) photographic experiments. The camera scanned the lunar surface from the CSM during lunar orbit. The stellar camera was operated on the lunar dark-side in conjunction with a laser altimeter as the film budget permitted. The time-correlated stellar photographs were used to provide a reference for the determination of the laser altimeter pointing vector and for the cartographic lens pointing vector for metric camera light-side photography. The metric camera provided 20-m resolution photography from an orbital altitude of 111 km. The ranges for the metric camera were (1) focal length, 3 in. (76 mm), (2) field of view, 74 deg by 74 deg, (3) image coverage (from 111.12 km), a 166 km sq area, (4) image size, 4.5 by 4.5 in., and (5) film capacity, 1500 ft of 5-in. film. The mapping camera system was composed of two individual camera subsystems -- the metric (terrain mapping) camera, which performed the cartographic function, and the stellar camera. These subsystems were integrated into a single unit that had the optical axis relationship necessary to satisfy the precision mapping camera and the laser altimeter attitude (pointing) determination requirement. This system shared a gaseous nitrogen pressure vessel assembly with the SIM panoramic camera to provide an inert and pressurized atmosphere within the camera. The camera optics system, film drive/exposure/takeup system, and a removable cassette (containing both metric and stellar camera film) completed the camera system. The film cassette was retrieved by a crewman during eva after photographic operations were completed. The mapping camera system was mounted on the top shelf in the CSM SIM bay and was deployed on a rail-type mechanism in order to provide an unobstructed field of view for the stellar camera. This mechanism ensured that the star field photographed was not obscured by either the lunar horizon or the sim mold line. A cover attached to the sim shelf protected the metric camera lens and laser altimeter optics from spacecraft contamination sources during reaction control system firings and effluent dumps. This cover provided for multiple openings and closing cycles. Camera controls in the command module allowed the crew to activate or deactivate camera heaters and camera functions, to activate or deactivate the image motion compensation switch and increment the camera velocity-to-height control signal (five incremental steps were possible before recycling), and to activate and extend or retract the camera system on its deployment rails. Over 2000 useful photographs were obtained.

*************************** APOLLO 16 CSM*********************

SPACECRAFT COMMON NAME- APOLLO 16 CSM
ALTERNATE NAMES- 06000

NSSDC ID- 72-031A

LAUNCH DATE- 04/16/72 WEIGHT- 48606. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- SELENOCENTRIC EPOCH DATE- 04/20/72
ORBIT PERIOD- 120.0 MIN INCLINATION- 12.0 DEG
PERIAPSIS- 94.0 KM ALT APOAPSIS- 120.0 KM ALT

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS

BRIEF DESCRIPTION
Apollo 16 was the fifth mission in the Apollo series in which men landed on the moon. The 11-day scientific mission began on April 16, 1972, at 1754 UT. (The launch was postponed from the originally scheduled date, March 17, because of a docking ring jettison malfunction.) Navy Capt. John W. Young and Air Force Lt. Charles M. Duke landed on the lunar surface in the lunar module (LM) on April 21. Navy Lt. Thomas K. Mattingly remained in the command module (CM) performing scientific experiments while the CM was in an equatorial orbit about the moon. The LM landed in the Descartes region of the moon at approximately 9 deg S, 16 deg E. An Apollo lunar surface experiments package (ALSEP) was deployed on the surface, terrain samples were acquired, and photographs were obtained by the surface astronauts and from the CM using 16-, 35-, and 70-mm film, 5- by 48-in. panoramic film, and 5- by 5-in. mapping film. The surface astronauts also tested the second lunar roving vehicle to be taken to the moon by exploring regions within 4 km of the LM landing site. A subsatellite carrying an experiment package was launched into lunar orbit on April 24, 1972, and impacted with the moon after 425 revolutions on May 29, 1972. The Apollo 16 spacecraft was launched on April 16, 1972, and was injected into lunar orbit on April 19. The LM landed on the moon on April 21 and returned to the CM on April 24. The CM left lunar orbit on April 26 and returned to earth on April 27, 1972.

------- APOLLO 16 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- HANDHELD PHOTOGRAPHY

NSSDC ID- 72-031A-01 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The handheld photography experiment included three cameras each on the command module and on the lunar module. On the CM there was a 70-mm Hasselblad electric camera (HEC), a 16-mm data acquisition camera (DAC), and a 35-mm Nikon camera. For the lunar surface, there was a 16-mm data acquisition camera (LDAC), and two 70-mm Hasselblad electric cameras (HEC), one with a 500-mm telephoto lens, and the other with a 60-mm lens. The types of film used in these cameras were II A-O (spectroscopic) for the S-177 UV photography experiment, SO-368 and SO-168 color films, and 3414 (LBW), 2485 (VHBW), and 3401 black and white films. Photographic targets on the surface of the moon were core tube samples, in situ rock samples (some stereoscopic), panoramas of the landing site area and surroundings, alsep instruments after deployment, trenches, interesting craters, other surface features, and field relationships. From orbit, the photographic targets were the earth and moon in UV (experiment S-177), the lunar farside and eastern limb regions, the solar corona at sunset and sunrise times, the earth's limb during solar eclipse, a comet if available, the lunar libration region, zodiacal light, the near terminator regions of the lunar surface, and the lunar surface in earthshine. The various cameras had several different lenses with different focal lengths. The HEC had lenses with focal lengths of 60, 80, 105 and 250 mm. The 35-mm camera had a 55-mm focal length, and the 16-mm DAC had lenses of 18- and 10-mm focal length. Seventy-five percent of the low-light-level targets were photographed. Thousands of useful photographs were obtained.

------- APOLLO 16 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- PANORAMIC PHOTOGRAPHY

NSSDC ID- 72-031A-02 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
This experiment was a photographic task accomplished aboard the command service module (CSM) in the scientific instrument module bay (SIM bay). The Itek panoramic camera had a 610-mm (24 in.) focal length lens and used 127- by 1219-mm (5- by 48-in.) B/W 3414 film. The camera was operated automatically and provided stereoscopic coverage by tilting forward and aft on a gimbal. This motion compensated for the forward motion of the spacecraft. The purpose of the experiment was to obtain high-resolution (1 to 2 m) panoramic photographs of the lunar surface at 100-km altitude with stereoscopic and monoscopic coverage. The experiment will help the principal investigators for the other SIM experiments to correlate their experimental data with lunar surface terrain features. Targets included farside features, eastern limb areas, nearside Maria, the LM landing site in the Descartes region, near-terminator regions (under very low-angle illumination providing high relief of the terrain), and possible Apollo 17 landing areas. Over 1400 useful photographs were obtained.

------- APOLLO 16 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- METRIC PHOTOGRAPHY

NSSDC ID- 72-031A-03 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The purpose of this experiment was to obtain high-quality metric photographs of the lunar surface taken simultaneously with photographs from the stellar camera. A laser altimeter, which was used in conjunction with the mapping camera, accurately measured the distance to the terrain being photographed for selenodetic purposes. The stellar photographs provided accurate spacecraft orientation (attitude) data. The metric camera was capable of 20-m resolution from an orbital altitude of 100 km. The metric camera had a 76-mm (3-in) focal length and used 3400 B/W film, and the f/2.8, 35-mm stellar camera used 3401 B/W film. The camera system was mounted in the SIM bay of the CSM and operated automatically. The targets were the same as those for the panoramic camera--farside features, eastern limb areas, nearside maria, the LM landing site, near-terminator regions of low-angle illumination, and possible Apollo 17 landing areas. The photographs had 78 percent overlap for each frame and 55 percent side overlap between consecutive revolutions. Over 2000 useful photographs were obtained.

************************** APOLLO 17 CSM **************************

SPACECRAFT COMMON NAME- APOLLO 17 CSM
ALTERNATE NAMES- APOL17A, APOLLO 17A
06300

NSSDC ID- 72-096A

LAUNCH DATE- 12/07/72 WEIGHT- 48606. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OHSF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- SELENOCENTRIC EPOCH DATE- 12/12/72
ORBIT PERIOD- 118.0 MIN INCLINATION- 159.9 DEG
PERIAPSIS- 1833.6 KM ALT APOAPSIS- 1864.4 KM ALT

PERSONNEL
PM - R. PETRONE NASA HEADQUARTERS

BRIEF DESCRIPTION
The Apollo 17 mission was the sixth and last of the manned lunar landing missions in the Apollo series. The crewmen were commander Eugene A. Cernan, command module (CM) pilot Ronald E. Evans, and lunar module (LM) pilot (the first scientist to go to the moon) Harrison H. Schmitt. The lunar module lm carrying astronauts Cernan and Schmitt landed on the moon on the morning of December 11, in the Taurus-Littrow area at 20 deg 10 min N 30 deg 48 min E and, in a valley 11 km wide between mountains 1500 m high in the north and 2000 m high in the southwest. This location is on the SE rim of Mare Serenitatis. The astronauts remained on the surface for 73 h. Astronaut Evans remained in the CM in orbit and conducted experiments while the others were on the surface. Astronauts Cernan and Schmitt had a lunar roving vehicle (LRV) and rode to distances up to about 3 km from the LM. There were three periods of extravehicular activity (EVA) on the surface in which the astronauts deployed the Apollo lunar surface experiments package (ALSEP) and conducted geological studies of a variety of lunar features. Orange-colored material was found for the first time on any of the Apollo missions. The Apollo 17 spacecraft was launched on December 7, 1972, and was injected into lunar orbit on December 10. The LM (72-096C) landed on the moon on December 11 and returned to the CM on December 14. The CM left lunar orbit on December 16 and returned to earth on December 19, 1972.

------- APOLLO 17 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- HANDHELD PHOTOGRAPHY

NSSDC ID- 72-096A-05 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The purposes of the handheld photography experiment were (1) to obtain photographs of lunar surface features of scientific interest from lunar orbit and during translunar coast and (2) to obtain low-brightness photographs of astronomical and terrestrial sources. The lunar surface target photographs included specific segments taken in earthshine and low light levels near the terminator to complement the photographs obtained by the panoramic and metric (mapping) cameras. Photographs of dim light phenomena such as the diffuse galactic light from selected celestial subjects, the solar corona, and the zodiacal light were acquired from orbit. Comets in the appropriate combination of trajectory and celestial conditions were also to be photographed. The equipment used included a 16-mm data acquisition camera (DAC) with an 18-mm focal length lens (a sextant was used with this camera for comet photography), a 70-mm Hasselblad electric camera with 80-mm and 25-mm focal length lenses, and a 35-mm Nikon camera with a 55-mm focal length lens. No comets were observed.

------- APOLLO 17 CSM, DOYLE-----------------------------------

INVESTIGATION NAME- PANORAMIC PHOTOGRAPHY

NSSDC ID- 72-096A-06 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The purpose of the panoramic camera photography experiment was to obtain high-resolution panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface. These photographs will aid the principal investigators of other scientific instrument module (SIM) experiments in correlating their sensor data with data on the lunar surface. The camera, which has a 24-in. (610-mm) focal length, provided 1- to 2-m resolution from an orbital altitude of 110 km. The camera had

four main components : (1) a roll frame assembly that rotated continuously in the cross-track scan direction, (2) a gimbal assembly that tilted fore and aft to provide stereo coverage and forward motion compensation (fmc), (3) the main frame, and (4) a gaseous nitrogen (GN2) pressure vessel assembly. The optics system, camera/film drive and control system, and film cassette completed the camera system. The camera system was mounted in the CSM SIM bay between the two SIM shelves. It was stored with the lens inward to protect it from contamination sources. The photography was automatic, but the crewmen could activate, deactivate, and control the camera power and operational modes. A crewman retrieved the cassette with the pan camera photography from the SIM bay on an EVA during transearth coast. About 1500 photographs of good quality were obtained.

------- APOLLO 17 CSM, DOYLE-------------------------------

INVESTIGATION NAME- METRIC PHOTOGRAPHY

NSSDC ID- 72-096A-07 INVESTIGATIVE PROGRAM
CODE EL

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - F.J. DOYLE US GEOLOGICAL SURVEY

BRIEF DESCRIPTION
The purpose of this experiment was to obtain high-quality metric photographs of the lunar surface from lunar orbit combined with time-correlated stellar photography for selenodetic/cartographic control. A laser altimeter was operated with it. The equipment was a Fairchild 76-mm (3-in.) focal length lens and a 74 by 74 arc-sec field-of-view camera. The camera was oriented so that the terrain lens was pointed at the nadir, while the 35-mm stellar camera lens was pointed at the stellar field at an angle of 96 deg from the local vertical and 90 deg from the direction of flight. Photographs were taken with 78 percent overlap to provide stereoscopic imagery. Five-in. 3400 B/W film was used, stored in a cassette that was retrieved by an astronaut in an EVA. The camera system, operated automatically, was housed in the SIM bay of the service module. The stellar photography, using 3401 B/W film, provided accurate spacecraft attitude information. The mapping camera provided 20-m resolution from its orbital height. The targets were the same as for the Itek panoramic camera.

*************************** ASTP-APOLLO***********************

SPACECRAFT COMMON NAME- ASTP-APOLLO
ALTERNATE NAMES- APOLLO SOYUZ TEST PROJ., SOYUZ APOLLO

NSSDC ID- 75-066A

LAUNCH DATE- 07/15/75 WEIGHT- 14856. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 07/18/75
ORBIT PERIOD- 88.91 MIN INCLINATION- 51.75 DEG
PERIAPSIS- 217. KM ALT APOAPSIS- 231. KM ALT

PERSONNEL
PM - C.M. LEE NASA HEADQUARTERS

BRIEF DESCRIPTION
The United States and the U.S.S.R. launched an Apollo spacecraft and a Soyuz spacecraft, respectively, as a joint effort called the Apollo-Soyuz Test Project (ASTP). The Soyuz spacecraft was launched first, with a two-man crew who maneuvered their spacecraft into a docking orbit. The Apollo spacecraft was launched 7-1/2 h later, with a three-man crew who placed their spacecraft into a proper configuration for docking with the Soyuz spacecraft. The docking of the two spacecraft occurred on the third day. After docking, crew transfers took place, with the Apollo crew first visiting the Soyuz. The combined Apollo-Soyuz crews performed joint experiments and presented radio and TV reports. After joint experiments were completed, the spacecraft disengaged and each continued its separate mission.

------- ASTP-APOLLO, EL-BAZ-----------------------------------

INVESTIGATION NAME- EARTH OBSERVATIONS AND PHOTOGRAPHY

NSSDC ID- 75-066A-21 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY
METEOROLOGY
OCEANOGRAPHY

PERSONNEL
PI - F. EL-BAZ ITEK CORP

BRIEF DESCRIPTION
The objective of the earth observations and photography experiment of the Apollo-Soyuz Test Project was to photograph various terrestrial structures using man to visually study earth features and phenomena. Eleven mapping sites and 12 visual observing sites were chosen in part from inputs provided by specialists in the following disciplines: geology, oceanography, desert study, hydrology, and environmental science. The photographs of observation and mapping sites were made with a video tape recorder (VTR), a 70-mm Hasselblad reflex camera (HRC), a 70-mm Hasselblad data camera (HDC), a 35-mm Nikon camera, and a 16-mm data acquisition camera (DAC). Real-time television transmissions were also scheduled. The "Earth Observations Book" was the principal onboard aid, and it was divided into three major sections. Section two pertained to specific visual observational targets and was arranged according to site number. For each site there was a summary page with a map showing revolution ground tracks followed by a page (one for each target) that included specific questions, appropriate diagrams and photographs, and camera settings. Studies performed included observations of major active fault zones, river deltas, volcanoes, ocean eddies, currents, internal waves, eolian landform, desert color, snowcover, drainage patterns, cloud features, tropical storms, and sources of atmospheric and water pollution. Further details and some results are contained in the report, "Earth Observations And Photography - Experiment MA-136," by Farouk El-Baz and D. A. Mitchell, Apollo-Soyuz Test Project, Preliminary Science Report, NASA-JSC, TM-X-58173, pp. 10.1-10.64, 1976.

------- ASTP-APOLLO, PEPIN-----------------------------------

INVESTIGATION NAME- STRATOSPHERIC AEROSOL MEASUREMENT

NSSDC ID- 75-066A-19 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL
PI - T.J. PEPIN U OF WYOMING

BRIEF DESCRIPTION
The Stratospheric Aerosol Measurement (SAM) experiment was flown to demonstrate that solar occultation measurements by photometer and camera can be used for determining the vertical distribution of stratospheric aerosols. The instrument consisted of a photometer and associated electronics that provided a signal to the command module (CM) telemetry. Solar photographs, taken with the accompanying camera, corroborated the refraction model used here and for similar experiments on future flights. The photometer had a pin diode detector with a 10-deg field of view. A Hasselblad data camera equipped with a special infrared film and filter was used to photograph a series of timed spacecraft sunsets and sunrises. Immediately before satellite night, as the spacecraft approached the shadow of the earth, the line of sight to the sun passed first through the upper layers of the stratosphere and then steadily down to the lower layers of the troposphere. During the 1.5 min required for the instrument line of sight to pass through the lower 150 km of the atmosphere, the solar intensity was recorded by the photometer and solar disk shape changes were recorded by the camera. The same measuring procedures were followed when the spacecraft emerged from the darkside. From the measured variation of solar intensity as a function of total air mass distributed along the line of sight, the total extinction coefficient was determined. At the effective wavelength of the photometer and photographic system, the extinction was produced principally by atmospheric aerosols, and the measurements obtained were used to determine aerosol concentrations. To verify the operation of the SAM experiment, ground truth data were obtained by a balloon-borne aerosol optical counter (dust-sonde) and a ground-based laser radar (lidar) system. Further details can be found in "Stratospheric Aerosol Measurement - Experiment MA-007" by T. J. Pepin and M. P. McCormick, Apollo-Soyuz Test Project, Preliminary Science Report, NASA-JSC, TM-X-58173, pp. 9.1-9.8, 1976.

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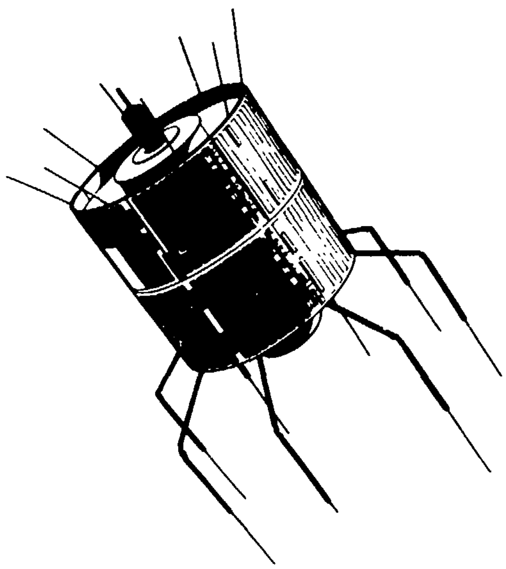
ATS



APPLICATIONS TECHNOLOGY SATELLITE (ATS) PROGRAM

The Applications Technology Satellite (ATS) series of NASA R&D spacecraft was designed to test new concepts in spacecraft design, stabilization, propulsion, and communication, and to conduct a variety of technical applications and scientific experiments. Six ATS spacecraft were launched, and most achieved a geosynchronous orbit; all except ATS 5 carried meteorological experiments. On ATS 1 and 3, weather facsimile (WEFAX) communications experiments were operated. This was a data relay system that retransmitted NOAA-processed satellite and facsimile products to APT ground stations. On ATS 3, an Omega Position and Location Experiment (OPLE) was operated. OPLE was designed to demonstrate the feasibility of using the Navy Omega Navigation System in conjunction with a synchronous satellite to establish an operational global platform for a location and data collection system. It was the forerunner of more sophisticated data-collection experiments flown on Nimbus 3 and 4. The experiments previously reviewed in this section are considered as weather-communications and data-location (navigation) experiments, hence are not included in the following descriptions of individual meteorology experiments.

The primary meteorological experimentation operated by the ATS program involved high-time-resolution cloud imaging. Important developments included techniques to obtain wind data from cloud tracking, the study of mesoscale storm phenomena, and surveillance of tropical storms, hurricanes, and typhoons. A Multicolor Spin-Scan Cloudcover camera (MSSCC) operated on ATS 3, and its black-and-white predecessor (SSCC) operated on ATS 1. These cameras utilized the spacecraft spin in the imaging system and every 20 minutes produced imagery of the complete disk between approximately 55 deg S and 55 deg N. Observations from the MSSCC were made in red, blue, and green, and were combined into a multicolor image. Both cameras were designed for daylight operation. Two Advanced Vidicon Camera Systems (AVCS), one wide- and the other narrow-angle, were flown on ATS 2; their design was similar to the AVCS flown on Nimbus 1 and 2. Due to a spacecraft failure to obtain the desired orbit, only a very limited operation was realized.

Imaging experiments on both ATS 4 and 6 were designed to have a day/night capability. The image orthicon camera on ATS 4 was designed to obtain simultaneous cloud imagery in the vicinity of the terminator where both sunlit and dark conditions were present. Unfortunately, as in the case of ATS 2, the designed orbit was not achieved by the ATS 4 spacecraft. In addition, spacecraft separation did not occur, and no data were obtained. A two-channel (visible and IR) Geosynchronous Very High Resolution Radiometer (GVHRR) was successfully flown on ATS 6, and a considerable amount of data were obtained. These data have been used for cloud studies and sea surface temperature mapping.

**************************** ATS 1******************************

SPACECRAFT COMMON NAME- ATS 1
ALTERNATE NAMES- ATS-B, 02608

NSSDC ID- 66-110A

LAUNCH DATE- 12/07/66 WEIGHT- 352. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 02/10/67
ORBIT PERIOD- 1436.1 MIN INCLINATION- 0.1 DEG
PERIAPSIS- 35782. KM ALT APOAPSIS- 35793. KM ALT

PERSONNEL
PM - R.J. DARCEY(NLA) NASA-GSFC
PM - C.M. MACKENZIE NASA-GSFC
PS - T.L. AGGSON NASA-GSFC

BRIEF DESCRIPTION
ATS 1 (Applications Technology Satellite) was designed and launched for the purpose of (1) testing new concepts in spacecraft design, propulsion, and stabilization, (2) collecting high-quality cloudcover pictures and relaying processed meteorological data via an earth-synchronous satellite, (3) providing in situ measurements of the aerospace environment, and (4) testing improved communication systems. The spin-stabilized spacecraft was cylindrically shaped and measured 135 cm long and 142 cm in diameter. The primary structural members were a honeycombed equipment shelf and thrust tube. Support rods extended radially outward from the thrust tube. Solar panels were affixed to the support rods and formed the outer walls of the spacecraft. Equipment components and payload were mounted in the annular space between the thrust tube and solar panels. In addition to solar panels, the spacecraft was equipped with two rechargeable nickel-cadmium batteries to provide electrical power. Eight 150-cm-long VHF experiment whip antennas were mounted around the aft end of the spacecraft, while eight telemetry and command antennas were placed on the forward end. Spacecraft guidance and orbital corrections were accomplished by 2.3-kg hydrogen peroxide and hydrazine thrusters, which were activated by ground command. The satellite was initially placed at 151.16 deg W longitude over the Pacific Ocean in a geosynchronous orbit. In general, most of the experiments were successful. Data coverage was nominal until about 1970, after which limited real-time data acquisition was carried out by NOAA until the May 1974 launch of SMS 1. Limited ATS 1 data acquisition was begun by NASA at about that time for ATS 1 - ATS 6 correlative studies. The spacecraft has served as a communications satellite for a number of state, federal, and public organizations up to the present. It is planned to continue operations at its final longitude of 164 deg E until September 1985 and then move the spacecraft out of the geostationary orbit.

------- ATS 1, SUOMI--

INVESTIGATION NAME- SPIN-SCAN CLOUDCOVER CAMERA (SSCC)

NSSDC ID- 66-110A-09 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - V.E. SUOMI U OF WISCONSIN
OI - NESDIS STAFF NOAA-NESDIS

BRIEF DESCRIPTION
The ATS 1 Spin-Scan Cloudcover Camera (SSCC) was designed to provide nearly continuous observations of cloudcover patterns over the whole sunlit earth disk. The 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 deg to produce a north-south scan, corresponding to an earth coverage from 52 deg N to 52 deg S. The east-to-west scan was provided by the spin of the satellite itself. Twenty minutes were required to scan one picture, and 2 min to retrace it at a nominal satellite rotation of 100 rpm. From its geosynchronous orbit the camera system had a ground resolution of better than 4 km at the subsatellite point. The experiment was highly successful through October 16, 1972. For a listing and description of the different forms of photographic data available from this experiment and their location, see the "Meteorological data catalog for the Applications Technology Satellites" (TRF B09264), available through NSSDC.

**************************** ATS 2******************************

SPACECRAFT COMMON NAME- ATS 2
ALTERNATE NAMES- ATS-A, 02743

NSSDC ID- 67-031A

LAUNCH DATE- 04/06/67 WEIGHT- 319.11 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 04/09/67
ORBIT PERIOD- 218.9 MIN INCLINATION- 28.40 DEG
PERIAPSIS- 178. KM ALT APOAPSIS- 11124. KM ALT

PERSONNEL
PM - J.M. THOLE(NLA) NASA-GSFC
PM - R.J. DARCEY(NLA) NASA-GSFC
PS - T.L. AGGSON NASA-GSFC

BRIEF DESCRIPTION
ATS 2 (Applications Technology Satellite) was a medium altitude, gravity-gradient-stabilized spacecraft designed to (1) test new concepts in spacecraft design, propulsion, and stabilization, (2) take high-quality cloudcover pictures, (3) provide in situ measurements of the aerospace environment, and (4) test improved communication systems. The cylindrically-shaped spacecraft measured 142 cm in diameter and 183 cm in length. The spacecraft structure consisted primarily of a corrugated thrust tube with honeycombed bulkheads secured to each end. Equipment components and payload were externally mounted on the outer surface of the thrust tube as well as on a structure that slid into the interior of the thrust tube. Electric power was provided by two solar arrays mounted on either end of the spacecraft's outer shell and by two rechargeable nickel-cadmium batteries. Extending radially outward from the side of the spacecraft were four 28.2-m, adjustable gravity-gradient booms. The spacecraft telemetry system consisted of four 2.1-W transmitters (two at 136.47 MHz and two at 137.35 MHz), in addition to a microwave communications experiment. The second stage of the ATS 2 launch vehicle failed to ignite, resulting in an unplanned elliptical orbit. Stresses induced by this orbit eventually induced spacecraft tumbling. In spite of these conditions, useful data were obtained from some of the experiments, most notably the cosmic-ray and particle experiments and the field detection experiments. The satellite reentered the atmosphere on September 2, 1969.

------- ATS 2, OSTROW--

INVESTIGATION NAME- ADVANCED VIDICON CAMERA SYSTEM (AVCS)

NSSDC ID- 67-031A-10 INVESTIGATIVE PROGRAM
CODE EC

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - H. OSTROW NASA-GSFC

BRIEF DESCRIPTION
The ATS 2 Advanced Vidicon Camera System (AVCS) was a modified version of the AVCS used on Nimbus 1 and 2. The camera system was designed to provide nearly continuous cloudcover 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 deg) camera, and one high-resolution, narrow-angle (3 deg) 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 s 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-min intervals and the narrow-angle camera at 5-min intervals. The sequencing was timed so that only a single camera operated at any one time. Data from both cameras were read out either directly or stored on a four-track tape recorder (up to 56 pictures) for subsequent playback to a ground data acquisition station. Because the second stage of the launch vehicle failed to ignite, ATS 2 failed to achieve its planned circular orbit, thus resulting in a highly elliptical orbit and subsequently limiting the usefulness of the collected data. Only 33 useful pictures were provided by the wide-angle camera, and 19 from the narrow-angle camera. The last useful data were transmitted on July 19, 1967.

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************************** ATS 3 **************************

SPACECRAFT COMMON NAME- ATS 3
ALTERNATE NAMES- ATS-C, 03029

NSSDC ID- 67-111A

LAUNCH DATE- 11/05/67 WEIGHT- 365.0 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 01/08/68
ORBIT PERIOD- 1436.8 MIN INCLINATION- 0.45 DEG
PERIAPSIS- 35776. KM ALT APOAPSIS- 35812. KM ALT

PERSONNEL
PM - C.M. MACKENZIE NASA-GSFC
PS - T.L. AGGSON NASA-GSFC

BRIEF DESCRIPTION
ATS 3 (Applications Technology Satellite) was one of a series of spacecraft designed to demonstrate the utility and feasibility of a variety of technological and scientific activities that could be carried out by an earth-synchronous spacecraft. Of the 11 experiments on board, 8 were technological engineering experiments concerned with navigation, communications, and spacecraft operation and equipment. Two of the remaining experiments were photographic imaging experiments that could produce near real-time daylight pictures of the earth-atmosphere system. The remaining experiment was an ionospheric beacon. The spin-stabilized spacecraft was cylindrically shaped and measured 180 cm in length and 142 cm in diameter. The primary structural members were a honeycombed equipment shelf and thrust tube. Support rods extended radially outward from the thrust tube and were affixed to solar panels which formed the outer walls of the spacecraft. Equipment components and payload were mounted in the annular space between the thrust tube and solar panels. In addition to solar panels, the spacecraft was equipped with two rechargeable nickel-cadmium batteries to provide electrical power. Eight 150-cm VHF experiment whip antennae were mounted around the aft end of the spacecraft, while eight telemetry and command whip antennae were placed on the forward end. Spacecraft guidance and orbital corrections were accomplished by 2.3-kg hydrogen peroxide and hydrazine thrusters, which were activated by ground command. Initially placed at 48 deg W longitude over the Atlantic Ocean in a geosynchronous orbit, the satellite position later varied between 45 and 95 deg W longitude in support of meteorological operations. In general, the various experiments have been successful.

------- ATS 3, BRANCHFLOWER-----------------------------------

INVESTIGATION NAME- IMAGE DISSECTOR CAMERA (IDC)

NSSDC ID- 67-111A-03 INVESTIGATIVE PROGRAM
CODE EC

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - G.A. BRANCHFLOWER(NLA) SPAR AEROSPACE

BRIEF DESCRIPTION
The ATS 3 Image Dissector Camera (IDC) was a camera system designed to (1) test the feasibility of using electrical scanning techniques in an earth-cloud camera and (2) provide daylight cloudcover data on a real-time basis with full earth coverage. The camera was mounted with its optical axis perpendicular to the spacecraft spin axis in such a manner that the camera produced a scan line with each revolution of the spacecraft. The direction of the scan, north to south or east to west, was determined by ground command. The image dissector tube consisted of a visible wavelength electrically scanning photocathode, a 0.018-mm scanning aperture, and a 12-stage electron multiplier. Light entering the camera was focused on the face of the photocathode, causing photoelectrons to be emitted from the surface in proportion to the number of impinging light photons. The emitted photoelectrons were propelled past the aperture by means of an external magnetic deflection coil. After passing through the aperture, the signal current was amplified by the 12-stage multiplier. The signal was further amplified and then transmitted at 28 KHz to a ground acquisition station. The 2.54-cm image dissector tube had a resolution capability of 1300 TV lines, which, at nominal spacecraft altitude, corresponded to a ground resolution of about 7 km at nadir. Successfully flown for the first time, the IDC system on ATS 3 served as a prototype for similar experiments on Nimbus 3 and 4. The camera performed normally until May 1969, when the IDC system was beset by erratic spacecraft antenna performance. Routine data acquisition ceased after May 30, 1969. The IDC system, although still capable of operation, was left in an operationally off mode since that time except for periodic engineering tests. For a listing and description of the different forms of photographic data available from this experiment, see the "Meteorological Data Catalog for the Applications Technology Satellites" (TRF B09264), available from NSSDC. Data can be obtained through SDSD.

------- ATS 3, SUOMI--

INVESTIGATION NAME- MULTICOLOR SPIN-SCAN CLOUDCOVER CAMERA (MSSCC)

NSSDC ID- 67-111A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - V.E. SUOMI U OF WISCONSIN
OI - R.S. PARENT U OF WISCONSIN

BRIEF DESCRIPTION
The ATS 3 Multicolor Spin-Scan Cloudcover Camera (MSSCC) represented a significant advance over a similar but monochromatic spin-scan camera on ATS 1. The MSSCC 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 min was required to scan one frame and 2.4 min to retrace with a nominal satellite rotation of 100 rpm. From its geosynchronous orbit, 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 3 months after launch, however, the red and blue channels failed, and the system subsequently was limited to producing black-and-white pictures. Good quality black-and-white pictures were received daily until December 11, 1974, when operations were curtailed to three pictures a week. Experiment operation was completely discontinued on October 30, 1975. For a listing and description of the different forms of photographic data, see the "Meteorological Data Catalog for The Applications Technology Satellites" (TRF B09264), available from NSSDC. Data can be obtained through SDSD.

************************** ATS 4 **************************

SPACECRAFT COMMON NAME- ATS 4
ALTERNATE NAMES- ATS-D, PL-683A
03344

NSSDC ID- 68-068A

LAUNCH DATE- 08/10/68 WEIGHT- 305. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 08/22/68
ORBIT PERIOD- 93.92 MIN INCLINATION- 29.04 DEG
PERIAPSIS- 219. KM ALT APOAPSIS- 726. KM ALT

PERSONNEL
PM - J.M. THOLE NASA-GSFC
PS - T.L. AGGSON NASA-GSFC

BRIEF DESCRIPTION
ATS 4 (Applications Technology Satellite) was a gravity-gradient-stabilized spacecraft designed to (1) test new concepts in spacecraft design, propulsion, and stabilization, (2) take high-quality cloudcover pictures, (3) provide in situ measurements of the aerospace environment, and (4) test improved communication systems while in an earth-synchronous orbit. The cylindrically-shaped spacecraft measured 142 cm in diameter and 183 cm in length. The spacecraft structure consisted primarily of a corrugated thrust tube with honeycombed bulkheads secured to each end. Equipment components and payload were externally mounted on the outer surface of the thrust tube as well as on a structure that slid into the interior of the thrust tube. Electric power was provided by two solar arrays mounted on either end of the spacecraft's outer shell and by two rechargeable nickel-cadmium batteries. Extending radially outward from the side of the spacecraft were four 28.2-m-long adjustable gravity-gradient booms. The spacecraft telemetry system consisted of four 2.1-W transmitters, (two at 136.47 MHz and two at 137.35 MHz), in addition to a microwave communications experiment. The second stage of the launch vehicle failed to ignite, and the planned synchronous orbit was not achieved. The spacecraft and its Centaur booster rocket were left attached together in a parking orbit. In spite of an anomalistic attitude, some of the experiments did perform successfully before the satellite and its attached booster reentered the earth's atmosphere on October 17, 1968. The primary objective of inserting a gravity-gradient-stabilized spacecraft into a geosynchronous orbit was not accomplished.

------- ATS 4, MOODY---

INVESTIGATION NAME- IMAGE ORTHICON (DAY/NIGHT) CAMERA

NSSDC ID- 68-068A-03 INVESTIGATIVE PROGRAM CODE EC

INVESTIGATION DISCIPLINE(S) METEOROLOGY

PERSONNEL
PI - J.C. MOODY NASA-GSFC

BRIEF DESCRIPTION
The ATS 4 image orthicon (day/night) camera was designed to determine the feasibility of simultaneous day/night imaging of cloudcover patterns from an earth-synchronous spacecraft. The camera, whose optical axis was oriented perpendicular to the spacecraft's spin axis, viewed the earth through a special aperture in the spacecraft's side. Camera optics consisted of a two-axis steerable primary mirror, an objective lens, a beam splitter, a photomultiplier tube (pmt), a mechanical sun shade, two variable density filter wheels, and a 5.08-cm-diameter orthicon tube. The two density filters operated in conjunction with the pmt to automatically regulate the amount of light striking the highly light-sensitive orthicon tube. The sun shade was also controlled by the pmt and protected the image orthicon camera from accidentally pointing the optics toward the sun. The optics were steerable by ground command. Steps of 0.1 deg through an angle of plus or minus 11.2 deg in both pitch and roll were possible. Thus the camera could track areas of meteorological interest, knowing the spacecraft altitude and location of the desired viewing area. The camera had a 3-deg field-of-view, which corresponded to an earth coverage of approximately 1700 sq km, with a horizontal resolution of better than 4 km at nadir. Full earth coverage could be achieved by taking a series of overlapping pictures. The data were to be transmitted (60 kHz) in near real time. ATS 4 failed to achieve its planned geosynchronous orbit. The booster rocket remained attached to the spacecraft and hindered attitude control. Due to the spacecraft's anomalistic attitude, no pictures were obtained although telemetry did indicate that the system was working.

************************** ATS 6 ****************************

SPACECRAFT COMMON NAME- ATS 6
ALTERNATE NAMES- PL-71A, ATS-F
7318

NSSDC ID- 74-039A

LAUNCH DATE- 05/30/74 WEIGHT- 930. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- TITAN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 05/31/74
ORBIT PERIOD- 1436.3 MIN INCLINATION- 1.8 DEG
PERIAPSIS- 35763.0 KM ALT APOAPSIS- 35818.0 KM ALT

PERSONNEL
PM - C.M. MACKENZIE NASA-GSFC
PM - J.M. THOLE(NLA) NASA-GSFC
PS - E.A. WOLFF(NLA) NASA-GSFC

BRIEF DESCRIPTION
The primary objectives of ATS 6 (Applications Technology Satellite) were to erect in orbit a large high-gain steerable antenna structure capable of providing a good-quality TV signal to a ground-based receiver and to measure and evaluate the performance of such an antenna. A secondary objective was to demonstrate new concepts on space technology in the areas of aircraft control, laser communications, and visual and infrared mapping of the earth/atmosphere system. The spacecraft was also capable of (1) measuring radio frequency interference in shared frequency bands and propagation characteristics of millimeter waves, (2) performing spacecraft-to-spacecraft communication and tracking experiments, and (3) making particle and radiation measurements of the geosynchronous environment. Configured somewhat like an open parasol, the ATS 6 spacecraft consisted of four major assemblies: (1) a 9.15-m-diameter dish antenna, (2) two solar cell paddles mounted at right angles to each other on opposite sides of an upper equipment module, (3) an earth-viewing equipment module (EVM) connected by a tubular mast to the upper equipment module, and (4) an attitude control and stabilization system. The EVM, in addition to housing the earth-viewing experiments, provided support for the propulsion system and tanks, batteries, a multifrequency transponder, and the telemetry, command, and thermal control systems. The upper equipment module provided a platform for the space-viewing experiments. Inertia wheels were the prime means for torquing the spacecraft, with both hydrazine and ammonia multijet thruster systems included to provide the necessary torques for unloading the wheels. Also included was a small environment measurement package containing a MAG and several particle experiments. The satellite was turned off on June 30, 1979 and boosted into a higher orbit. For detailed descriptions of the spacecraft and of the individual experiments, see the IEEE Trans. on Aerosp. Electron. Syst., v. AES-11, n. 6, November, 1975, and also the "ATS-6 Final Engineering Performance Report," NASA, RP-1080, Wash., D.C., November, 1981 (TRF B33477).

------- ATS 6, SHENK---

INVESTIGATION NAME- GEOSYNCHRONOUS VERY HIGH RESOLUTION RADIOMETER (GVHRR)

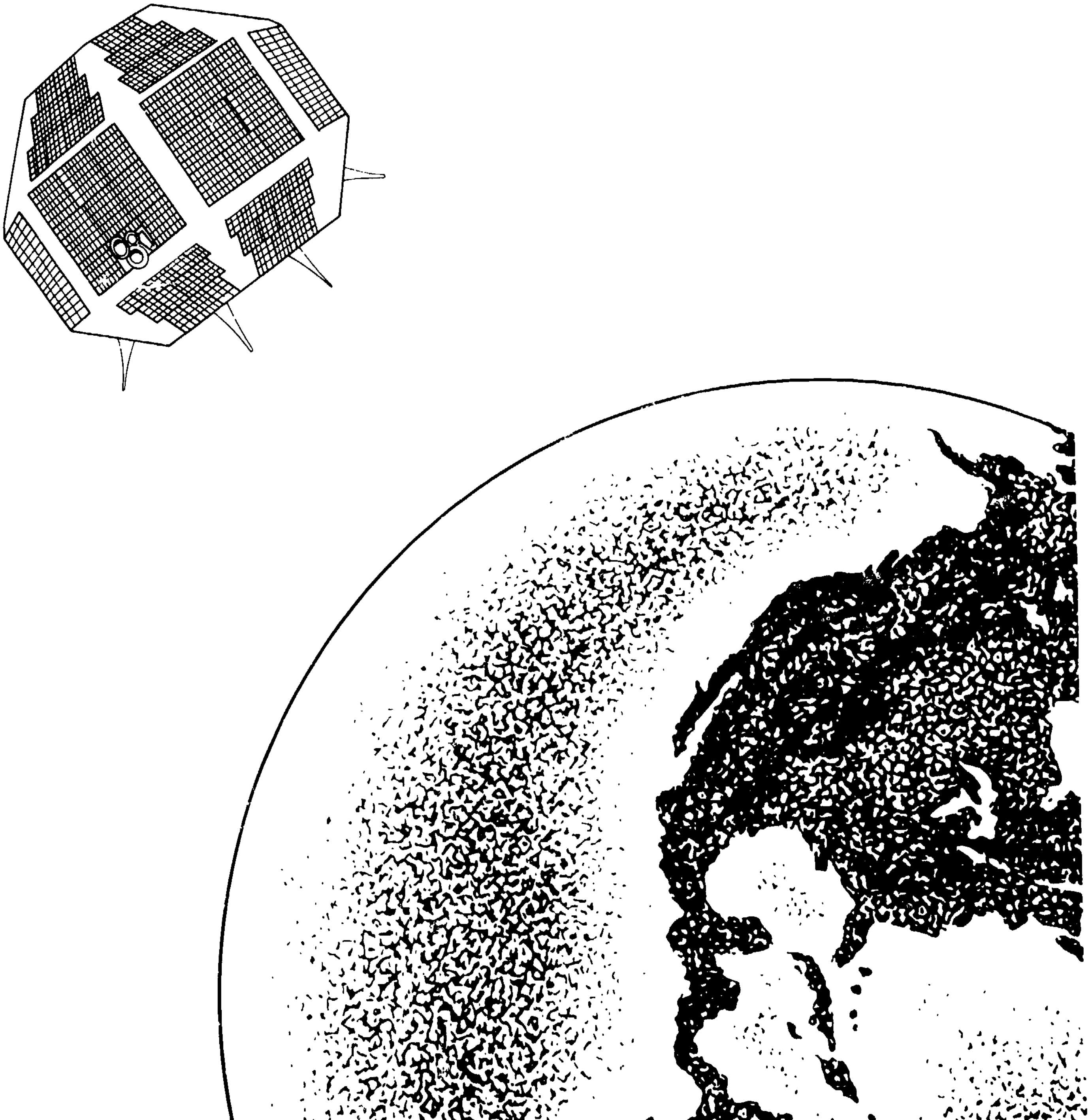
NSSDC ID- 74-039A-08 INVESTIGATIVE PROGRAM CODE EC

INVESTIGATION DISCIPLINE(S) METEOROLOGY

PERSONNEL
PI - W.E. SHENK NASA-GSFC
OI - A.W. MCCULLOCH NASA-GSFC
OI - I.L. GOLDBERG NASA-GSFC

BRIEF DESCRIPTION
The Geosynchronous Very High Resolution Radiometer (GVHRR) experiment provided both day and night cloudcover data for determining cloud motions, tropical and extratropical storm life cycles, and mesoscale phenomena. They were also used for cloud climatology studies. The GVHRR had one infrared channel (10.5 to 12.5 micrometers) and one visible channel (0.55 to 0.75 micrometers). The instantaneous field of view was 3.0E-4 rad for the infrared channel (10.8-km resolution at subsatellite point) and 1.5E-4 rad for the visible channel (5.4-km resolution at subsatellite point). The dynamic range for the infrared channel was from 0 to 340 deg K and 1 to 100% albedo for the visible channel. The infrared channel had a noise equivalent temperature difference of 1.5 deg K at 200 deg K and 0.5 deg K at 300 deg K. Data from this experiment were used to determine surface temperatures and horizontal wind vectors based on cloud motions derived from sequential images formed by both channels of the GVHRR. The experiment became inoperable on August 15, 1974. For further details see Shenk, W. E., et al., IEEE Trans. on Aerosp. Electron. Syst., v. AES-11, n. 6, p. 1095, November 1975.

BHASKARA



BHASKARA PROGRAM

Bhaskara is an experimental remote sensing program conducted by India. Two spacecraft have been launched from a U.S.S.R. launch vehicle into a 525-km, near-circular orbit, one in June 1979, and the other in November 1981. Designated as part of India's Satellite-for-Earth-Observation (SEO) Program, each of the two Bhaskaras carried two black-and-white television cameras and a passive microwave radiometer. The cameras provided high-resolution (1 km) images of cloud/earth surface during daytime passes over India. The applications of TV images are meteorology and land mapping for forests, water bodies, and earth physiography; namely, mountain ranges and river basins with various degrees of vegetation. The radiometer provided data on sea surface temperatures, sea surface winds, and atmospheric water vapor and liquid water contents for passes over the Arabian Sea and the Bay of Bengal.

Some engineering experiments, as well as a data collection system to collect meteorological data from remotely located platforms, were also aboard the spacecraft. Each spacecraft was designed for a 2-year lifetime, and the performance of Bhaskara 2 was better than expected.

############################ BHASKARA ############################

SPACECRAFT COMMON NAME- BHASKARA
ALTERNATE NAMES- SEO, 11392

NSSDC ID- 79-051A

LAUNCH DATE- 06/07/79 WEIGHT- 444. KG
LAUNCH SITE- KAPUSTIN YAR, U.S.S.R.
LAUNCH VEHICLE- INTRCOS

SPONSORING COUNTRY/AGENCY

INDIA	ISRO
U.S.S.R.	INTERCOS

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 06/07/79
ORBIT PERIOD- 95.2 MIN	INCLINATION- 50.7 DEG
PERIAPSIS- 512. KM ALT	APOAPSIS- 557. KM ALT

PERSONNEL

PD - K.	KASTURIRANGAN	ISRO SATELLITE CENTER
PS - D.P.N.CALLA		SPACE APPLICATIONS CTR
PS - G.	JOSEPH	SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
Bhaskara was the second Indian satellite (the first was Aryabhata with 3 nonmeteorological experiments). It was launched as part of the satellite-for-earth-observations (SEO) program, and was placed in orbit by a Soviet vehicle launched from a Cosmodrome in the U.S.S.R. The main objectives were to conduct earth observation experiments for applications related to hydrology, forestry, and geology using a two-band TV camera system, and to conduct ocean-surface studies using a two-frequency satellite microwave radiometer (SAMIR) system. Secondary objectives were to test engineering and data processing systems, to collect limited meteorological data from remote platforms, and to conduct scientific investigations in X-ray astronomy. Bhaskara was a 26-faced quasi-spherical polyhedron. It had a height of 1.66 m, and a diameter of 1.55 m. Named after the two "Bhaskaracharyas," astronomer-mathematicians of ancient India, the satellite was formally turned off in March 1981. Information and data are available from the Space Application Centre, Ahmedabad, India.

------- BHASKARA, CALLA---

INVESTIGATION NAME- SATELLITE MICROWAVE RADIOMETER (SAMIR)

NSSDC ID- 79-051A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY

PERSONNEL
PI - O.P.N.CALLA SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
The objectives of this investigation were to conduct studies over the Indian subcontinent and surrounding seas using a 19- and 22-GHz microwave radiometric system. Spatial resolutions were 150 km for the 19-GHz channel, and 230 km for the 22-GHz channel. Swath widths were 300 km and 230 km, respectively.

------- BHASKARA, JOSEPH---

INVESTIGATION NAME- TV CAMERA

NSSDC ID- 79-051A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY

PERSONNEL
PI - G. JOSEPH SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
The objectives of this investigation were to conduct earth observation studies for applications related to hydrology, forestry, and geology using two television cameras operating in visible (0.54- to 0.65-micrometer) and near-infrared (0.75- to 0.85-micrometer) wavelengths. About one year of visible images were collected.

############################ BHASKARA 2 ############################

SPACECRAFT COMMON NAME- BHASKARA 2
ALTERNATE NAMES- 12968, SAT. FOR EARTH OBS. 2
SEO 2

NSSDC ID- 81-115A

LAUNCH DATE- 11/20/81 WEIGHT- 444. KG
LAUNCH SITE- KAPUSTIN YAR, U.S.S.R.
LAUNCH VEHICLE- C-1

SPONSORING COUNTRY/AGENCY
INDIA ISRO

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 11/20/81
ORBIT PERIOD- 95.2 MIN	INCLINATION- 50.6 DEG
PERIAPSIS- 520. KM ALT	APOAPSIS- 542. KM ALT

PERSONNEL

PD - K.	KASTURIRANGAN	ISRO SATELLITE CENTER
PS - O.P.N.CALLA		SPACE APPLICATIONS CTR
PS - G.	JOSEPH	SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
Bhaskara 2 was launched as part of India's Satellite-for-Earth-Observations (SEO) program. It was placed in orbit by a Soviet vehicle launched from a Cosmodrome in the U.S.S.R. The main objectives were to conduct earth observation experiments for applications related to hydrology, forestry, and geology using a two-TV-camera system, and to conduct ocean-surface studies using a three-frequency satellite microwave radiometer (SAMIR) system. Secondary objectives were to test engineering and data processing systems, and to collect limited meteorological data from remote platforms. Bhaskara 2 was a 26-faced quasi-spherical polyhedron. It had a height of 1.66 m, and a diameter of 1.55 m. The satellite was named after the two "Bhaskaracharyas," astronomer-mathematicians of ancient India. Information and data are available from the Space Application Centre, Ahmedabad, India.

------- BHASKARA 2, CALLA---

INVESTIGATION NAME- SATELLITE MICROWAVE RADIOMETER (SAMIR)

NSSDC ID- 81-115A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL
PI - O.P.N.CALLA SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
The objectives of this investigation were to conduct studies over the Indian subcontinent and surrounding seas using a 19.35-, 22.235-, and 31.0-GHz microwave radiometric system. The system monitored the changes in microwave radiation from the sea surface, yielding information on the sea state and the sea surface temperature.

------- BHASKARA 2, JOSEPH---

INVESTIGATION NAME- DUAL TV CAMERA

NSSDC ID- 81-115A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY

PERSONNEL
PI - G. JOSEPH SPACE APPLICATIONS CTR

BRIEF DESCRIPTION
The objectives of this investigation were to conduct earth observation studies for applications related to hydrology, forestry, and geology using two television cameras operating in visible (0.54- to 0.66-micrometer) and near-infrared (0.75- to 0.85-micrometer) wavelengths. Each picture frame had an area of 325 x 325 km, with a resolution of 1 km. Thousands of images were collected in both visible and infrared wavelengths. Subsequent to a component malfunction, the camera operating in the visible band was shut down about two months after launch.

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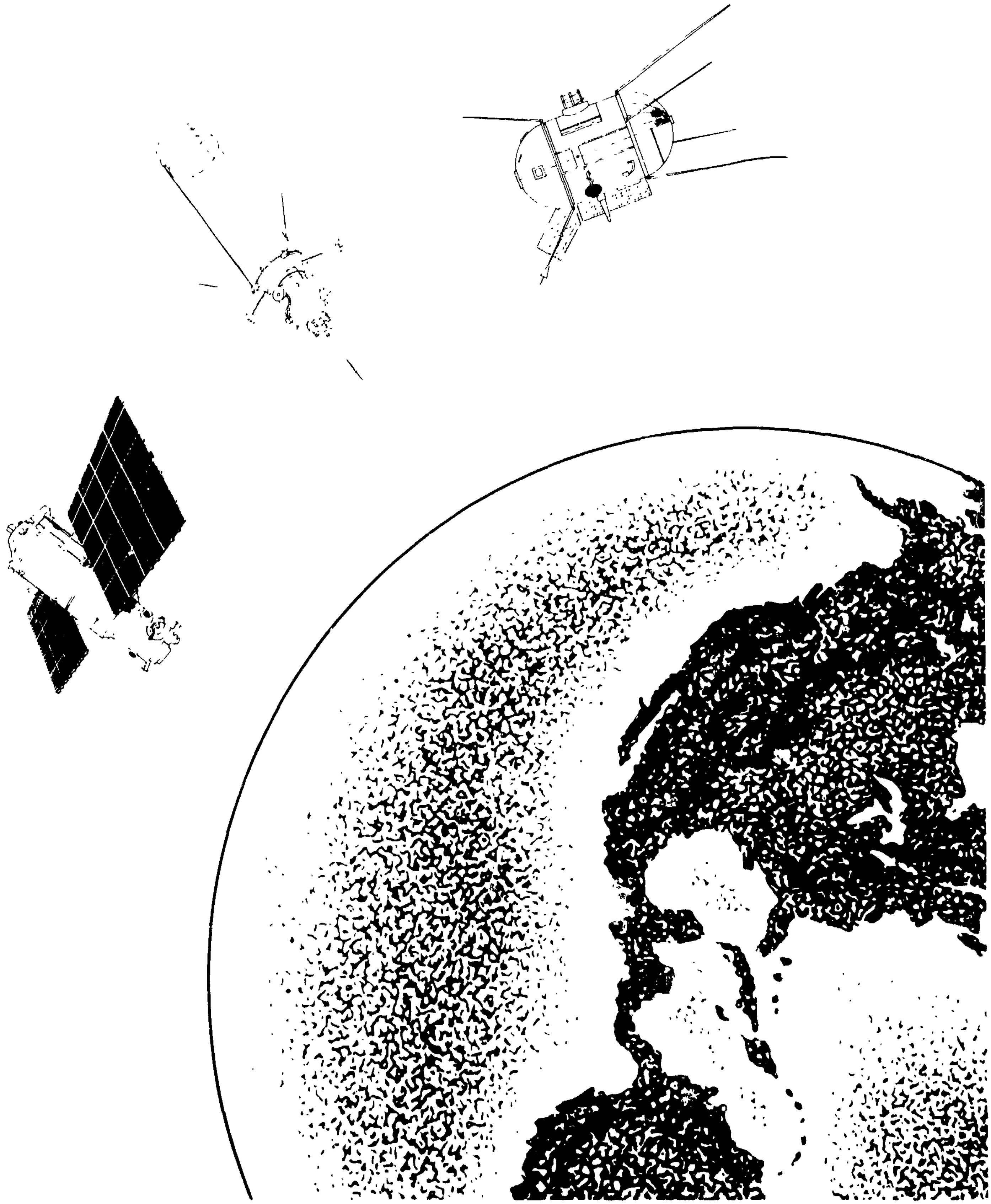
COSMOS



COSMOS SATELLITE PROGRAM

The Cosmos (or Kosmos) satellite series is a long, continuing series of U.S.S.R. satellites with 1837 having been successfully launched between March 1962 (Cosmos 1) and April 1987. The Cosmos name is given to a wide variety of satellite missions and types. Known to have been included are military missions, scientific missions, engineering tests, planetary launches that were mission failures, and prototypes for navigation, communications, manned flights and extra-terrestrial planetary satellites. The great majority of flights have been military missions, but there have been a large number of scientific missions. These scientific missions have included experiments related to meteorology, aeronomy, ionospheric physics, energetic particles, magnetic fields, biology, and nonterrestrial planetary sciences. A number of the Cosmos meteorological satellites are known to have been of a reconnaissance type mission with a relatively short lifetime. Their payloads often included a data capsule that was designed to be physically recovered subsequent to its separation from the satellite and reentry through the atmosphere.

At least 16 other Cosmos satellites were closely related to the development, early operation, testing, and demonstration of a prototype meteorological satellite system (Meteor 1). Cosmos 122 was the first officially announced meteorological satellite and was the first U.S.S.R. weather satellite to provide data for the conventional weather communications circuits to the U.S. Several of the early Cosmos meteorological satellites were prototype operational vehicles for the subsequent Meteor 1 system. The orbits and hardware of Cosmos 144 and 156 (and their replacements) were planned with orbit precession and imaging field-of-view to receive data from half the earth's surface during a 24-h period, thus requiring two satellites to obtain once-per-day global observations of cloud cover. Cosmos 149 and 320 included prototype narrow-angle scanning telephotometers to measure the earth's radiation in the visible and near-IR regions and the window regions of 8 to 12, and 10.5 to 11.5 micrometers. Cosmos 384 used a microwave sensing instrument to obtain information about sea ice under all weather conditions, day or night. An increasing emphasis on oceanographic observations continued with the launch of Cosmos 1076. It was launched on February 12, 1979, to obtain operational information about the world's oceans using visible, infrared, and microwave sensor data.

Table 4 lists Cosmos satellites launched prior to 1976, which had, or were likely to have had, payloads useful for meteorological purposes. The first U.S.S.R. operational meteorological satellite (Meteor 1-1) is included in the table to provide perspective. Prior to Cosmos 226, most of the listed spacecraft usage has been verified as closely related to the development of meteorological satellites. After 1976, virtually no information other than orbital characteristics has been found to

TABLE 4

SELECTED COSMOS LAUNCHES*

NSSDC ID	COSMOS NUMBER	LAUNCH DATE	INACTIVE OR REENTRY DATE	ORBIT INFORMATION a/p (km)	inc (deg)	pd (min)	REMARKS†
62-014A	4	04-29-62	04-29-62	317-285	65	91	A1
62-033A	7	07-28	08-01	369-210	65	90	C5
62-048A	9	09-27	10-01	358-301	65	91	A1
63-010A	14	04-13-63	08-29-63	512-265	49	92	B1
63-011A	15	04-22	04-27	371-173	65	90	A1
63-050A	23	12-13	03-27-64	613-240	49	93	B1
64-053A	44	08-28-64	-------	860-618	65	100	C4
64-055A	45	09-13	09-18	327-206	65	90	A2
65-014A	58	02-26-65	-------	659-581	65	97	C1
65-029A	65	04-17	04-25-65	342-210	65	90	A2
65-083A	92	10-16	10-24	353-212	65	90	A2
65-106A	100	12-17	-------	650-650	65	98	C1
66-038A	118	05-11-66	-------	640-640	65	97	C1
66-054A	121	06-17	06-25-66	354-210	73	90	A2
66-057A	122	06-25	-------	625-625	65	97	C1

* Launched prior to 1976 and likely to be of importance to meteorological programs

† Estimates of satellite weight (kg), dimension in meters (dia. length), and shape are coded according to the following key (Ref. King-Hele, 1983).

CODE	WEIGHT	DIA-LENGTH	SHAPE
A1	4750	2.4 - 4.3	Sphere + cylinder
A2	5530	2.4 - 5.0	Sphere + cylinder
A3	5700	2.4 - 5.0	Sphere + cylinder
A4	5900	2.4 - 5.9	Sphere + cylinder
A5	6300	2.4 - 6.5	Sphere + cylinder
B1	400	1.2 - 2.8	Ellipsoid
B2	400	1.2 - 1.8	Ellipsoid
B3	300/400	1.2 - 6.5	Ellipsoid + annular tail
B4	550	1.5 - 1.8	Octagonal ellipsoid
C1	2000	1.5 - 5	Cylinder + 2 vanes or panels
C2	2200	1.5 - 5	
C3	2500	1.5 - 5	
C4	—	1 - 3	
C5	1440	2.6 - 3.8	Cylinder
D		1.5	Spheroid + paddles

TABLE 4

SELECTED COSMOS LAUNCHES* (continued)

NSSDC ID	COSMOS NUMBER	LAUNCH DATE	INACTIVE OR REENTRY DATE	ORBIT INFORMATION a/p (km)	inc (deg)	pd (min)	REMARKS†
67-018A	144	02-28-67	(09-14-82)	625-625	81	97	C1
67-024A	149	03-21	04-07-67	297-248	48	90	D
67-039A	156	04-27	-------	630-630	81	97	C1
67-102A	184	10-25	-------	635-635	81	97	C1
67-104A	185	10-27	01-14-69	888-522	64	99	D
68-019A	206	03-14-68	-------	630-630	81	97	C1
68-049A	226	06-12	10-07	650-603	81	97	C1
68-060A	232	07-16	07-24-68	352-202	65	90	A2
68-080A	243	09-23	10-04	319-210	71	90	A4
68-111A	258	12-10	12-18	325-210	65	90	A2
69-029A	(METEOR 1-1)	03-26-69	-------	687-633	81	98	C2
70-005A	320	01-16-70	02-10-70	342-240	49	90	D
70-105A	384	12-10	12-22-70	314-212	73	89	A4
70-113A	389	12-18	-------	699-655	81	98	C3
72-020A	481	03-25-72	09-02-72	540-279	71	92	B2
72-028A	485	04-11	08-30	506-28-1	71	92	B1
72-033A	487	04-21	09-24	531-278	71	92	B1
72-048A	497	06-30	11-07	812-282	71	95	B1
72-050A	498	07-05	11-25	511-282	71	92	B2
72-078A	523	10-05	03-07-73	507-283	71	92	B2
72-084A	526	10-25	04-08	511-282	71	92	B2
73-004A	545	01-24-73	07-31	521-279	71	92	B2
73-020A	553	04-12	11-11	519-282	71	92	B2
73-029A	558	05-17	12-22	526-279	71	92	B2
73-035A	562	06-05	01-07-74	510-282	71	92	B2
73-057A	580	08-22	04-01	518-283	71	92	B2
73-091A	608	11-20	07-10	528-281	71	92	B2
73-099A	615	12-13	12-17-73	859-280	71	96	B2
74-010A	633	02-27-74	10-04-74	516-280	71	92	B2
74-047A	662	06-26	-------	838-282	71	96	B2
74-058A	668	07-25	02-21-75	519-281	71	92	B2
74-075A	686	09-26	05-01	303-208	71	92	B2
74-076A	687	10-11	02-05-78	698-286	74	94	B4
74-091A	695	11-20	07-15-75	493-283	71	92	B2
74-106A	701	12-27	01-09-75	314-170	71	89	A5
75-002A	702	01-17-75	01-29	313-205	71	90	A3
75-006A	705	01-28	11-18-76	524-281	71	92	B2
75-026A	725	04-08	01-06	508-283	71	92	B2
75-058A	745	06-24	03-12	540-274	71	92	B2
75-067A	750	07-17	09-29-77	830-281	71	95	B2

aid in identification of U.S.S.R. Cosmos series satellites that were used for meteorological observations. The orbital characteristics are available along with estimates of spacecraft shape and weight in King-Hele et al., "The RAE Table of Earth Satellites 1957-1982," Wiley-Interscience. Over 60 spacecraft launches between January 1977 and December 1984 were found to have orbital characteristics that were similar to the previously launched spacecraft shown in the table. Descriptions of a few of these Cosmos spacecraft and experiments are included as typical examples.

**************************** COSMOS 122**************************

SPACECRAFT COMMON NAME- COSMOS 122
ALTERNATE NAMES- KOSMOS 122, 02254

NSSDC ID- 66-057A

LAUNCH DATE- 06/25/66 WEIGHT- KG
LAUNCH SITE- TYURATAM (BAIKONUR COSMODROME), U.S.S.R.
LAUNCH VEHICLE- A-1

SPONSORING COUNTRY/AGENCY
U.S.S.R. SAS

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 06/25/66
ORBIT PERIOD- 97.12 MIN	INCLINATION- 65.14 DEG
PERIAPSIS- 683. KM ALT	APOAPSIS- 657. KM ALT

PERSONNEL

PM -	UNKNOWN	SOVIET ACAD OF SCI
PS -	UNKNOWN	SOVIET ACAD OF SCI

BRIEF DESCRIPTION

Cosmos 122 was the first announced Russian meteorological satellite and the last in a series of prototype meteorological satellites that included Cosmos 44, 58, 100, and 118. It was the last meteorological satellite launched from the Tyuratam site with an A-1 launch vehicle at a 65-deg orbital inclination, and it provided a transition from the prototype series to the Cosmos "Meteor" experimental weather satellite system. Cosmos 122 was orbited to test meteorological instrumentation designed for obtaining images of cloud cover, snow cover, and ice fields on the day and night sides of the earth and for measuring fluxes of outgoing radiation reflected and radiated by the earth-atmosphere system. The instrumentation consisted of (1) two vidicon cameras for daytime cloudcover pictures, (2) a high-resolution scanning IR radiometer for nighttime and daytime imaging of the earth and clouds, and (3) an array of narrow- and wide-angle radiometers covering the 0.3- to 3-, 8- to 12-, and 3- to 30-micrometer channel for measuring the intensity of radiation reflected from the clouds and oceans, the surface temperatures of the earth and cloud tops, and the total flux of thermal energy from the earth-atmosphere system into space, respectively. The satellite was in the form of a large cylindrical capsule, 5 m long and 1.5 m in diameter. Two large solar cell panels of three segments each were deployed from opposite sides of the cylinder after satellite separation from the launch vehicle. The solar panels were rotated to constantly face the sun during satellite daytime by means of a sun sensor controlled drive mechanism fitted in the top end of the center body. The meteorological instruments were housed in a hermetically sealed compartment located in the lower part of the capsule, while the basic satellite servicing systems were contained in a special hermetically sealed compartment in the upper part of the capsule. Data were transmitted to earth at a frequency of 90 MHz by means of a steerable high-gain parabolic antenna that was attached to the center section of the satellite body by a long arm. The satellite was triaxially stabilized by a series of inertial flywheels, driven by electric motors, whose kinetic energy was dampened by torques produced by electromagnets interacting with the earth's magnetic field. Cosmos 122 was oriented by earth sensors with one of its axes directed earthward along the local vertical, a second oriented along the orbital velocity vector, and a third oriented perpendicular to the orbital plane. This orientation ensured that the optical axes of the instruments were constantly directed earthward. Cosmos 122 ceased operations in late October 1966.

------- COSMOS 122, UNKNOWN----------------------------------

INVESTIGATION NAME- DUAL VIDICON CAMERAS

NSSDC ID- 66-057A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI -	UNKNOWN	SOVIET ACAD OF SCI

BRIEF DESCRIPTION

The Cosmos 122 dual vidicon camera experiment was designed to test the capability of Russian weather satellites to provide daytime pictures of the earth's cloudcover distribution, local storms, and global weather systems for use by the Soviet Hydrometeorological Service The instrumentation consisted of two identical vidicon cameras that were mounted in the satellite base and were directed toward the earth. Each camera viewed a 500- by 500-km area -- one to the left and the other to the right of nadir -- with a resolution of 1.25 km at nadir from a satellite altitude of 600 to 700 km. The cameras took a one-frame image of the earth's cloud cover with slight overlapping of successive frames to provide continuous coverage. The cameras switched on automatically any time the sun was more than 5 deg above the horizon. Because the earth illumination varied so much, automatic sensors adjusted the camera apertures to produce high-quality pictures under a variety of illumination conditions. The image formed by each vidicon tube either was transmitted directly to the ground if the satellite was in radio contact with one of two ground stations or was recorded on magnetic tape for later transmission if the satellite was beyond the zone of radio communication. The TV images received by these ground stations were processed and transmitted to the Hydrometeorological Center in Moscow, where they were analyzed and used in various forecast and analysis products. The pictures were archived at the Hydrometeorological Center. The Cosmos 122 cameras, although having 2.5 times the resolution of those carried on the ESSA satellites, could not provide continuous overlapping global coverage as do the ESSA cameras owing to the lower orbit of the Cosmos 122 satellite (620 km compared to 1400 km). Thus, to close the gaps in coverage, at least two satellites were required in the weather satellite system. In addition, cloudcover mosaics were produced from 10 or more individual cloudcover pictures at the Hydrometeorological Center to provide a more comprehensive view of global weather systems. Some of the individual pictures and the cloud mosaics were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received some of these pictures at the National Environmental Satellite Service (NESS) in Suitland, Maryland, via the "cold line" facsimile link with Moscow. Pictures were transmitted to NESS from September 11, 1966, through October 26, 1966. These pictures were archived at NESS for 1 yr and then, unless of unusual interest, were discarded. The experiment terminated operations in October 1966.

------- COSMOS 122, UNKNOWN----------------------------------

INVESTIGATION NAME- SCANNING HRIR

NSSDC ID- 66-057A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI -	UNKNOWN	SOVIET ACAD OF SCI

BRIEF DESCRIPTION

The Cosmos 122 high-resolution scanning IR radiometer was designed to make measurements of cloud distribution and snow and ice cover on the dayside and nightside of the earth. The radiometer measured the outgoing radiation from the earth-atmosphere system in the 8- to 12-micrometer atmospheric window. Measurements made in this spectral region permitted construction of brightness patterns of the thermal relief and determination of equivalent radiation temperatures of the earth's surface and cloud tops. The instrument was a narrow-angle scanning radiometer with an instantaneous viewing angle of 1.5 by 1.5 deg. It was mounted in the base of the satellite in a sealed instrument compartment with its optical axis directed along the local vertical and toward nadir. The radiometer measured the intensity of the outgoing radiation by comparing the earth's radiation flux with the radiation flux from space. Each type of radiation entered the radiometer through separate windows, which were oriented in mutually perpendicular directions. The radiation from the earth-atmosphere system fell on a plane scanning mirror that was mounted at an angle of 45 deg to the satellite velocity vector and scanned through an angle of plus or minus 50 deg from nadir. The radiation was reflected from the scanning mirror through a stationary modulating disk and filter window onto a parabolic mirror that focused the parallel beam through a movable modulating disk onto a thermistor bolometer. The stationary and movable modulating disks provided the channel switching, sending first the earth-atmosphere radiation and then the space radiation to the parabolic mirror and finally to the bolometer. The bolometer converted the radiant flux into variable electric voltages (0 to 6 V) whose frequency was equal to the modulator frequency and whose magnitudes were proportional to the differences in the radiant flux intensities between earth and space developed at the bolometer output. During the movement of the scanning mirror through a plus or minus 40-deg sector, line scanning (40 lines/min) of the target area was accomplished in a plane normal to the orbital plane using a forward and back path, while scanning along the flight path was provided by the relative motion of the satellite with respect to the earth. In each scan, with the indicated viewing and scanning angles from the satellite's orbital altitude, the radiometer recorded the mean radiation intensities from a band about 1100 km wide with a resolution of about 15 km at nadir to about 24 to 27 km at the edges. The radiometer was capable of measuring radiation temperatures within 2 to 3 deg for temperatures above 273 deg K and within 7 to 8 deg for temperatures below 273 deg K. The video signals were amplified and sent either to the satellite memory unit for later transmission or to the radiotelemetry unit for direct transmission to earth, depending on whether the satellite was beyond or within the zone of radio communication with a ground receiving station, respectively. The ground receivers recorded the transmitted data in digital form on magnetic tape and simultaneously on 80-mm photographic film in the form of a brightness image of the thermal relief of the earth-atmosphere system. The data on magnetic tape were processed by computer at the Soviet Hydrometeorological Center and were used to produce a digital map of the equivalent radiation temperature field with a superposed geographic grid. The photographic film was developed and processed into an IR picture also with a superposed grid. The pictures were archived at the Hydrometeorological Center. Some of these pictures were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received these pictures at the National Environmental Satellite Service (NESS), Suitland, Maryland, via the "cold line" facsimile link with Moscow. Pictures were transmitted to NESS from mid-September until late October 1966.

These IR pictures were kept at NESS for 1yr and then, unless of unusual interest, were discarded. The experiment terminated operations in October 1966.

------- COSMOS 122, UNKNOWN------------------------------------

INVESTIGATION NAME- ACTINOMETRIC INSTRUMENT

NSSDC ID- 66-057A-03 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION

The Cosmos 122 actinometric experiment was designed to measure (1) the outgoing longwave radiation (3 to 30 micrometers) from the earth-atmosphere system, (2) the outgoing near UV, visible, and near IR solar radiation (0.3 to 3 micrometers) reflected and backscattered by the earth-atmosphere system, and (3) the effective radiation temperature of the earth's surface and cloud tops (8 to 12 micrometers). The instrumentation consisted of four radiometers: a pair of scanning, narrow-angle, two-channel radiometers and a pair of nonscanning, wide-angle, two-channel radiometers. The narrow-angle (4 by 5 deg field of view (FOV)) radiometers measured radiation in all three spectral bands, while the wide-angle (136 to 140 deg FOV) radiometers operated only in the 0.3- to 3- and 3- to 30-micrometer bands. In the narrow-angle radiometer, the 0.3- to 3-micrometer band was measured in one channel and the 8- to 12- and 3- to 30-micrometer bands were combined in the second channel. In the second channel, the two bands were separated by the exchange of corresponding filters as the radiometer scanned in alternate directions. The earth radiation entered the narrow-angle radiometer through a cylindrical fairing (KRS-5 crystal) and fell onto a conical scanning mirror. The radiation was reflected from the mirror through a three-lobed rotating mirror chopper that modulated the radiation flux at a frequency of 80 Hz. The chopper alternately reflected earth radiation and space radiation, which entered through a separate KRS-5 crystal window, onto one of three openings in a color filter wheel -- one filter for each spectral band. The particular spectral band that was passed through then fell on an off-axis parabolic mirror that focused the radiation flux onto a bolometric receiver. Periodic calibration was made when the scanning mirror moved to a 90-deg angle from nadir with simultaneous turning on and viewing of a silicon standard lamp. The 0.3- to 3-micrometer channel did not use the two-beam system or filter switching. The output from the modulated flow of radiation on the bolometer was amplified, rectified, filtered, and fed into the radio-telemetry system over eight channels. The wide-angle radiometers had identical optical systems for both channels. The earth radiation entered the radiometer through a hemispherical shell composed of quartz or KRS-5 crystal with a coating that determined the passband. The radiation was then modulated with a frequency of 64 Hz and fell on a bolometric receiver. As in the narrow-angle radiometers, the bolometer output was processed and fed into the radio-telemetry system. The wide-angle radiometer was standardized simultaneously with the narrow-angle radiometers by the input of a standard 64-Hz calibrating frequency into the amplification circuit. The relative rms measuring error for both types of radiometers was about 0.5%. To provide a backup capability, one wide-angle and one narrow-angle radiometer were held in reserve and could have been activated on command from the ground. The orientation of the Cosmos 122 satellite insured that the primary optical axes of the radiometers were oriented vertically downward toward nadir. The survey of the earth's surface by both radiometers was carried out by the motion of the satellite relative to the earth. In addition, the narrow-angle radiometer scanned 66 deg to either side of nadir in a plane normal to the orbital plane by rocking the scanning mirror about the optical axis. The radiometers covered a strip about 2500 km wide on the earth's surface and had a ground resolution of 50 km at nadir. The data were reduced at the ground stations and were transmitted in binary form to the Hydrometeorological Center in Moscow, where they were recorded in digital form on magnetic tape and were used to produce various analysis products such as earth-atmosphere albedo charts and radiation temperature maps. The data were archived at the Hydrometeorological Center. Some of these charts were transmitted in graphical form to various foreign meteorological centers, including the National Environmental Satellite Service (NESS), Suitland, Maryland. These actinometric charts were received at NESS via the "cold line" facsimile link with Moscow from mid-August 1966 until late October 1966. The charts were microfilmed and archived at the National Climatic Data Center (NCDC), Asheville, North Carolina. The experiment terminated operations in October 1966.

************************** COSMOS 149**********************

SPACECRAFT COMMON NAME- COSMOS 149
ALTERNATE NAMES- KOSMOS 149, 02714

NSSDC ID- 67-024A

LAUNCH DATE- 03/21/67 WEIGHT- 300. KG
LAUNCH SITE- KAPUSTIN YAR, U.S.S.R.
LAUNCH VEHICLE- B-1

SPONSORING COUNTRY/AGENCY
U.S.S.R. SAS

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 03/23/67
ORBIT PERIOD- 89.76 MIN INCLINATION- 48.40 DEG
PERIAPSIS- 243. KM ALT APOAPSIS- 285. KM ALT

PERSONNEL
PM - UNKNOWN SOVIET ACAD OF SCI
PS - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION

Cosmos 149 was the thirteenth Russian experimental meteorological satellite, the third announced meteorological satellite, and the third launched from the Kapustin Yar site. The satellite, which was basically an orbiting optical station and equipped with (1) two medium-resolution, narrow-angle, three-channel scanning telephotometers operating in the visible spectral region to determine the statistical values of cloud fields and surface formations, cloudtop heights, and atmospheric water vapor content, (2) a high-resolution, narrow-angle, IR radiometer operating in the 8- to 12-micrometer window to determine surface and cloudtop temperatures, (3) a pair of three-channel, wide-angle radiometers to determine the radiative balance of the earth-atmosphere system, and (4) a television camera system to provide cloudcover pictures for correlation with the radiation data. The satellite was in the form of a domed cylinder with an annular base and was 6.5 m long and 1.2 m in diameter. Mounted in the top of the domed nose section of the spacecraft was one of the telephotometers, which scanned in a plane perpendicular to the flight path. The other telephotometer was mounted on the left side of the cylindrical center section and scanned along the flight path. The television system was housed in the side of the domed nose section, and its optical axis was directed parallel to nadir. The radiation balance sensor units were attached to booms that telescoped out from the lower and upper sides of the satellite base. The lower sensor unit faced nadir, and the upper one viewed in the zenith direction. Also attached to the base, by means of four long bars, was an annular dynamic air stabilizer. This was the first time such an aerogyroscopic system had been employed for satellite stabilization, and it was capable of providing an orientation in space with an error less than 5 deg relative to the three coordinate axes. The satellite's orientation was also regulated with rather high accuracy from the measurements made by the scientific instruments themselves. The orientation and stabilization systems made it possible to relate data to geographical location with an accuracy of 10 to 15 km at nadir. All the instruments operated in either of two modes: (1) the "continuous cycle mode" or (2) the "data storing mode." The satellite instrumentation included a programming and timing device for controlling the various units and the telemetry system in both the data storage mode and the continuous cycle mode. The satellite transmitted data at 90 MHz via an antenna mounted on the upper side of the satellite base. The temperatures of the various instruments were monitored by resistance thermometers, and the data were used to regulate the temperature and to adjust the results of the basic measurements. In general, the equipment worked as planned. However, problems with the stabilization system developed during the early part of the flight. This resulted in satellite roll about the longitudinal axis and, consequently, the amount of data acquired was relatively limited. Cosmos 149 reentered the earth's atmosphere on April 7, 1967, after 17 days in orbit.

------- COSMOS 149, FARAPANOVA-------------------------------

INVESTIGATION NAME- THREE-CHANNEL WIDE-ANGLE RADIOMETERS

NSSDC ID- 67-024A-03 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - G.P. FARAPANOVA SAS-IPA
OI - B.P. KOZVREV SAS-IPA
OI - E.F. KLIMCHUK SAS-IPA
OI - A.I. PASHKOV SAS-IPA

BRIEF DESCRIPTION

The Cosmos 149 three-channel, wide-angle radiometer experiment was designed to determine the global distribution of the balance between incoming solar radiation and outgoing terrestrial and reflected solar radiation. The instrumentation consisted of two three-channel wide-angle (180 deg) radiometers that were placed in special containers to provide optical and thermal isolation from the satellite. They were mounted on telescoping booms that extended from opposite sides of the satellite base, with one directed toward the zenith and the other toward nadir. Each radiometer contained three radiation thermocouples, which measured the total radiation flux in the shortwave (0.3 to 3 micrometers), near-IR (0.8 to 3 micrometers), and longwave (3 to 30 micrometers) spectral bands. Each radiation thermocouple, in turn, consisted of a xenon-filled balloon that was covered by a hemispherical filter, with a radiation receiving area and the thermopiles mounted below on a lead base. The filters determined the passband for each channel: a UV-glass filter for the shortwave channel, a no. 3 IR-glass filter for the near-IR channel, and a no. 5 crystal filter for the longwave channel. The radiation receiving area was divided into the inner and outer areas. The inner area was disc-shaped, was coated with black and white paint, and was attached to the hot thermopile junctions. The outer area was annular, was also coated with black and white paint, but was attached to the cold thermopile junctions. Platinum resistance thermometers were located near the cold junctions and hemispherical filters to monitor their temperatures. The earth-oriented radiometer measured solar radiation in the longwave and shortwave channels and space radiation or channel noise in the near-IR channel. The earth-oriented unit, however, did not remain in the planned orientation. Instead, the optical axes of the radiometers were directed at an angle to the horizon and measured the sum of fluxes from both the satellite body and the earth. During the initial phase of the flight, when the satellite was operated in an oriented state, the solar flux measurements were used to estimate the efficiency and reliability of the data from the earth-oriented radiometer and to determine the satellite orientation with respect to the sun. After satellite roll had developed and the orientation system was disconnected, however, the zenith-oriented radiometer received radiation from zenith to nadir during one rotation of the satellite and measured the relected solar, incident solar, outgoing terrestrial thermal, and space radiation. The sensitivity of the shortwave and longwave channels in this radiometer decreased gradually by 40% during the first 10 days of the mission. The radiometer resolution was such that at nadir the radiometer averaged the radiation being emitted from a circular area of 100 km radius. In the continuous cycle (direct transmission) mode, data were obtained over a 4-s observing period with continuous repetitions, while in the memory (delayed transmission) mode the observing period was 8 s long with a 3-min pause. Owing to the problem of satellite rotation, the volume of data acquired was small but was considered to be quite reliable. Results indicated that the radiation balance during daytime for optimal solar elevations varied in the range 0.5 to 0.7 cal/sq cm-min. A similar experiment was flown on Cosmos 320.

------- COSMOS 149, GORODETSKIY------------------------------

INVESTIGATION NAME- NARROW-ANGLE IR RADIOMETER

NSSDC ID- 67-024A-02 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI - A.K.	GORODETSKIY	SAS-IPA
OI - M.S.	MALKEVICH	SAS-IPA
OI - E.F.	KLIMCHUK	SAS-IPA

BRIEF DESCRIPTION

The Cosmos 149 narrow-angle IR radiometer experiment was designed to determine surface and cloudtop temperatures by measuring the outgoing radiation in the 8- to 12-micrometer window. The instrumentation consisted of a high-resolution, narrow-angle, nonscanning IR radiometer with a 2- by 4-deg field of view. The radiometer was mounted with its optical axis directed along the local vertical when the satellite assumed its normal orientation. The radiometer scanned the earth owing to the progression of the satellite along its orbital path. The main components of the radiometer were (1) a parabolic mirror with a 30-mm focal length, (2) a chopper, (3) an interference filter, (4) a 1- by 4-mm bolometer platform, (5) a thermistor, and (6) blinds. Radiation from earth and space entering the radiometer was combined by the mirror, modulated by the chopper, passed through the interference filter, and focused on the bolometer. The signal was amplified and sent either to the telemetry system for direct transmission or to a recording device. A thermistor was mounted on the radiometer casing to determine the instrument temperature, which allowed the data to be corrected based on the temperature dependence of the radiometer sensitivity. Blinds with a set of diaphragms in front of the lenses were used to reduce the effect of lateral exposure. In the continuous cycle mode, the radiometer had a 4-sec cycle observing period with continuous repetitions, while in the memory mode the observation interval was 8 s with a 3-min pause. During the latter part of the flight, the stability of the instrument zero level was tested as the satellite rotated about its longitudinal axis. When the optical axis of the radiometer was in the plane of the local horizon, radiation from space reached both inputs and was used as a zero reference signal in most of the measurements. The instrument zero was stable and remained at its calibration value. Laboratory calibration indicated that the radiometer was capable of measuring radiation temperatures with an error of no more than 1 deg for 250 to 320 deg K and 2 to 3 deg for 200 to 250 deg K. The rather high spatial resolution of the radiometer (10 to 15 km at nadir) made it possible to observe the details of the thermal structure of the cloud cover and to estimate the problems involved in determining the temperature of the underlying surface. This high accuracy also made it possible to determine the contribution of the aerosol component to the transformation of the thermal radiation emitted from the earth's surface and the lower layer of the atmosphere. The radiometer worked as planned. However, after a few days in orbit, problems with the satellite stabilization caused the satellite to roll about its longitudinal axis and limited the amount of useful data acquired.

------- COSMOS 149, MALKEVICH------------------------------

INVESTIGATION NAME- THREE-CHANNEL NARROW-ANGLE TELEPHOTOMETERS

NSSDC ID- 67-024A-01 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI - M.S.	MALKEVICH	SAS-IPA
OI - V.I.	SYACHINOV	SAS-IPA
OI - L.G.	ISTOMINA	SAS-IPA

BRIEF DESCRIPTION

The Cosmos 149 three-channel, narrow-angle telephotometer experiment was designed primarily to measure quantitatively the angular, spatial, and spectral parameters of the structure of cloud fields, aerosols, and the underlying surface that determine the radiation field of the earth. Secondary goals were to measure reflected solar radiation in various sections of the spectrum in order to determine cloudtop heights and to test the feasibility of determining the mass of atmospheric water vapor from measurements in the 0.72-micrometer water vapor absorption band. The instrumentation consisted of two three-channel, medium-resolution telephotometers that scanned in two mutually orthogonal planes and produced two photometric profiles of the earth's brightness field in narrow intervals of the visible spectral region. They both operated in the intensity range of 0.5 to 70 mW/sq cm-ster-micrometer, and each had a 3-deg field of view. The first telephotometer (TF-3A) was mounted on top of the nose section of the satellite and scanned perpendicular to the flight trajectory. It measured the intensity of reflected solar radiation in narrow bands centered at 0.34, 0.47, and 0.74 micrometer. The second telephotometer (TF-3B) was mounted on the left side of the cylindrical center section and scanned along the flight trajectory. It measured the intensity of reflected solar radiation in the absorption bands of water vapor (0.76 micrometer) and molecular oxygen (0.75 micrometer) and in the comparison band of 0.74 micrometer. Radiation first entered the telephotometer through a synthetic quartz protective cap, was reflected from a plane scanning mirror that scanned in a circular motion, and passed through a protective tubular diaphragm consisting of 1400 blackened tubes 50 mm long and with a 6-mm inner diameter. The radiation then passed through one of three interference filters on to one of four openings in a rotating programming disk. The programming disk performed four successive operations during the measurement cycle: (1) it allowed each channel to record its own zero level, (2) it opened the aperture for low light flux measurements from earth, space, sun, and satellite stabilizer, (3) it allowed the viewing of a brightness standard for sensitivity calibration, and (4) it inserted a neutral attenuation filter for comparison measurements of the radiation fluxes. The radiation fluxes that were passed through the programming disk aperture fell on one of three photomultipliers, whose outputs were amplified and went either to the telemetry system for direct transmission or to a recording device. Each cycle of measurement began with the scanning mirror positioned so that the optical axes of the three channels deviated from the zenith by 15 deg. The cycle consisted of two full revolutions of the scanning mirror and lasted 3.6 s. Complete cycles were repeated continuously when the experiment was in the direct transmission mode; while in the memory mode, the cycles were separated by 3-min intervals. Each cycle provided 100 individual measurements of radiation at maximum sensitivity and 100 comparison measurements made with the neutral attenuating filter. After the first few cycles on the first orbit, the absolute sensitivity of the telephotometers fell off and their zero levels began to vary. The decline in sensitivity for TF-3A was caused by a flash of sunlight overloading the photomultiplier, particularly in the 0.74-micrometer channel. By the third orbit, the sensitivities were so degraded that reference signals were no longer recorded and data on terrestrial brightness were not reliable. All three channels of TF-3B, however, produced terrestrial brightness profiles throughout the life of the experiment, despite considerable variation (up to 30%) in the absolute sensitivity. The error in the measurement of absolute terrestrial brightness for these channels plus the 0.34- and 0.74-micrometer channels of TF-3A for characteristic intensities was less than 5% and no more than 2% for weak signals. The cross sections of the scanning bands at nadir from an average satellite altitude of 265 km were about 20 km wide and 30 km apart. When the optical axis of the instrument was shifted from nadir through an angle of more than 30 deg, the areas of successive scans overlapped and independent information was obtained. The ground resolution of the telephotometers was 10 to 15 km at nadir. Problems with the satellite orientation and stabilization systems further limited the amount of useful data obtained. A similar experiment was flown on Cosmos 320.

------- COSMOS 149, UNKNOWN------------------------------

INVESTIGATION NAME- TV CAMERA SYSTEM

NSSDC ID- 67-024A-04 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - UNKNOWN SAS-IPA

BRIEF DESCRIPTION
The Cosmos 149 TV camera system provided cloudcover and earth pictures for use in analysis of the various measured quantities of the radiation field of the earth-atmosphere system obtained by the other three experiments (i.e., a three-channel telephotometer and a narrow-angle and a wide-angle IR radiometer). The camera, which was mounted in the lower side of the domed nose section, had its optical axis directed along nadir and produced television pictures with a 30-deg field of view at nadir. At the same time, the camera gave a picture of the transition zone between the earth's atmosphere and space in four directions. This allowed visual control of the satellite's orientation. The system worked as planned. However, spacecraft stabilization problems limited the amount of useful data being collected.

*************************** COSMOS 156***********************

SPACECRAFT COMMON NAME- COSMOS 156
ALTERNATE NAMES- KOSMOS 156, 02762

NSSDC ID- 67-039A

LAUNCH DATE- 04/27/67 WEIGHT- KG
LAUNCH SITE- PLESETSK, U.S.S.R.
LAUNCH VEHICLE- A-1

SPONSORING COUNTRY/AGENCY
U.S.S.R. SAS

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 04/28/67
ORBIT PERIOD- 96.96 MIN INCLINATION- 81.17 DEG
PERIAPSIS- 593. KM ALT APOAPSIS- 635. KM ALT

PERSONNEL
PM - UNKNOWN SOVIET ACAD OF SCI
PS - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION
Cosmos 156 was the fourth announced Russian meteorological satellite and the second interim operational weather satellite in the experimental "Meteor" system. It was also the second launch of a semi-operational weather satellite from the Plesetsk site into a near-polar, near-circular orbit. Unlike the U.S. Weather satellites, however, the orbit was prograde (not sun-synchronous) because, as a result of geographic limitations, a retrograde orbit was not possible. Cosmos 156 was orbited to test, in a semi-operational mode, meteorological instruments designed for obtaining images of cloud cover, snow cover, and ice fields on the day and night sides of the earth and for measuring fluxes of outgoing radiation reflected and radiated by the earth-atmosphere system. This instrumentation consisted of (1) two vidicon cameras for daytime cloudcover pictures, (2) a high-resolution scanning IR radiometer for nighttime and daytime imaging of the earth and clouds, and (3) an array of narrow- and wide-angle radiometers covering the 0.3- to 3-, 8- to 12-, and 3- to 30-micrometer channels for measuring the intensity of radiation reflected from the clouds and oceans, the surface temperatures of the earth and cloud tops, and the total flux of thermal energy from the earth-atmosphere system into space, respectively. The satellite was in the form of a large cylindrical capsule, 5 m long and 1.5 m in diameter. Two large solar cell panels of four segments each were deployed from opposite sides of the cylinder after satellite separation from the launch vehicle. The solar panels were rotated to constantly face the sun during satellite daytime by means of a sun-sensor-controlled drive mechanism fitted in the top end of the center body. The meteorological instruments, a magnetometer, 465-MHz radio antennas, and orbital control devices were housed in a hermetically sealed cylinder located on the earthward-facing end of the cylindrical satellite body. The satellite was triaxially stabilized by a series of inertial flywheels, driven by electric motors, whose kinetic energy was dampened by torques produced by electromagnets interacting with the earth's magnetic field. Cosmos 156 was oriented by earth sensors with one of its axes directed earthward along the local vertical, a second oriented along the orbital velocity vector, and a third oriented perpendicular to the orbital plane. This orientation ensured that the optical axes of the instruments were constantly directed vertically earthward along the nadir. When two of the "Meteor" system satellites were in operation at the same time in near-polar orbits and with suitable differences in the longitudes of the ascending nodes, data could be received from one-half the earth's surface in a 24-h period. It is believed that the satellite ended operations in late August 1967, as indicated by the termination of data transmission to the United States via the "cold line" facsimile link with Moscow.

------- COSMOS 156, UNKNOWN-----------------------------------

INVESTIGATION NAME- DUAL VIDICON CAMERAS

NSSDC ID- 67-039A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION
The Cosmos 156 dual vidicon camera experiment was designed to test the capability of Russian weather satellites to provide daytime pictures of the earth's cloudcover distribution, local storms, and global weather systems for use by the Soviet Hydrometeorological Service. The instrumentation consisted of two identical vidicon cameras that were mounted in the satellite base and were directed toward the earth. Each camera viewed a 500- by 500-km area, one to the left and the other to the right of nadir, with a resolution of 1.25 km at nadir from a satellite altitude of 600 to 700 km. The cameras took a one-frame image of the earth's cloud cover with slight overlapping of successive frames to provide continuous coverage. The cameras switched on automatically any time the sun was more than 5 deg above the horizon. Because the earth illumination varied so much, automatic sensors adjusted the camera apertures to produce high-quality pictures under a variety of illumination conditions. The image formed by each vidicon tube either was transmitted directly to the ground if the satellite was in radio contact with one of two ground stations or was recorded on magnetic tape for later transmission if the satellite was beyond the zone of radio communication. The TV images received by these ground stations were processed and transmitted to the Hydrometeorological Center in Moscow, where they were analyzed and used in various forecast and analysis products. The pictures were archived at the Hydrometeorological Center. The Cosmos 156 cameras, although having 2.5 times the resolution of those carried on the ESSA satellites, could not provide continuous overlapping global coverage as do the ESSA cameras owing to the lower orbit of the Cosmos 156 satellite (614 km compared to 1400 km). Thus, to close the gaps in coverage, at least two satellites were required in the weather satellite system. In addition, cloudcover mosaics were produced from 10 or more individual cloudcover pictures at the Hydrometeorological Center to provide a more comprehensive view of global weather systems. Some of the individual pictures and the cloud mosaics were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received some of these pictures at the National Environmental Satellite Service (NESS) in Suitland, Maryland, via the "cold line" facsimile link with Moscow. The experiment appeared to have a short useful life as pictures were transmitted to NESS for only 4 months, from late April to late August 1967 at which time the experiment is believed to have terminated operations. These pictures were archived at NESS for 1 yr and then, unless of unusual interest, were discarded.

------- COSMOS 156, UNKNOWN-----------------------------------

INVESTIGATION NAME- SCANNING HRIR

NSSDC ID- 67-039A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION
The Cosmos 156 high-resolution scanning IR radiometer was designed to make measurements of cloud distribution and snow and ice cover on the dayside and nightside of the earth. The radiometer measured the outgoing radiation from the earth-atmosphere system in the 8- to 12-micrometer atmospheric window. Measurements made in this spectral region permitted construction of brightness patterns of the thermal relief and determination of equivalent radiation temperatures of the earth's surface and cloud tops. The instrument was a narrow-angle scanning radiometer with an instantaneous viewing angle of 1.5 by 1.5 deg. It was mounted in the base of the satellite in a sealed instrument compartment with its optical axis directed along the local vertical and toward nadir. The radiometer measured the intensity of the outgoing radiation by comparing the earth's radiation flux with the radiation flux from space. Each type of radiation entered the radiometer through separate windows, which were oriented in mutually perpendicular directions. The radiation from the earth-atmosphere system fell on a plane scanning mirror that was mounted at an angle of 45 deg to the satellite velocity vector and scanned through an angle of plus or minus 50 deg from nadir. The radiation was reflected from the scanning mirror through a stationary modulating disk and filter window onto a parabolic mirror that focused the parallel beam through a movable modulating disk onto a thermistor bolometer. The stationary and movable modulating disks provided the channel switching, sending first the earth-atmosphere radiation and then the space radiation to the parabolic mirror and finally to the bolometer. The bolometer converted the radiant flux into variable electric voltages (0 to 6 V) whose frequency was equal to the modulator frequency and whose magnitudes were proportional to the differences in the radiant flux intensities

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between earth and space developed at the bolometer output. During the movement of the scanning mirror through a plus or minus 40-deg sector, line scanning (40 lines/min) of the target area was accomplished in a plane normal to the orbital plane using a forward and back path, while scanning along the flight path was provided by the relative motion of the satellite with respect to the earth. In each scan, with the indicated viewing and scanning angles from the satellite's orbital altitude, the radiometer recorded the mean radiation intensities from a band about 1100 km wide with a resolution of about 15 km at nadir to about 24 to 27 km at the edges. The radiometer was capable of measuring radiation temperatures within 2 to 3 deg for temperatures above 273 deg K and within 7 to 8 deg for temperatures below 273 deg K. The video signals were amplified and sent either to the satellite memory unit for later transmission or to the radiotelemetry unit for direct transmission to earth, depending on whether the satellite was beyond or within the zone of radio communication with a ground receiving station, respectively. The ground receivers recorded the transmitted data in digital form on magnetic tape and simultaneously on 80-mm photographic film in the form of a brightness image of the thermal relief of the earth-atmosphere system. The data on magnetic tape were processed by computer at the Soviet Hydrometeorological Center and were used to produce a digital map of the equivalent radiation temperature field with a superposed geographic grid. The photographic film was developed and processed into an IR picture also with a superposed grid. The pictures were archived at the Hydrometeorological Center. Some of these pictures were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received these pictures at the National Environmental Satellite Service (NESS), Suitland, Maryland, via the "cold line" facsimile link with Moscow. Pictures were transmitted to NESS from early May until late August 1967, when, it is believed, the experiment operations terminated. These IR pictures were kept at NESS for 1 yr and then, unless of unusual interest, were discarded.

------- COSMOS 156, UNKNOWN------------------------------------

INVESTIGATION NAME- ACTIONMETRIC INSTRUMENT

NSSDC ID- 67-039A-03 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION
The Cosmos 156 actinometric experiment was designed to measure (1) the outgoing longwave radiation (3 to 30 micrometers) from the earth-atmosphere system, (2) the outgoing near UV, visible, and near IR solar radiation (0.3 to 3 micrometers) reflected and backscattered by the earth-atmosphere system, and (3) the effective radiation temperature of the earth's surface and cloud tops (8 to 12 micrometers). The instrumentation consisted of four radiometers: a pair of scanning, narrow-angle, two-channel radiometers and a pair of nonscanning, wide-angle, two-channel radiometers. The narrow-angle (4 by 5 deg field of view (FOV)) radiometers measured radiation in all three spectral bands, while the wide-angle (136 to 140 deg FOV) radiometers operated only in the 0.3- to 3- and 3- to 30-micrometer bands. In the narrow-angle radiometer, the 0.3- to 3-micrometer band was measured in one channel and the 8- to 12- and 3- to 30-micrometer bands were combined in the second channel. In the second channel, the two bands were separated by the exchange of corresponding filters as the radiometer scanned in alternate directions. The earth radiation entered the narrow-angle radiometer through a cylindrical fairing (KRS-5 crystal) and fell onto a conical scanning mirror. The radiation was reflected from the mirror through a three-lobed rotating mirror chopper that modulated the radiation flux at a frequency of 80 Hz. The chopper alternately reflected earth radiation and space radiation, which entered through a separate KRS-5 crystal window, onto one of three openings in a color filter wheel -- one filter for each spectral band. The particular spectral band that was passed through then fell on an off-axis parabolic mirror that focused the radiation flux onto a bolometric receiver. Periodic calibration was made when the scanning mirror moved to a 90-deg angle from nadir with simultaneous turning on and viewing of a silicon standard lamp. The 0.3- to 3-micrometer channel did not use the two-beam system or filter switching. The output from the modulated flow of radiation on the bolometer was amplified, rectified, filtered, and fed into the radio-telemetry system over eight channels. The wide-angle radiometers had identical optical systems for both channels. The earth radiation entered the radiometer through a hemispherical shell composed of quartz or KRS-5 crystal with a coating that determined the passband. The radiation was then modulated with a frequency of 64 Hz and fell on a bolometric receiver. As in the narrow-angle radiometers, the bolometer output was processed and fed into the radio-telemetry system. The wide-angle radiometer was standardized simultaneously with the narrow-angle radiometer by the input of a standard 64-Hz calibrating frequency into the amplification circuit. The relative rms measuring error for both types of radiometers was about 0.5%. To provide a backup capability, one wide-angle and one narrow-angle radiometer were held in reserve and could have been activated on command from the ground. The orientation of the Cosmos 156 satellite insured that the primary optical axes of the radiometers were oriented vertically downward toward nadir. The survey of the earth's surface by both radiometers was carried out by the motion of the satellite relative to the earth. In addition, the narrow-angle radiometer scanned 66 deg to either side of nadir in a plane normal to the orbital plane by rocking the scanning mirror about the optical axis. The radiometers covered a strip about 2500 km wide on the earth's surface and had a ground resolution of 50 km at nadir. The data were reduced at the ground stations and were transmitted in binary form to the Hydrometeorological Center in Moscow, where they were recorded in digital form on magnetic tape and were used to produce various analysis products such as earth-atmosphere albedo charts and radiation temperature maps. The data were archived at the Hydrometeorological Center. Some of these charts were transmitted in graphical form to various foreign meteorological centers, including the National Environmental Satellite Service (NESS), Suitland, Maryland. These actinometric charts were received at NESS via the "cold line" facsimile link with Moscow from may 1967 until late August 1967, when, it is believed, the experiment operations terminated. The charts were microfilmed and archived at the National Climatic Center (NCC), Asheville, North Carolina.

*************************** COSMOS 384**********************

SPACECRAFT COMMON NAME- COSMOS 384
ALTERNATE NAMES- KOSMOS 384, 04791

NSSDC ID- 70-105A

LAUNCH DATE- 12/10/70 WEIGHT- KG
LAUNCH SITE- PLESETSK, U.S.S.R.
LAUNCH VEHICLE- A-2

SPONSORING COUNTRY/AGENCY
U.S.S.R. SAS

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 12/11/70
ORBIT PERIOD- 89.5 MIN INCLINATION- 72.9 DEG
PERIAPSIS- 212. KM ALT APOAPSIS- 314. KM ALT

PERSONNEL
PM - UNKNOWN SOVIET ACAD OF SCI
PS - UNKNOWN SOVIET ACAD OF SCI

BRIEF DESCRIPTION
Cosmos 384 was the twenty-second Russian experimental meteorological satellite and the ninth launched from the Plesetsk site. Although it was primarily part of the recoverable payload reconnaissance series, Cosmos 384 also carried a supplemental scientific payload designed to test instruments that could be used to increase the viewing capability of conventional weather satellites and continue the investigations begun by Cosmos 243. The payload consisted of a narrow-angle, nonscanning, IR radiometer that measured outgoing terrestrial radiation in the 10- to 12-micrometer window and four microwave radiometers that measured outgoing terrestrial thermal radio (microwave) emissions at 0.8, 1.35, 3.4, and 8.5 cm. The IR and microwave radiometers made synchronized measurements of the various brightness temperatures to provide surface and atmospheric conditions, as well as cloudcover parameters. The data were stored in a memory device and then were transmitted by telemetry at 19.995 MHz. The satellite was in the form of a cylinder with hemispherical ends and was 5 m long and 2.44 m in diameter. Cosmos 384 reentered the atmosphere after more than 11 days in orbit and was recovered. On December 17, 1970, a 2- -diameter spherical capsule was ejected from the satellite and remained in orbit until December 27, 1970.

------- COSMOS 384, BASHARINOV-----------------------------

INVESTIGATION NAME- MICROWAVE RADIOMETERS

NSSDC ID- 70-105A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - A.E. BASHARINOV SAS-IPA
OI - A.S. GURVICH SAS-IPA

BRIEF DESCRIPTION
The Cosmos 384 microwave radiometer experiment was designed to measure the earth's thermal radio (microwave) emission with the purpose of developing techniques for the determination of the geophysical parameters of the atmosphere, clouds, and the underlying surface. It continued the studies begun by the Cosmos 243 microwave experiment. The instrumentation consisted of four radiometric receivers tuned to four wavelengths (8.5, 3.4, 1.35, and 0.8 cm) by means of an antenna system whose axis pointed toward nadir. The receivers and antennas resembled ground-based radio telescopes in design but were fully automated. The sensitivity of the receivers was about 0.7 deg K for the 8.5- and 3.4-cm bands and about 2 deg K for the 1.35- and 0.8-cm bands. The antennas had half-power directional pattern widths of about 3.5 deg at 0.8, 1.35, and 3.4 cm and 8.8 deg at 8.5 cm. The reference signal in the radiometers was the space background radiation, which was received by small horns directed toward the zenith. Calibration in flight was provided by switching the radiometers from the antennas to a noise generator at a temperature of

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about 300 deg K, which provided a zero level control. The fine adjustment of the radiometer scales was based on measurements made over specific reference points with known brightness temperatures and on average climatic data. These reference points made it possible to obtain relative radio brightness temperatures accurate to within 1 to 2 deg K and absolute radio brightness temperatures to within 4 to 6 deg K. The results of the measurements were accumulated in a recording device and were transmitted to the ground by radio telemetry when the satellite passed over the Soviet Union. For the most part, the results of measurements made at 8.5 cm were used to estimate the latitudinal variations in the thermodynamic temperatures of the surface of the ocean, land, and ice fields. Measurements at 0.8 and 3.4 cm were used to account for the effects of cloud droplet and raindrop absorption on the measurements made at 8.5 cm. The 1.35-cm measurements accounted for the absorption due to water vapor and were used to obtain the total atmospheric moisture content over the oceans. Changes in radio brightness temperatures in the 8.5- and 3.4-cm bands were also used to detect areas of rough seas and to delineate the boundaries of sea-ice fields. The measurements at 0.8 cm provided a unique source of information on the latitudinal distribution of cloud liquid water content (LWC) and allowed an estimate of the total LWC in the earth's atmosphere. The main advantage of this experiment was that the total moisture content of the atmosphere and the temperature of the underlying surface were measured simultaneously with the cloud LWC, thus permitting their correlation.

------- COSMOS 384, GORODETSKIY-------------------------------

INVESTIGATION NAME- NARROW-ANGLE IR RADIOMETER

NSSDC ID- 70-105A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

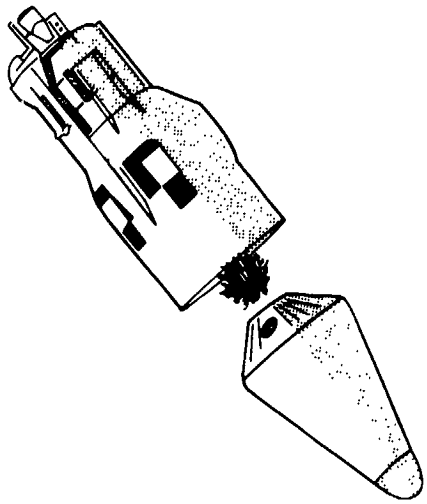
INVESTIGATION DISCIPLINE(S)

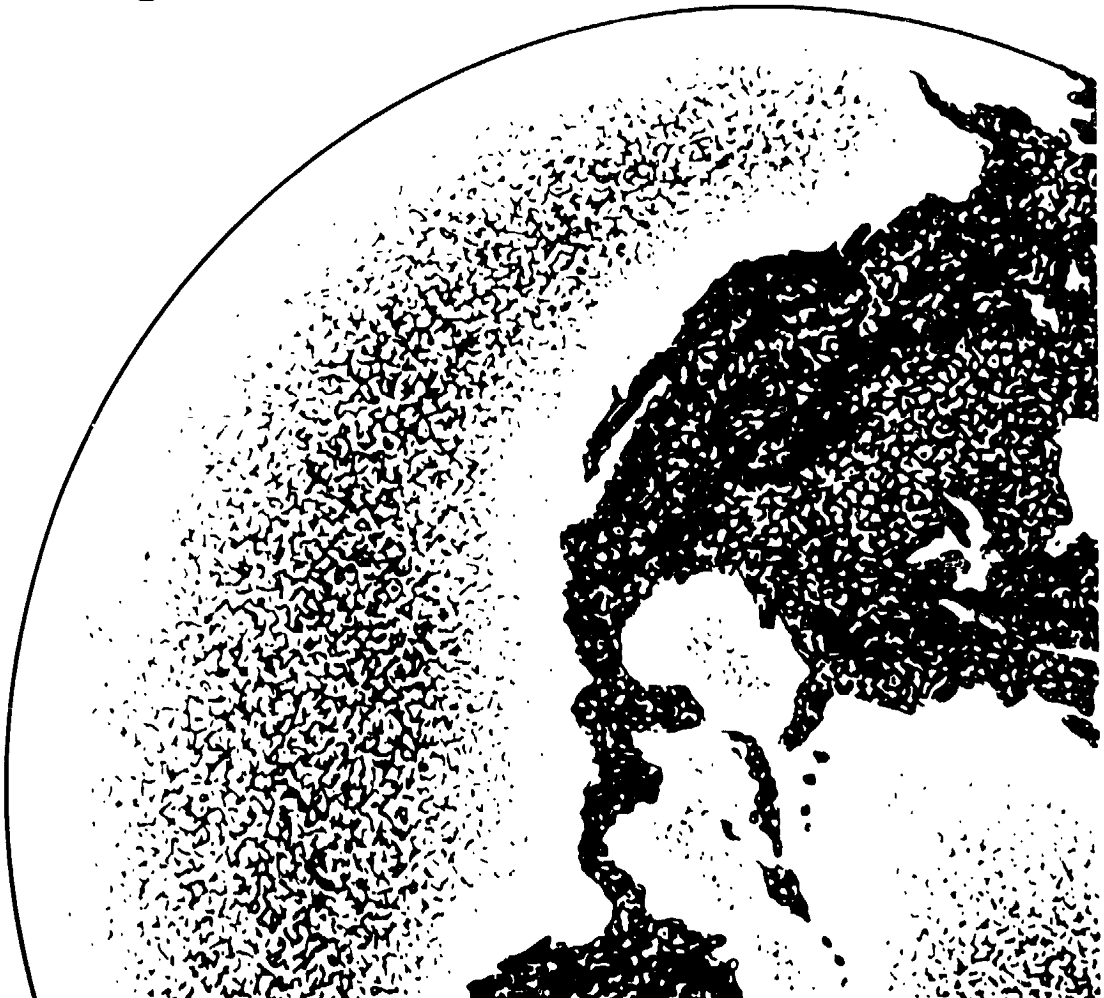
PERSONNEL
PI - A.K. GORODETSKIY SAS-IPA
OI - M.S. MALKEVICH SAS-IPA

BRIEF DESCRIPTION

The Cosmos 384 narrow-angle IR radiome[illegible]riment was designed to determine surface and clou[illegible]temperatures by measuring the outgoing radiation in th[illegible]o 12-micrometer window. The instrumentation consist[illegible] a high-resolution, narrow-angle, nonscanning IR radiometer whose basic principles of design and operation were identical to the radiometers flown on Cosmos 149, 243, and 320. The main components of the radiometer were (1) a parabolic mirror, (2) a chopper, (3) an improved interference filter that eliminated possible effects from water vapor, carbon dioxide, and ozone absorption bands, (4) a bolometer platform, (5) a thermistor, and (6) blinds. Earth and space radiation that entered the radiometer were combined by the mirror, modulated by the chopper, passed through the interference filter, and focused on the bolometer. The signal was amplified and sent to a memory device for later transmission. An improvement over the Cosmos 149 and 320 instruments was made by controlling the amplification factor, which made it possible to introduce a correction when a change in sensitivity occurred and thus increased the reliability of the measured values. The thermistor mounted on the radiometer casing monitored the instrument temperature and provided information for this correction. Blinds with a set of diaphragms in front of the lenses were used to reduce the effect of lateral exposure. Laboratory calibration indicated that the radiometer was capable of measuring brightness temperatures with an error of 1 to 2 deg in the 300- to 250-deg K range and 2 to 4 deg in the 250- to 220-deg K range. The optical axis of the radiometer was aligned parallel to the local vertical and was directed toward nadir. The radiometer viewed successive rectangular strips 15 km wide and 300 km long as the satellite progressed along its orbital path at an altitude of about 300 km. The high spatial resolution made it possible to observe the details of the cloud cover's thermal structure and to determine the temperature of the underlying surface.

DISCOVERER





DISCOVERER SATELLITE PROGRAM

The Discoverer satellite program was the early U.S. Air Force (USAF) effort in space. Discoverer was intended to be an open-ended scientific research program to carry out preliminary and general space research by means of a series of short-lived, low-altitude satellites. Much of the experimentation on the 38 Discoverer satellites was classified, but unclassified reports indicate that a significant portion of the effort in this program could have been related to the development of weather satellite technology. The horizon sensor (necessary for most instrumentation observing the earth and the earth atmosphere) was first flown on Discoverer 2. Cameras were reportedly flown on Discoverer 2 and 5. Discoverer 9, 21, and 26 were reported to have flown IR sensors. Although these were for preliminary information in the development of missile launch detection (MIDAS and SAMOS programs), it would be surprising if some of the information obtained was not applied to meteorological IR sensor development. A scanning radiometer was carried on Discoverer 35. As with most of the early programs, there were numerous launch failures (12 out of the 38 launched).

The last of the series, Discoverer 38, was launched in February 1962. The ongoing USAF program then became primarily a series of named, unpublicized launches with satellites of a variety of configurations as contrasted with the short-tubular configuration of the Discoverers. The descriptions of a Discoverer satellite and a meteorological experiment are provided here. Due to the lack of specific information and its apparently rather casual relation to the meteorological satellite development, no other experiment descriptions are provided.

############################ DISCOVERER 35####################

SPACECRAFT COMMON NAME- DISCOVERER 35
ALTERNATE NAMES- 1961 ALPHA ZETA 1, 00201

NSSDC ID- 61-030A

LAUNCH DATE- 11/15/61 WEIGHT- 1150. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 11/21/65
ORBIT PERIOD- 90. MIN	INCLINATION- 81.6 DEG
PERIAPSIS- 238. KM ALT	APOAPSIS- 278. KM ALT

PERSONNEL

PM -	UNKNOWN	UNKNOWN
PS -	UNKNOWN	UNKNOWN

BRIEF DESCRIPTION

Discoverer 35 (1961 Alpha Zeta) program objectives were to evaluate refinements in design changes to prior spacecraft. The spacecraft was also one of a series used to support space program experiments. Special measuring devices were on board to telemeter voltages, pressures, and other performance factors in addition to normal telemetry equipment. The reentry capsule was ejected after 18 orbits and was recovered in mid-air by a C-130 aircraft at 13,000 ft.

------- DISCOVERER 35, JURSA-------------------------------

INVESTIGATION NAME- SCANNING RADIOMETER

NSSDC ID- 61-030A-02

INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)

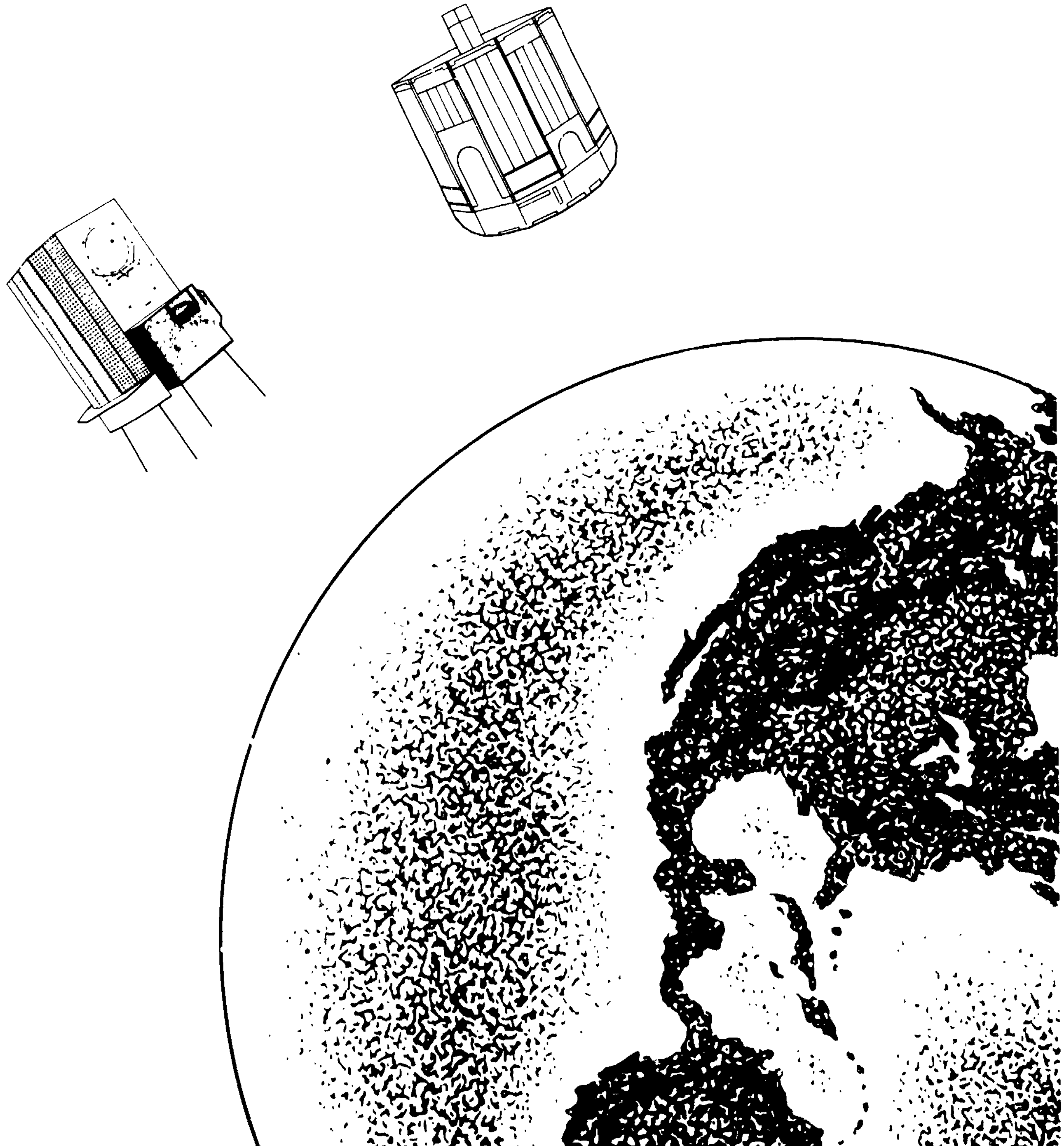
PERSONNEL

PI - A.	JURSA	USAF GEOPHYS LAB
OI - E.P.	TODD	U OF COLORADO

BRIEF DESCRIPTION

The Discoverer 35 scanning radiometer was capable of measuring both thermal emissions and reflected solar radiation from the earth. The radiometer subsystem consisted of an optics turret with appropriate filters and two flake-thermistor bolometers, one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers). Other components included a vibrating-wand chopper, an ac amplifier, and telemetry. A polished rotating mirror located in the optics turret allowed the radiometer to scan the earth from horizon to horizon. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5 deg. Similar radiometers were flown on MIDAS 3 and 4. A complete description of the radiometer can be found in "Transistorized radiometers and high altitude measurements," final report by Dr. E. Todd, University of Colorado, November 1963. Only the thermal detector functioned properly. However, the experiment was a success, with good data obtained for some 110 orbits (approximately 165 operational hours).

DMSP



DEFENSE METEOROLOGY SATELLITE PROGRAM (DMSP)

The Defense Meteorology Satellite Program (DMSP), originally known as the Defense System Applications Program (DSAP) and the Defense Acquisition and Processing Program (DAPP), is a long-term USAF effort in space. Since 1966, data from DMSP satellites have been routinely transmitted directly to Air Force and Navy ground terminals and Navy carriers. All spacecraft launched (Table 5) have had a tactical (direct readout) as well as a strategic (stored data) capability. Real-time data are provided to local Air Weather Service and Navy ground and shipborne terminals. Air transportable receiving terminals are installed at a number of U.S. and overseas locations to provide tactical commanders with observed and forecast meteorological data based on current observations.

In December 1972, DMSP data were declassified and made available to the civil/scientific community through the National Oceanic and Atmospheric Administration (NOAA). DMSP spacecraft history prior to July 1, 1965, is still classified. Since 1965, there have been two major spacecraft models flown: Block 4, Versions A and B; and Block 5, Versions A, B, C, and D.

The Block 4 version spacecraft employed a pair of vidicon cameras to acquire television pictures showing the earth's cloud cover and some terrain features as they appeared in the visible wavelength region. The resolution of these pictures was approximately 1.5 nautical miles (2.8 km) at nadir, but it degraded rapidly toward the picture edge. A supplementary system to observe albedo was also incorporated on later Block 4 spacecraft. This system of 16 thermopile sensors, known as the "C" system, acquired data on energy emitted by large areas of the earth in two selected IR intervals: 0.4 to 4.0 micrometers (energy from reflected sunlight) and 8.0 to 12.0 micrometers (energy emitted by the earth). Resolution was on the order of 100 nautical miles (185 km).

The first Block 5 version spacecraft was launched in February 1970. Block 5 versions A, B, and C replaced the vidicon cameras and the "C" system with a new primary sensor known as the Sensor Avenue Package (SAP) to gather visual and infrared data at improved resolutions. Visual data and IR data were collected at 1/3-nautical-mile (0.6-km) resolution and smoothed in real time to 2 nautical miles (3.7 km). The 1/3 nautical-mile (0.6-km) data were available to Air Force Global Weather Central, Omaha, Nebraska, while the smoothed data were routinely transmitted directly to Air Force and Navy tactical sites around the globe. Versions B and C incorporated various special sensors for obtaining vertical profiles of atmospheric temperature and density, and for measuring precipitating electron activity at spacecraft altitude. Many of these sensor packages have been improved for Block 5D.

TABLE 5

DMSP ON-ORBIT PERFORMANCE HISTORY

-66—67—68—69—70—71—72—73—74—75--76—77—78—79—80—81—82—83—84—85—86-

Satellite	MM	DD	YY	(OPERATIONAL DAYS)
4A-1	09	15	66	(788)
2	02	08	67	(100)
3	08	22		(1020)
4	10	11		(168)
4B-1	05	22	68	(617)
2	10	22		(711)
3	07	22	69	(720)
4				(NOT LAUNCHED)
5A-1	02	11	70	(78)
2	09	03		(81)
3	02	17	71	(770)
5B-1	10	14		(350)
2	03	24	72	(700)
3	11	08	73	(732)
4	08	17	73	(1210)
5	03	16	74	(900)
5C-1	08	09	74	(100)
2	05	24	75	(867)
3	02	18	76	(BOOSTER FAILURE)
5D-1 /F1	09	11		(1100)
/F2	06	05	77	(957)
/F3	05	01	78	(1755)
/F4	06	06	79	(425)
/F5	06	06		(LAUNCH FAILURE)
5D-2 /F6	12	21	82	( )
/F7	11	18	83	( )

The first Block 5D spacecraft was launched in September 1976. Although anomalies in spacecraft operation precluded collection of operational data immediately after launch, the satellite was restored to nominal operational condition and provided meteorological data of previously unmatched quality. The second, third, and fourth Block 5D satellites have subsequently been launched and placed in operation (Table 5). The fifth failed at launch. The 5D version included a new primary sensor, the Operational Linescan System (OLS), which provided improved resolution of 0.3 nautical miles (0.56 km) for both visual and IR fine data, and 1.5 nautical miles (2.8 km) for smoothed data. The biggest improvement over the SAP was that the OLS had uniform resolution along the scan line. At 800 nautical miles (1482 km) from nadir, the SAP experienced a degraded resolution of 13 nautical miles (24 km), while the OLS maintained a resolution of two nautical miles (3.7 km) or better.

Two spacecraft (F6 and F7) from the second generation Block 5D satellites (5D-2) were launched in 1982 and 1983, respectively. The 5D-2 satellites provide an improved capability on orbit with longer spacecraft structure (larger payload), increased power and data processing, and an increase in reliability and mission lifetime. The primary sensor is the imaging operational linescan system (OLS), as in the first Block 5D. Other meteorological instruments include: (1) the infrared temperature and moisture profile sounder (SSH-2), (2) the microwave temperature sounder (SSM/T), and (3) the microwave imager (SSM/I). The 16-channel SSH-2 sensor, which collects radiance data in the IR spectrum for inversion into temperature and water vapor profiles of the troposphere, is carried on at least three satellites. The SSM/T scans radiation in seven microwave spectra (50-60 GHz frequency), providing temperature profiles from the earth's surface to above 30 km. This microwave sensor complements the SSH-2 infrared sensor by providing temperature sounding over previously inaccessible cloudy regions. It was first carried on the F7 satellite and will be aboard all the planned satellites in the series, except S9 (F9 when launched). Another microwave sensor to be flown in the future mission is the microwave imager (SSM/I), which provides data on soil moisture, wind speed over the ocean, and the morphology and extent of sea ice.

Besides the meteorological sensors mentioned above, there are also X-ray and gamma ray detectors, a precipitating electron spectrometer, and an ionospheric plasma monitor carried on board the Block 5D-2 spacecraft. Notice that the DMSP spacecraft structural design is utilized in the NOAA series spacecraft subsequent to NOAA 5 and in the TIROS-N spacecraft.

Inquiries about data from the primary sensor (OLS) and the microwave imager (SSM/I) can be directed to the National Snow and Ice Data Center, CIRES, Campus Box 449, University of Colorado, Boulder, CO 80309. SSH-2 and SSM/T data are available from the National Climatic Data Center, Satellite Data Services Division, NOAA/NESDIS, Washington, DC 20233.

****************************DMSP 4A/F1-F4, 4B/F1-F3****************************

Spacecraft Name - DMSP 4A/F1-F4, 4B/F1-F3

S/C	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
DMSP 4A/F1	66-082A	09/15/66	98.5	705	891	100.9
DMSP 4A/F2	67-010A	02/08/67	98.8	796	868	101.5
DMSP 4A/F3	67-080A	08/22/67	99.0	834	892	102.2
DMSP 4A/F4	67-096A	10/11/67	99.2	667	866	100.2
DMSP 4B/F1	68-042A	05/22/68	98.9	817	904	102.2
DMSP 4B/F2	68-092A	10/22/68	99.0	797	855	101.4
DMSP 4B/F3	69-062A	07/22/69	98.8	787	857	101.4

PM - Space Division Staff — USAF Space Division

Brief Description

The cylindrically shaped Block 4 satellites incorporated two new one-inch diameter vidicon cameras, two video, a large-capacity tape recorder, and an all-digital command subsystem with magnetic core memory, giving fully programmable coverage of either direct readout or readout of recorded data without interference. Nominal satellite spin rate was decreased to reduce smear, permitting a higher resolution TV system for improved picture quality. Dual cameras and a high capacity recorder provided complete daily coverage of the entire Northern Hemisphere and tactical coverage anywhere on the earth. An improved IR "C" system was incorporated on this spacecraft. The Defense Meteorological Satellite Program's Block 4 space segment consisted of satellites in 450-nautical-mile, sun-synchronous, polar orbits, each carrying a payload of meteorological sensors. Primary cloud imaging sensors capable of globally viewing the earth in the visible and infrared spectrums were carried by every satellite. The ascending node of the satellites was either in the early morning time period or at midday. The final data product was a film product directly usable for imagery analysis. Originally part of a classified system of USAF weather satellites, the spacecraft mission was not revealed until March 1973.

------------------------------- DMSP 4A/F1-F4, 4B/F1-F3, AFGWC Staff -------------------------------

Investigation Name - Vidicon Camera System

Flown on - DMSP 4A/F1-4, 4B/F1-F3

NSSDC ID - 66-082A-01, 67-010A-01, 67-080A-01, 67-096A-01, 68-042A-01, 68-092A-01, 69-062A-01

PI - AFGWC Staff — AFGWC

Brief Description

The vidicon camera system fulfilled the requirement of the primary mission of the Block 4 satellites which was to acquire, store, and transmit television pictures of the earth's cloud cover ground stations. The pictures showed clouds and some terrain features as they appeared in the visible wavelength region. The resolution of these pictures was approximately 1.5 nautical miles. The primary data subsystem consisted of two vidicon cameras with their associated electronics packages and a tape transport with its associated drive and signal electronics packages. The cameras each had a 56 deg field of view (measured in the plane containing a line parallel to the satellite spin axis and the camera optical axis) whose axes were inclined approximately 26.5 degrees from the orbit plane. The cameras, each consisting of a camera head on a camera electronics package, were lightweight devices capable of providing video signals of images observed from the satellites. The camera head consisted of a lens, a vidicon, a deflection yoke, and a video preamplifier, and the camera electronics consisted of the electronic circuitry necessary to provide deflection potentials, shutter pulses, and other operating potentials to the camera. The lens was a Kinoptic Apochromat (Tegea), f/1.8-9.8mm focal length lens. The camera data format had an aspect ratio of 8:7 with the longer dimension of the format from left to right of the scene referenced to the horizontal. The line scan was along the longer dimension of the format from left to right of the scene referenced to the horizontal. The line scan rate was 76 lines/s with 1/18 scan period blanking. The frame consisted of 648 active lines which were scanned in approximately 8.5 s. The camera reproduced seven discernable gray levels. At the reference time in the desired spin period, the first camera's shutter was operated, storing, on the vidicon target, the image of the area indicated. During the next spin period, this image was read out as an electrical waveform and stored on magnetic tape. At the reference time of the next spin period, the second camera was similarly exposed, and its signal was read out during this second spin period. The result was a continuous video signal, lasting for two spin periods, representing the sequential images from the two cameras.

-------------------------------- DMSP 4A/F1-F4, 4B/F1-F3, AFGWC Staff ------------------------------

Investigation Name - C System

Flown on - DMSP 4A/F1-F4, 4B/F1-F3

NSSDC ID - 66-082A-02, 67-010A-02, 67-080A-02, 67-096A-02, 68-042A-02, 68-092A-02, 69-062A-02

PI - AFWGC Staff AFGWC

Brief Description

The "C" system fulfilled the supplementary mission of the Block 4 satellites to acquire, share, and transmit data on IR energy emitted by the earth's surface. This system consisted of 16 thermopile sensors arranged in an array, a multicolor unit containing a solid state commutator, differential amplifier and a/d converter, and a tape recorder. The "C" system normally operated in one of three modes: record, calibrate, or playback. In the record mode, each sensor was sampled on alternate spins of the satellite when the sensor pointed toward the earth. The data were digitized and stored with auxiliary satellite data. In the calibrate mode, each sensor was sampled on alternate spins of the satellite when the sensor axis looked at space. This provided a means for calibrating the sensors against a known radiance source. The data were digitized and recorded as in the record mode. In the playback mode, data recording was stopped and recorded data were played back and transmitted to the earth via the data transmitter. The radiometric calibration of the subsystem is accurate to within 2%. Each sensor was an absolute radiometric device whose output was proportional to the radiation exchange between it and the target in its field of view. In the 16-sensor array, equal numbers of two types of sensors were used; the A type operated in the spectral range of 0.4 to 4.0 micrometers and the B type operated in the range of 8.0 to 12.0 micrometers. Individual sensors were sized and positioned so that they viewed nominal, equal 100-nautical-mile-square areas on the earth across a continuous 800-nautical-mile width swath centered on the orbital track. The data were digital, each number representing a sample of the average radiance from an area approximately 116 nautical miles square. The coverage consisted of a swath of four such samples on each side of the subsatellite track, giving a total width of 928 nautical miles. These data were acquired continuously (except during playback).

*********************DMSP 5A/F1-F3, 5B/F1-F5, 5C/F1,F2***********************

Spacecraft Name - DMSP 5A/F1-3, 5B/F1-F5, 5C/F1,F2

S/C		NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
DMSP	5A/F1	70-012A	02/11/70	98.7	773	874	101.4
DMSP	5A/F2	70-070A	09/03/70	98.7	764	874	101.3
DMSP	5A/F3	71-012A	02/17/71	98.8	763	833	101.9
DMSP	5B/F1	71-087A	10/14/71	99.0	796	877	101.7
DMSP	5B/F2	72-018A	03/24/72	98.8	803	885	101.8
DMSP	5B/F3	72-089A	11/09/72	98.8	797	853	101.4
DMSP	4B/F4	73-054A	08/17/73	98.5	795	836	101.2
DMSP	5B/F5	74-015A	03/16/74	99.1	768	860	101.2
DMSP	5C/F1	74-063A	08/09/74	98.6	792	860	101.4
DMSP	5C/F2	75-043A	05/24/75	98.7	795	881	101.7

PM - Space Division Staff USAF Space Division

Brief Description

DMSP Blocks 5A, B, and C were a series of meteorological satellites developed and operated by the Air Force under the Defense Meteorological Satellite Program. This program, previously known as the Data Acquisition and Processing Program (DAPP), was classified until March 1973. The objective of this program was to provide global visual and infrared (IR) cloud cover data and specialized environmental data to support Department of Defense requirements. Operationally, the program consisted of two satellites in 830-km, sun-synchronous, polar orbits, with the ascending node of one satellite near the sunrise terminator and the other near local noon. The satellite, shaped like the frustum of a polyhedron, consisted of four subassemblies: (1) a solar array hat, (2) a base-plate assembly, (3) a sensor AVE (aerospace vehicle electronics) package (SAP), and (4) a data processing system. The primary sensor (SAP) was a scanning radiometer. Blocks 5B and C also carried secondary sensors, which included a vertical temperature profile radiometer (Supplementary Sensor E-SSE) and an electron spectrograph (Supplementary Sensor J or J/2-SSJ or SSJ/2), that were mounted, along with the primary sensor, on the base assembly. Spacecraft stabilization was controlled by a combination flywheel and magnetic control coil system so the sensors were maintained in the desired earth-looking mode. The data processing system included three tape recorders capable of storing a total of 440 min of data, which allowed full global coverage twice daily. Either recorded or real-time data were transmitted to ground receiving sites via an S-band transmitter. Recorded data were read out to tracking sites located at Fairchild AFB, WA, and Loring AFB, ME, and relayed to Air Force Global Weather Central, Offutt AFB, NE. Real-time data were read out at mobile tactical sites located around the world.

Investigation Name - Scanning Radiometer (SR)

Flown on - DMSP 5A/F1-F3, 5B/F1-F5, 5C/F1,F2

NSSDC ID - 70-012A-01, 70-070A-01, 71-012A-01, 71-087A-01, 72-018A-01, 72-089A-01, 73-054A-01, 74-015A-01, 74-063A-01, 75-043A-01

PI - AFGWC Staff AFGWC

Brief Description

The three-channel scanning radiometer, designated the sensor AVE (aerospace vehicle electronics) package (SAP), was the primary experiment on the DMSP 5A series. The purpose of this experiment was to provide global, day/night observations of cloud cover and cloud temperature measurements to support Department of Defense requirements for operational weather analysis and forecasting. The radiometer operated in two spectral intervals: (1) visible and near infrared (0.4 to 1.1 micrometers), and (2) infrared (8 to 13 micrometers). The radiometer was essentially two scanning radiometers driven by a common motor. One radiometer produced high resolution (HR) visual and infrared (IR) data with nadir resolutions of 3.7 and 4.4 km, respectively. The other radiometer produced very high resolution (VHR) visual data with nadir resolutions of 0.63 km. Beginning with 5B/F2, a fourth channel was added to produce very high resolution infrared (WHR) data with nadir resolutions of 0.67 km. Onboard recorders had a storage capacity of 210 min of both HR and IR data and a total of 20 min of VHR data. For direct readout to tactical sites, the experiment was programmed so that VHR and IR data were obtained during the daytime, and HR and IR/WHR data were obtained at night. The infrared channels (IR and WHR) covered a temperature range of 210 to 310 K with an accuracy of 1 K. Electronic circuitry in the sensor converted the sensed infrared energy directly into equivalent black body temperature (as opposed to radiance) prior to transmission to ground sites. The HR channel included a zero resolution sensor that measured solar input and was used to control channel gain, thereby producing an output signal that represents scene albedo. This feature also made it possible to obtain useful visual data at night. The sensor incorporated sunshades and glare suppression devices in conjunction with a long-scan automatic gain control which allowed the HR channel to provide usable data through the day/night terminator. Besides the earth surface/cloud cover imagery archived at the National Snow and Ice Data Center, University of Colorado, Campus Box 449, Boulder, CO 80309, the auroral imagery data are available from the National Geophysical and Solar-Terrestrial Data Center, NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), Boulder, CO 80303.

------------------------- DMSP 5A/F1-F3, 5B/F1-F5, 5C/F1,F2, AFGWC Staff ---------------------

Investigation Name - Vertical Temperature Profile Radiometer (SSE)

Flown on - DMSP 5B/F2, F3, F5, 5C/F1, F2

NSSDC ID - 72-018A-02, 72-089A-02, 74-015A-02, 74-063A-02, 75-043A-02

PI - AFGWC Staff AFGWC

Brief Description

The Special Sensor E (SSE) was a vertical temperature profile radiometer. The objective of this experiment was to obtain vertical temperature and water vapor profiles of the atmosphere to support Department of Defense requirements in an operational weather analysis and forecasting. The SSE was an eight-channel sensor with six channels (668.5, 677, 695, 708, 725, and 747 cm-1) in the carbon dioxide 15-micrometer absorption band, one channel (535 cm-1) in a water vapor absorption band, and one channel (835 cm-1) in the 11-micrometer atmospheric window. The experiment consisted of an optical system, a detector and associated electronics, and a scanning mirror. The scanning mirror stepped across the satellite subtrack, allowing the SSE to view 25 separate columns of the atmosphere every 32 s over a cross-track ground swath of 185 km. While the scanning mirror stopped at a scene station, the channel filters were sequenced throughout the field of view. The surface resolution of the SSE was approximately 37 km at nadir. The carbon dioxide band radiation data were transformed to a temperature profile by a mathematical inversion technique. By a similar technique, this information could be combined with water vapor band data to obtain a water vapor profile. No archival data were produced, due to lack of funds and storage facilities in the operational environment.

*************************** ***DMSP 5D-1/F1-F4*********************************

Spacecraft Name - DMSP 5D/F1-F4

S/C	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
DMSP 5D/F1	76-091A	09/11/76	98.6	806	832	101.3
DMSP 5D/F2	77-044A	06/05/77	99.0	787	851	101.3
DMSP 5D/F3	78-042A	05/01/78	98.6	802	815	101.1
DMSP 5D/F4	79-050A	06/06/79	98.6	806	825	101.2

DMSP 5D-1/F1,F2 PM - J. J. McGlinchey USAF Space Division
DMSP 5D-1/F3,F4 MG - J. Rivers USAF Space Division

Brief Description

The DMSP 5D-1 series was one of a meteorological satellite series developed and operated by the Air Force. Previously known as DAPP (Data Acquisition and Processing Program), it was classified until March 1973. The objectives of this program were to provide global visual and infrared cloud cover and specialized environmental data to support Department of Defense requirements for operational weather analysis and forecasting. The program consisted of two satellites in planned 830-km, sun-synchronous, polar orbits, with the ascending node of one satellite in early morning and the other at local noon. The 5.4-m-long spacecraft was separated into four sections: (1) a Precision Mounting Platform (PMP) for sensors and equipment requiring precise alignment; (2) an Equipment Support Module (ESM) containing the electronics, reaction wheels, and some meteorological sensors; (3) a Reaction Control Equipment (RCE) support structure containing the spent third-stage rocket motor and supporting the ascent phase reaction control equipment; and (4) a 9.29-sq-m solar cell panel. The Block 5D spacecraft stabilization was controlled by a combination flywheel and magnetic control coil system so sensors could be maintained in the desired "earth-looking" mode. One feature of Block 5D was the precision-pointing accuracy of the primary imager to 0.01 deg provided by a star sensor and an updated ephemeris navigation system. This allowed automatic geographical mapping of the digital imagery to the nearest picture element. The Operational Linescan System (OLS) was the primary data acquisition system that provided real-time or stored, multi-orbit, day-and-night visual and infrared imagery at 0.6-km resolution for all major land masses, and 2.8-km resolution for complete global coverage. This series also had special meteorological sensors (SSC, SSD, SSH, and SSM/T) and other sensors to measure electrons, gamma rays, ionospheric plasma, and X-rays. The data processing system included three high-density tape recorders, each of which could store 400 min of data. Either recorded or real-time data were transmitted to ground-receiving sites via two redundant S-band transmitters. Recorded data were read out to tracking sites located at Fairchild AFB, WA, and Loring AFB, ME, and relayed via Satcom to Air Force Global Weather Central, Offutt AFB, NE. Real-time data were read out at mobile tactical sites located around the world. A more complete description of the Block 5D spacecraft can be found in the report by D. A. Nichols, "The Defense Meteorological Satellite Program," Optical Engineering, v. 14, n. 4, July-August 1975. For information on meteorological data, users may contact SDSD. For the availability of unclassified environmental data, users may direct inquiries to the National Geophysical and Solar-Terrestrial Data Center, NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), Boulder, CO 80303.

------------------------------------ DMSP 5D-1/F1-F4, AFGWC Staff ------------------------------------

Investigation Name - Operational Linescan System (OLS)

Flown on - DMSP 5D-1/F1-F4

NSSDC ID - 76-091A-01, 77-044A-01, 78-042A-01, 79-050A-01

PI - AFGWC Staff AFGWC

Brief Description

The Operational Linescan System (OLS) was the primary experiment on the DMSP Block 5D spacecraft. The purpose of this experiment was to provide global, day/night observations of cloud cover and cloud temperature measurements to support Department of Defense requirements for operational weather analysis and forecasting. The OLS employed a scanning optical telescope driven in an oscillating motion, with optical compensation for image motion, which resulted in near-constant resolution throughout the sensor field of view. The radiometer operated in two ("light" and "thermal infrared") spectral intervals: (1) visible and near infrared (0.4 to 1.1 micrometers), and (2) infrared (8 to 13 micrometers). With DMSP 5D-1/F4, the OLS IR spectral band was changed from 8-13 micrometers to 0.5-12.6 micrometers to improve the sea-surface temperature resolution. With onboard processing, the radiometer produced data in four modes: LF (light fine) and TF (thermal fine) data with a resolution of 0.56 km, and LS (light smoothed) and TS (thermal smoothed) data with a resolution of 2.8 km. There were three onboard recorders, and each had a storage capability of 400 min of both LS and TS data or 20 min of LF and TF data. For direct readout to tactical sites, the experiment was programmed so that LF and TS data were obtained at night. The infrared data (TF and TS) covered a temperature range of 210 to 310 K with an accuracy of 1 K. The LS data mode provided visual data through a dynamic range from full sunlight down to a quarter moon. This mode also automatically adjusted the gain along scan to allow useful data to be obtained across the terminator. Additional information on this experiment is contained in the report by D. A. Nichols, "Primary Optical Subsystems for DMSP Block 5D," Optical Engineering, v. 14, n. 4, July-August 1975. Besides the earth surface/cloud cover imagery at the National Snow and Ice Data Center, Campus Box 449, University of Colorado, Boulder, CO 80309, the auroral imagery is available from the National Geophysical and Solar-Terrestrial Data Center, NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), Boulder, CO 80303.

-------------------------------------- DMSP 5D-1/F1-F4, AFGWC Staff ----------------------------------

Investigation Name - Multispectral Filter Radiometer (SSH)

Flown on - DMSP 5D-1/F1-F4

NSSDC ID - 76-091A-02, 77-044A-02, 78-042A-02, 79-050A-02

PI - AFGWC Staff AFGWC

Brief Description

Special Sensor H (SSH), also known as a Vertical Temperature Profile Radiometer (VTPR), was a cross-track scanning, multichannel filter radiometer similar to the HIRS/2 on the TIROS-N series. The objective of this experiment was to obtain vertical temperature, water vapor, and ozone profiles of the atmosphere to support Department of Defense requirements in operational weather analysis and forecasting. The SSH was a 16-channel sensor with one channel (1022 cm-1) in the 9.6-micrometer ozone absorption band, one channel (835 cm-1) in the 12-micrometer atmospheric window, six channels (747, 725, 708, 695, 676, 668.5 cm-1) in the 15-micrometer CO_2 absorption band, and eight channels (535, 408.5, 441.5, 420, 374, 397.5, 355.4, 353.5 cm-1) in the 18- to 30-micrometer rotational water vapor absorption band. The experiment consisted of an optical system, detector and associated electronics, and a scanning mirror. The scanning mirror was stepped across the satellite subtrack, allowing the SSH to view 25 separate columns of the atmosphere every 32 s over a cross-track ground swath of 2000 km. While the scanning mirror stopped at a scene station, the channel filters were sequenced through the field of view. The surface resolution was approximately 39 km at nadir. Radiance data were transformed into temperature, water vapor, and ozone profiles by a mathematical inversion technique. A more complete description of the experiment can be found in the report by D. A. Nichols, "DMSP Block 5D Special Meteorological Sensor H, Optical Subsystem," Optical Engineering, v. 14, n. 4, pp. 284-288, July-August 1975. SDSD has the archival data, and NSSDC has some ozone data.

-------------------------------------- DMSP 5D-1/F1-F4, AFGWC Staff ----------------------------------

Investigation Name - Microwave Temperature Sounder (SSM/T)

Flown on - DMSP 5D-1/F4

NSSDC ID - 79-050A-06

PI - AFGWC Staff AFGWC

Brief Description

The special sensor microwave/temperature sounder was a seven-channel scanning radiometer which measured radiation in the absorption band of molecular oxygen (50.5, 53.2, 54.35, 54.9, 58.4, 58.825, and 59.4 GHz) to provide data for vertical temperatures from the earth's surface to above 30 km. It was designed to scan in synchronization with the Special Sensor H package, and it provided temperature soundings at higher altitudes and cloudy regions inaccessible to SSH. By choosing frequencies with different absorption coefficients on the wing of the oxygen absorption band, a series of weighting functions peaking at preselected altitudes was obtained. The radiometer scanned across the nadir track on seven scan positions and two calibration positions (cold sky and 300 K). The dwell time for the cross-track and calibration positions was 2.7 s each. The total scan period was 32 s. The instrument had an instantaneous field of view of 12 deg and scanned plus or minus 36 deg from the nadir. Data are available from SDSD.

------------------------------------ DMSP 5D-1/F1-F4, AFGWC Staff ------------------------------------

Investigation Name - Snow/Cloud Discriminator (SSC)

Flown on - DMSP 5D-1/F4

NSSDC ID - 79-050A-08

PI - AFGWC Staff AFGWC

Brief Description

The Snow/Cloud Sensor was an experimental unit used in conjunction with the OLS sensor on spacecraft F4. The experiment being performed by the simultaneous in-orbit use of these two sensors is primarily that of proving the proposition that snow/cloud scene discrimination can be obtained through the combination of near IR sensor data and OLS 1-channel (visual) information. The snow/cloud detector was a "push-broom" scan radiometer that depended upon orbital velocity of the spacecraft to provide the along-track scan and a linear array of 48 detector elements at the image plane of a wide lens to provide a 40.2 deg cross-track scan. The sensor measured the reflected solar energy in the 1.51- to 1.63-micrometer spectral band.

************************ DMSP 5D-2/F6-F8, AFGWC Staff *************************

Spacecraft Name - DMSP 5D-2/F6-F78

S/C	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
DMSP 5D-2/F6	82-118A	12/21/82	98.7	817	839	101.4
DMSP 5D-2/F7	83-113A	11/18/83	98.7	810	829	101.3
DMSP 5D-2/F8	87-053A	06/20/87	98.8	836	856	101.9

DMSP 5D-2/F6-F7 MG - S. McElroy USAF Space Division

Brief Description

The DMSP 5D-2 series was one of a meteorological satellite series developed and operated by the Air Force. This program, previously known as DAPP (Data Acquisition and Processing Program), was classified until March 1973. The objective of this program was to provide global visual and infrared cloud-cover data and specialized environmental data to support Department of Defense requirements for operational weather analysis and forecasting. Operationally, the program consisted of two satellites in planned 830-km, sun-synchronous polar orbits, with the ascending node of one satellite in early morning and the other at local noon. The 6.4-m-long spacecraft was divided into four sections: (1) a precision mounting platform for sensors and equipment requiring precise alignment; (2) an equipment support module containing the electronics, reaction wheels, and some meteorological sensors; (3) reaction control equipment to support structure containing the spent third-stage rocket motor, and supporting the ascent phase reaction control equipment; and (4) a 9.29-sq-m solar cell panel. The spacecraft stabilization was controlled by a combination flywheel and magnetic control coil system so sensors were maintained in the desired "earth-looking" mode. One feature was the precision-pointing accuracy of the primary imager to 0.01 deg, provided by a star sensor and an updated ephemeris navigation system. This allowed automatic geographical mapping of the digital imagery to the nearest picture element. The operational linescan system was the primary data acquisition system that provided real-time or stored, multiorbit, day-and-night, visual and infrared imagery. This series also had special meteorological sensors, such as the SSH-2 and the SSM/T, and other sensors to measure electrons, gamma rays, ionospheric plasma, and X-rays. Either recorded or real-time data were transmitted to ground-receiving sites by two redundant S-band transmitters. Recorded data were read out to tracking sites located at Fairchild AFB, WA, and at Loring AFB, ME, and relayed by SATCOM to Air Force Global Weather Central, Offutt AFB, NE. Real-time data were read out at mobile tactical sites located around the world. A more complete description of the satellite can be found in the report by D. A. Nichols, "The Defense Meteorological Satellite Program," Optical Engineering, v. 14, n. 4, July-August 1975. For information on meteorological data, users may contact the National Snow and Ice Data Center, CIRES, Campus Box 449, University of Colorado, Boulder, CO 80309. For the availability of unclassified environmental data, users may direct inquiries to the National Geophysical and Solar-Terrestrial Data Center, NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), Boulder, CO 80303.

------------------------------------ DMSP 5D-2/F6-F8, AFGWC Staff ------------------------------------

Investigation Name - Operational Linescan System (OLS)

Flown on - DMSP 5D-2/F6-F8

NSSDC ID - 82-118A-01, 83-113A-01, 87-053A-01

PI - AFGWC Staff AFGWC

Brief Description

The Operational Linescan System (OLS) was the primary experiment on the DMSP Block 5D spacecraft. The purpose of this experiment was to provide global day-and-night cloud-cover observations and cloud-temperature measurements. The OLS employed a scanning optical telescope driven in an oscillating motion, with optical compensation for image motion that resulted in near-constant resolution throughout the sensor field of view. The radiometer operated in two ("light" and "thermal") spectral intervals: (1) visible and near infrared (0.4 to 1.1 micrometers), and (2) infrared (10.2 to 12.8 micrometers). The radiometer produced, with onboard processing, data in four modes: LF (light fine) and TF (thermal fine) data with a resolution of 0.56 km, and LS (light smoothed) and TS (thermal smoothed) data with a resolution of 2.8 km. There were four onboard recorders, each having a storage capability of 400 min of both LS and TS data or 20 min of LF and TF data. For direct readout to tactical sites, the experiment was programmed so that LF and TS data were obtained at night. The infrared data (TF and TS) covered a temperature range of 190 to 310 K with an accuracy of at best 2 K. The LS data mode provided visual data through a dynamic range from full sunlight down to a quarter moon. This mode also automatically adjusted the gain along the scan to allow useful data to be obtained across the terminator. Additional information on this experiment is contained in the report by D. A. Nichols, "Primary Optical Subsystems for DMSP Block 5D, "Optical Engineering, v. 14, n. 4, July-August 1975. Data can be obtained through the National Snow and Ice Data Center, Campus Box 449, University of Colo-rado, Boulder, CO 80309.

---------------------------------- DMSP 5D-2/F6-F8, AFGWC Staff ----------------------------------

Investigation Name - Infrared Temperature Profile Sounder (SSH-2)

Flown on - DMSP 5D-2/F8

NSSDC ID - 82-118A-02, 87-053A-05

PI - AFGWC Staff AFGWC

Brief Description

The objective of this experiment was to obtain vertical temperature and water vapor profiles of the atmosphere at altitudes from 0 to 30 km. The infrared temperature and moisture sounder, SSH-2, was a 16-channel sensor with one channel (3.7 micrometers) in the 3.7-micrometer window, one channel (11.1 micrometers) in the 12-micrometer window, six channels (13.4, 13.7, 14.1, 14.4, 14.8, 15.0 micrometers) in the 15-micrometer CO_2 absorption band, and eight channels (12.5, 18.7, 20.1, 22.7, 23.9, 24.5, 25.2, 28.3 micrometers) in the 22- to 30-micrometer rotational water vapor absorption band. The experiment consisted of an optical system, detector and associated electronics, and a scanning mirror. The scanning mirror was stepped across the satellite ground track, allowing the sounder to view 25 separate columns of the atmosphere every 32 s over a cross-track ground swath of 2204 km. While the scanning mirror was stopped at each of the 25 positions, the channel filters were sequenced through the field of view. The cross-track surface resolution was approximately 60 km at nadir. The radiance data were transformed into temperature and water vapor profiles by a mathematical inversion technique. The rms error of the temperature was 2.5 to 3 K. Archival data are available from SDSD at the National Climatic Data Center (NCDC), Room 100, World Weather Building, Washington, DC 20233.

---------------------------------- DMSP 5D-2/F6-F8, AFGWC Staff ----------------------------------

Investigation Name - Microwave Imager (SSM/I)

Flown on - DMSP 5D-2/F8

NSSDC ID - 87-053A-06

PI - AFGWC Staff AFGWC

Brief Description

The microwave imager was designed to provide day and night measurements of ocean surface wind speed, ice coverage and age, area and intensity of precipitation, cloud water content, and land surface moisture. An estimate of atmospheric attenuation at each of the four sensor frequencies was also available. Microwave brightness temperatures were obtained with a seven-channel passive microwave radiometer operating at four frequencies, three with both vertical and horizontal polarization (19.35, 37.0, and 85.5 GHz) and one with vertical polarization (22.23 GHz). The instrument scanned across the ground track to gather data over a 1400-km swath width, with horizontal resolutions of 13 to 50 km for different frequencies. Data were used for tropical storm reconnaissance, ship routing in polar regions, agricultural weather, aircraft routing, and refueling.

Investigation Name - Microwave Temperature Sounder (SSM/T)

Flown on - DMSP 5D-2/F8

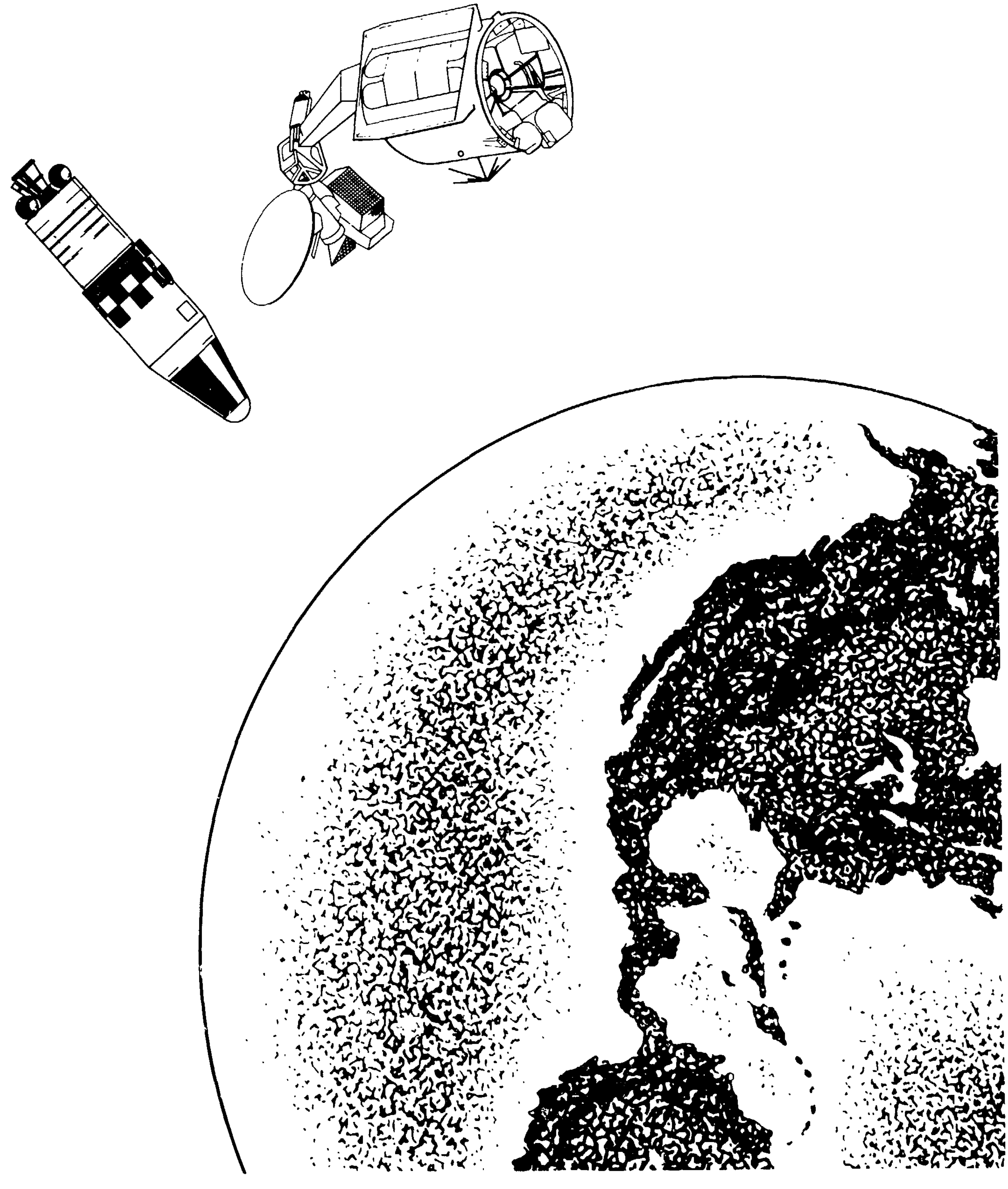
NSSDC ID - 83-113A-03, 87-053A-02

PI - AFGWC Staff AFGWC

Brief Description

The microwave temperature sounder SSM/T was a seven-channel scanning radiometer that measured radiation in the 5- to 6-mm wavelength (50- to 60-GHz) region (specifically 50.5, 53.2, 54.35, 57.9, 58.4, 58.825, and 59.4 GHz) to provide data on the vertical temperature profile from the earth's surface to above 30 km. The SSM/T provided temperature soundings at higher altitudes and over cloudy regions inaccessible to an infrared temperature and moisture sounder. By choosing frequencies with different absorption coefficients on the wing of the oxygen absorption band, a series of weighting functions peaking at preselected altitudes was obtained. The radiometer scanned across the nadir track on seven scan positions and two calibration positions (cold sky and 300 K). The dwell time for the cross-track and calibration positions was 2.7 s each. The total scan period was 32 s. The instrument had an instantaneous field of view of 12 deg and scanned plus or minus 36 deg from the nadir. Archival data are available from SDSD at the National Climatic Data Center (NCDC), Room 100, World Weather Building, Washington, DC 20233.

DOD



DOD - OTHERS

In 1962 the U.S. Department of Defense (DOD) began to launch many satellites having only classified program names. This program has continued to the present as principally an Air Force effort. By 1967 over 25 non-USAF satellites could be identified, and by December 1977 a total of 342 DOD unnamed satellites were launched. Many were undoubtedly reconnaissance satellites, but it is relatively certain that a significant number were related to the development of the DMSP meteorological satellite program, and others were early, still classified, launches of the same program. DOD has also announced certain named satellite series launches. Examples include Transit (navigation satellites), the OV series (USAF Orbiting Vehicle research satellites), SESP and STP (Space Environmental Satellite Program, subsequently named Satellite Technology Program), the DMSP series (since 1967), DSCS and IDSCS, MIDAS, SAMOS, SECOR, LES, VELA, ERS, SOLRAD, etc. Since unclassified descriptive material is not available on most early DMSP and meteorology-related satellites, only the MIDAS satellite/experiment descriptions are provided here as examples. (Note that MIDAS 1 failed to achieve orbit.)

****************************** MIDAS 2 ******************************

SPACECRAFT COMMON NAME- MIDAS 2
ALTERNATE NAMES- 1960 ZETA 1, 00043

NSSDC ID- 60-006A

LAUNCH DATE- 05/24/60 WEIGHT- 2300. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 05/24/60
ORBIT PERIOD- 94.44 MIN INCLINATION- 33.0 DEG
PERIAPSIS- 484. KM ALT APOAPSIS- 511. KM ALT

PERSONNEL
PM - UNKNOWN
PS - UNKNOWN

BRIEF DESCRIPTION
The MIDAS 2 (Missile Defense Alarm System) satellite was an earth-orbiting satellite designed to measure IR background and define IR sources. In addition, the satellite carried experiments to measure cosmic radiation, atmospheric density, thermal emission and reflected solar radiation from the earth, and micrometeorites. A plasma probe was included too. The spacecraft weighed 2268 kg (including the second stage) and was chemical-battery powered. IR radiation data were received for the lifetime of the battery pack, which powered the final transmission on May 26, 1960.

------- MIDAS 2, JURSA-------

INVESTIGATION NAME- NON-SCANNING RADIOMETER

NSSDC ID- 60-006A-03 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - A. JURSA USAF GEOPHYS LAB
OI - E.P. TODD U OF COLORADO

BRIEF DESCRIPTION
This non-scanning radiometer experiment was capable of measuring both thermal emission and reflected solar radiation from the earth. The radiometer subsystem consisted of an optics turret with appropriate filters; two flake-thermistor bolometers: one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers); a vibrating-wand chopper; an ac amplifier; and telemetry. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5 deg. The radiometer was mounted facing earthward in the nose cone of the spacecraft. A complete description of the radiometer can be found in E. Todd, "Radiometer for high altitude radiation measurements," LASP Project 1764-Final Report, University of Colorado, Boulder, Colorado, 1963. The radiometer functioned satisfactorily for 2 days until the spacecraft lost electrical power. The satellite failed to achieve the appropriate "earthward" looking orientation, and the data could not be used for determining the earth's thermal emission or albedo.

****************************** MIDAS 3 ******************************

SPACECRAFT COMMON NAME- MIDAS 3
ALTERNATE NAMES- 1961 SIGMA 1, 00163

NSSDC ID- 61-018A

LAUNCH DATE- 07/12/61 WEIGHT- 1600. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 07/12/61
ORBIT PERIOD- 161.5 MIN INCLINATION- 91.2 DEG
PERIAPSIS- 3358.00 KM ALT APOAPSIS- 3534.00 KM ALT

PERSONNEL

BRIEF DESCRIPTION
MIDAS 3 (Missile Defense Alarm System) was a satellite placed in a circular earth orbit to measure IR background and define IR sources. This was an overall test of a system for detection of missile launchings with satellite-borne IR sensors. The payload was the same as for MIDAS 2, except that an Agena B replaced the Agena A as the upper stage. The satellite carried experiments on cosmic radiation, atmospheric density, radiometric measurement, and micrometeorite detection, and had a plasma probe. The spacecraft weighed 3500 lb (including the second-stage casing), was chemical-battery-powered, and was launched from the pacific missile range. Useful IR radiation data were received for the lifetime of the battery pack.

------- MIDAS 3, JURSA-------

INVESTIGATION NAME- SCANNING RADIOMETER

NSSDC ID- 61-018A-04 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - A. JURSA USAF GEOPHYS LAB
OI - E.P. TODD U OF COLORADO

BRIEF DESCRIPTION
The scanning radiometer was capable of measuring both thermal emissions and reflected solar radiation from the earth. The experiment was designed, in particular, to detect the exhaust from a recently launched Intercontinental Ballistic Missiles (ICBM) and so provide an early warning against any probable attack. The radiometer subsystem consisted of an optics turret with appropriate filters; two flake-thermistor bolometers: one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers); vibrating-wand chopper; an ac amplifier; and telemetry. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5 deg. The radiometer was mounted facing earthward in the nose cone of the spacecraft. The radiometer was identical to those flown on MIDAS 1 and 2 with the exception of employing a polished rotating mirror that allowed the radiometer to scan the earth from horizon to horizon. A complete description of the radiometer can be found in "Transistorized radiometers and high altitude measurements." Final Report by Dr. E. Todd, University of Colorado, November 1963. The experiment produced some data. However, neither of the detectors functioned well enough for the data to be useful in calculating thermal emission or the albedo of the earth.

****************************** MIDAS 4 ******************************

SPACECRAFT COMMON NAME- MIDAS 4
ALTERNATE NAMES- ALPHA DELTA, 00192
WEST FORD (1)

NSSDC ID- 61-028A

LAUNCH DATE- 10/21/61 WEIGHT- 1800. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 10/28/61
ORBIT PERIOD- 166. MIN INCLINATION- 95.9 DEG
PERIAPSIS- 3496. KM ALT APOAPSIS- 3756. KM ALT

PERSONNEL

BRIEF DESCRIPTION
The MIDAS 4 (MIssile Defense Alarm System) satellite was designed primarily to detect the exhaust heat from a recently launched ICBM by use of infrared sensors. Secondary objectives included the measurement of cosmic radiation and the ejection of 350 million copper needles into orbit around the earth (Project West Ford). The needles were to serve as an artificial scattering medium for radio signals in the centimeter band. The spacecraft was cylindrical in shape and measured approximately 6 m in length and 1.5 m in diameter. The IR sensors and communication subsystem were chemical battery powered. Once in orbit, the spacecraft was stabilized in a nose-down attitude so that the IR sensors and telemetry antenna were always facing earthward. The satellite was successfully launched into a near polar orbit on October 21, 1961; however, the needles failed to release.

------- MIDAS 4, TODD-------

INVESTIGATION NAME- SCANNING RADIOMETER

NSSDC ID- 61-028A-02 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)

PERSONNEL
PI - E.P. TODD U OF COLORADO

BRIEF DESCRIPTION
The MIDAS 4 scanning radiometer was capable of measuring both thermal emissions and reflected solar radiation from the earth. The experiment was designed, in particular, to detect the exhaust from a recently launched ICBM and so provide an early warning against any probable attack. The radiometer subsystem consisted of an optics turret with appropriate filters; two flake-thermistor bolometers: one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers); a vibrating-wand chopper; an ac amplifier; and telemetry. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5

deg. The radiometer was mounted facing earthward in the nose cone of the spacecraft. The radiometer was identical to those flown on MIDAS 1 and 2 with the exception of employing a polished rotating mirror, which allowed the radiometer to scan the earth from horizon to horizon. A complete description of the radiometer can be found in "Transistorized radiometers and high altitude measurements," Final Report by Dr. E. Todd, University of Colorado, November 1963.

**************************** MIDAS 5 ****************************

SPACECRAFT COMMON NAME- MIDAS 5
ALTERNATE NAMES- 1962 KAPPA 1, 00271

NSSDC ID- 62-010A

LAUNCH DATE- 04/09/62 WEIGHT- 2000. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 05/01/62
ORBIT PERIOD- 153. MIN	INCLINATION- 86.7 DEG
PERIAPSIS- 2814. KM ALT	APOAPSIS- 3382. KM ALT

PERSONNEL

BRIEF DESCRIPTION
The MIDAS 5 (MIssile Defense Alarm System) satellite was designed primarily to detect the exhaust heat from a recently launched ICBM by use of infrared sensors. Secondary objectives included measuring cosmic radiation, energetic particles, and the effects of the space environment on certain metals and emulsions. The spacecraft was cylindrically shaped, measuring approximately 6 m in length and 1.5 m in diameter. Once in orbit, the spacecraft was stabilized in a nose-down attitude so that the IR sensors and antenna were always facing earthward.

------- MIDAS 5, JURSA---

INVESTIGATION NAME- SCANNING RADIOMETER

NSSDC ID- 62-010A-04 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI - A.	JURSA	USAF GEOPHYS LAB
OI - E.P.	TODD	U OF COLORADO

BRIEF DESCRIPTION
The MIDAS 5 scanning radiometer was capable of measuring both thermal emissions and reflected solar radiation from the earth. The experiment was designed, in particular, to detect the exhaust from a recently launched ICBM and so to provide an early warning against probable attack. The radiometer subsystem consisted of an optics turret with appropriate filters and two flake-thermistor bolometers, one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers). Other components included a vibrating-wand chopper, an ac amplifier, and telemetry. A polished rotating mirror located in the optics turret allowed the radiometer to scan the earth from horizon to horizon. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5 deg. Similar radiometers were flown on MIDAS 3 and 4. A complete description of the radiometer can be found in "Transistorized radiometers and high altitude measurements," Final Report by Dr. E. Todd, University of Colorado, November 1963. The experiment was considered partly successful since only the thermal detector functioned properly. Radiometer data were obtained for only the first six orbits.

**************************** MIDAS 6 ****************************

SPACECRAFT COMMON NAME- MIDAS 6
ALTERNATE NAMES- 00574, WEST FORD (2)

NSSDC ID- 63-014A

LAUNCH DATE- 05/09/63 WEIGHT- 2000. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- ATLAS

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-USAF

PERSONNEL

BRIEF DESCRIPTION
The MIDAS 6 (MIssil Defense Alarm System) satellite was designed primarily to detect the exhaust heat from a recently launched ICBM by use of infrared sensors. A secondary objective was to eject 350 million copper needles into earth orbit (Project West Ford). The needles were to serve as an artificial scattering medium for radio signals in the centimeter band. The spacecraft was cylindrically shaped measuring approximately 6 m in length and 1.5 m in diameter. Once in orbit, the spacecraft was stabilized in a nose-down attitude so that the IR sensors and telemetry antenna were always facing earthward. The satellite continued in orbit until April 1977.

------- MIDAS 6, TODD---

INVESTIGATION NAME- SCANNING RADIOMETER

NSSDC ID- 63-014A-02 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

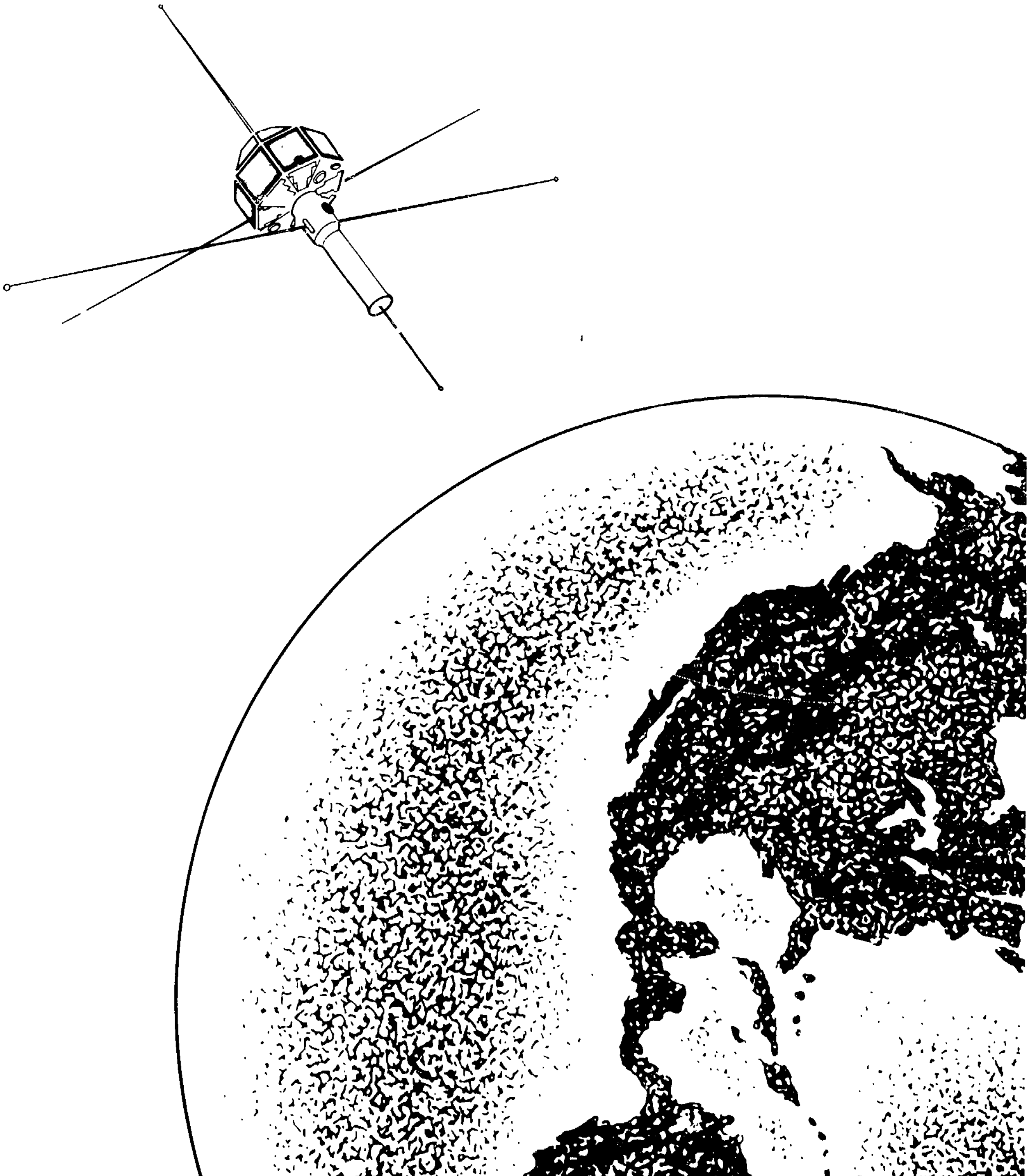
INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI - E.P.	TODD	U OF COLORADO

BRIEF DESCRIPTION
The MIDAS 6 scanning radiometer was capable of measuring both thermal emissions and reflected solar radiation from the earth. The experiment was designed, in particular, to detect the exhaust from a recently launched ICBM and so to provide an early warning against probable attack. The radiometer subsystem consisted of an optics turret with appropriate filters and two flake-thermistor bolometers, one sensitive to thermal radiation (3.5 to 30 micrometers) and the other to visible and near infrared radiation (0.2 to 4.5 micrometers). Other components included a vibrating-wand chopper, an ac amplifier, and telemetry. A polished rotating mirror located in the optics turret allowed the radiometer to scan the earth from horizon to horizon. Each detector was positioned at the base of a conical radiation shield that restricted the angular field of view to about 5 deg. Similar radiometers were flown on MIDAS 3, 4, and 5. A complete description of the radiometer can be found in "Transistorized radiometers and high altitude measurements," Final Report by Dr. E. Todd, University of Colorado, November 1963.

DODGE



DODGE SATELLITE

The Department of Defense Gravity Experiment (DODGE) satellite was launched by the Department of Defense primarily to study gravity-gradient stabilization techniques. It was a single engineering technology satellite, not intended to be part of a larger program. Placed into a nearly earth-synchronous orbit on July 1, 1967, the satellite carried two vidicon cameras: one narrow-angle (22 deg FOV) and one wide-angle (60 deg FOV). Both cameras were capable of black-and-white imaging, but the narrow-angle camera was designed to include capability for color pictures. To support the primary satellite mission, the cameras were directed to look earthward down the satellite mast and its extendable 4.6-m long boom to observe the induced bending of the boom and the alignment of the satellite with respect to the earth. Many meteorologically useful pictures were obtained, including the first color pictures from near earth-synchronous altitude.

****************************** ODGE*******************************

SPACECRAFT COMMON NAME- DODGE
ALTERNATE NAMES- 02867

NSSDC ID- 67-066F

LAUNCH DATE- 07/01/67 WEIGHT- 195.05 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- TITAN

SPONSORING COUNTRY/AGENCY

UNITED STATES	NASA-OSSA
UNITED STATES	DOD-NAVY

ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 01/15/68
ORBIT PERIOD- 1318.9 MIN	INCLINATION- 6.2 DEG
PERIAPSIS- 33270. KM ALT	APOAPSIS- 33659. KM ALT

PERSONNEL

PM - J.	DASSOULAS	APPLIED PHYSICS LAB
PM - L.P.	PRESSLER	US NAVAL RESEARCH LAB
PS - R.E.	FISCHELL	APPLIED PHYSICS LAB

BRIEF DESCRIPTION

The DODGE (Department of Defense Gravity Experiment) satellite was orbited primarily to study a number of advanced biaxial and triaxial gravity-gradient stabilization techniques at near-synchronous altitudes. Secondary objectives included obtaining measurements of the earth's magnetic field at near-synchronous altitudes and black-and-white and color TV photography of the entire earth disk. DODGE was launched as part of a multiple DOD satellite payload that included DATS 1, LES 5, and IDCSP 16, 17, and 18. The satellite was in the form of an octagonal aluminum shell with a truncated pyramid at the top and a 25.4-cm-diameter cylindrical mast extending 1.57 m from the satellite base. The satellite body was 2.41 m long and 1.22 m in diameter. A total of 10 knobbed booms were carried on board. Upon radio command, these booms could be independently extended or retracted along three axes to various limits out to 45.75 m. The cylindrical mast housed a 4.6-m boom that extended through the end of the mast, two 15.25-m-long damper booms that extended in the x-y plane, and triaxial vector magnetometer sensors. The remaining seven booms were contained in the satellite body along with a two-camera (one color and one black-and-white) vidicon camera system. The command system consisted of a dual command receiver, dual command logic, and power switching circuitry. The telemetry system included two directional antennas mounted on the mast, two 38-channel commutators for housekeeping data, and a dual transmitter system that transmitted analog data at a frequency of 240 MHz and TV data at 136.8 MHz. The satellite was successfully stabilized 12 days after launch by means of the gravity-gradient booms and libration dampening systems. It was oriented with its base and mast directed toward the center of the earth's disk. The mission was a success and proved the feasibility of achieving triaxial gravity-gradient stabilization at synchronous altitudes using passive and semipassive techniques. The satellite operated for over 3 yr and took thousands of black-and-white and color pictures of the earth. Early in 1971, problems with the batteries on board limited operation to only solar acquisition periods. The satellite was placed in an operational off mode in early 1971.

------- DODGE, THOMPSON---------------------------------------

INVESTIGATION NAME- DUAL VIDICON CAMERAS

NSSDC ID- 67-066F-01 INVESTIGATIVE PROGRAM
SPACE TEST PROGRAM

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

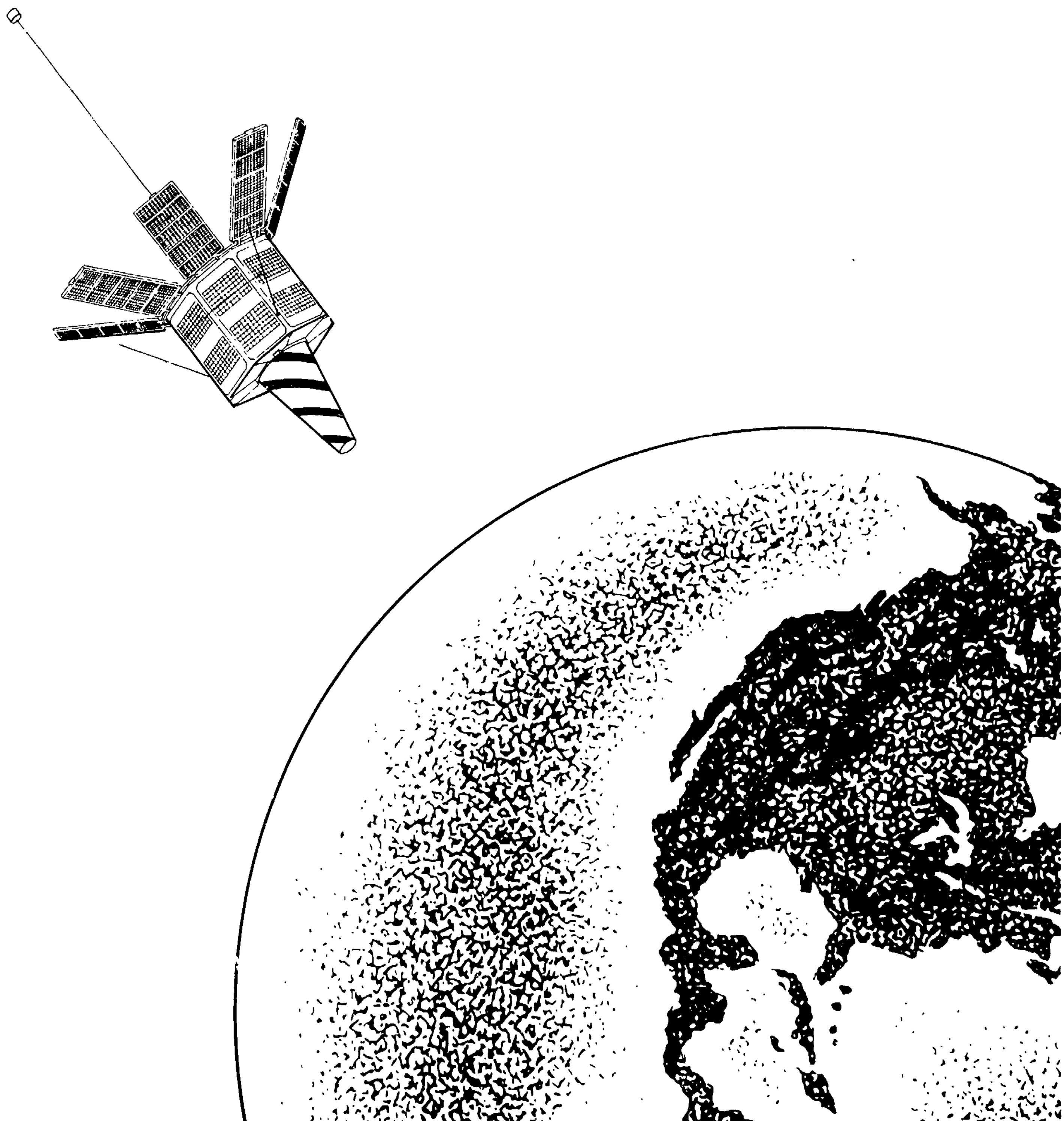
PERSONNEL

PI - T.	THOMPSON	APPLIED PHYSICS LAB

BRIEF DESCRIPTION

The DODGE dual vidicon camera experiment was designed primarily to determine (1) the alignment of the satellite with respect to the earth and (2) the amount of solar and gravitationally induced bending of the downward-pointing stabilization boom. In addition, the cameras were capable of providing information on the structure and dynamics of global cloud systems, cloud heights, airglow, and auroras. The cameras were mounted in the base of the satellite and viewed down the 1.57-m-long cylindrical mast toward the earth. The earth remained fixed in the field of view (FOV) when all oscillations were damped out and stabilization was achieved. The camera system consisted of two vidicon cameras, one with a 22-deg FOV and the other with a 60-deg FOV, and associated electronics and power converters. Both cameras were equipped with a 2.54-cm vidicon tube (512 lines/scan) and a special slow scan (200 sec/scan) video pickup. The 60-deg FOV camera took black-and-white pictures only and used a simple blade-type shutter. The 22-deg FOV camera, however, took both color and black-and-white pictures. It used a rotating eight-channel color wheel placed in front of the camera, which provided shuttering action. Three of the channels were equipped with blue, green, and red filters, one channel was left blank, and the remaining four had various shortwave cutoff (haze or Rayleigh) filters. High-purity quartz cover plates were placed over the optical filters for protection against radiation damage. The normal sequence of operation consisted of a 200-s charge cycle and alternate exposures and 200-s readouts of the 60-deg and 22-deg FOV vidicon tubes. In continuous operation, a 60-deg FOV camera exposure and read cycle followed immediately. Most of the pictures taken were black-and-white. On occasion, however, a command was sent from the ground to the satellite to initiate the color photography sequence. This sequence took 13.3 min and produced three frames, which were used to generate a composite color picture. The sequence consisted of alternate 1.2-s exposures of the camera tube with each of the color filters placed in the optical path of the camera. The information on the vidicon tube was read out for one color channel while the next color filter was moved into place. The video signals were then amplified, processed, and transmitted to the APL ground receiving station in Howard County, Maryland, where the color picture was reconstructed. The picture included a spherical color standard mounted on the end of the 4.6-m boom that extended out from the cylindrical mast. An identically colored sphere was kept in the ground acquisition station to monitor the accuracy of the colors displayed in the picture. To obtain data needed for the dynamic boom bending studies, a special fast scan (25 sec/scan) mode was included. Owing to the motion of the satellite across the face of the earth, pictures were taken for only 5.5 days out of its 11.2-day period, when the satellite was within communication range of the ground receiving station. During this period, the satellite programmer turned the camera system on every hour on the hour for 10 min. In the normal mode of operation (slow scan), one picture per camera was obtained every hour. The fast scan and color picture modes were initiated and controlled by ground commands. The pictures had a ground resolution of 66.6 and 24 km for the 60-deg and 22-deg FOV cameras, respectively. Separate sun sensors protected the cameras when the sun was in the FOV by preventing the shutter from opening. Pictures taken during the time when the sun was eclipsed by the earth provided information on airglow and auroral phenomena, while normal pictures of the earth provided data on cloud height by correlating the color bands of atmospheric scattering with altitude. The experiment was a success and produced over 25,000 pictures. On July 25, 1967, the DODGE 22-deg FOV camera took the first color picture of the earth ever made from a near-synchronous altitude. The negatives and positives of the pictures from 1967 and 1968 are kept at APL. About 300 pictures from the 1967-1968 period have been digitized and recorded on magnetic tape and are also kept at APL. Pictures from 1969 to 1971 are stored on magnetic tape in analog form and on 4- by 5-in. Polaroid prints. Problems with the spacecraft battery limited operations in 1971 to solar power acquisition times only. The last picture was taken in January 1971. Owing to limited funding, the experiment was placed in an operational off mode in the first quarter of 1971.

EOLE



EOLE/PEOLE SATELLITE PROGRAM

This French-U.S. satellite program consisted of the initial preliminary EOLE (which was a feasibility test of the EOLE satellite) and the subsequent operational version. Both were very similar in design and appearance, since the PEOLE design proved to be successful. The spacecraft was designed for gravity-gradient stabilization, and experimentation was primarily for weather communications. The satellite would systematically interrogate a number of constant pressure level, free-floating balloons to obtain meteorological data (altitude, pressure, temperature, and humidity) from balloon-borne instrumentation. The EOLE experiment included Doppler equipment which, in combination with satellite-to-balloon range measurements, could effectively track any given balloon to obtain wind vectors. Balloons were flown in the Southern Hemisphere to reduce problems of interference with commercial air traffic.

**************************** EOLE 1 ****************************

SPACECRAFT COMMON NAME- EOLE 1
ALTERNATE NAMES- CAS-A, 05435
EOLE

NSSDC ID- 71-071A

LAUNCH DATE- 08/16/71 WEIGHT- 84.7 KG
LAUNCH SITE- WALLOPS FLIGHT CENTER, UNITED STATES
LAUNCH VEHICLE- SCOUT

SPONSORING COUNTRY/AGENCY

FRANCE	CNES
UNITED STATES	NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 08/17/71
ORBIT PERIOD- 100.7 MIN	INCLINATION- 50. DEG
PERIAPSIS- 677. KM ALT	APOAPSIS- 906. KM ALT

PERSONNEL

PM - S.R. STEVENS	NASA-GSFC
PS - W.R. BANDEEN	NASA-GSFC

BRIEF DESCRIPTION

EOLE 1, the second French experimental meteorological satellite and the first launched by NASA under a cooperative agreement with the Centre National d'Etudes Spatiales (CNES), was designed to function primarily as a communications satellite to acquire and relay telemetered data on altitude, pressure, temperature, moisture, and upper atmospheric wind velocities from instrumented earth-circling constant density meteorological balloons. The octagonally shaped satellite measured 0.71 m across opposite corners and was 0.58 m long. Electrical power (20 W average) was supplied by eight rectangular solar panels deployed 45 deg from the EOLE 1 upper octagonal structure after orbital insertion, and by 15 rechargeable silver-cadmium batteries. Constant earth orientation was maintained by a deployable 10.06-m gravity gradient boom. Satellite spin was near zero rpm in orbit, and the attitude was programmed to remain stable within 9 deg of local vertical. The data were stored on board the spacecraft and unloaded on command when the spacecraft was within range of the ground station. The onboard telemetry consisted of (1) a 136.350-MHz downlink transmitter for relaying balloon telemetry to ground stations and also to serve as a tracking beacon, (2) a 148.25-MHz receiver for receiving spacecraft commands and telemetry programs for balloon operations, and (3) a spacecraft-to-balloon transmitter (464.84 MHz) and receiver (401.7196 MHz). The satellite operation was successful with the exception of the inadvertent destruction of 71 balloons by an erroneous ground command. The last balloon ceased transmitting in January 1973. However, the spacecraft was subsequently used to track and receive data from ocean buoys, icebergs, and ships.

------- EOLE 1, BANDEEN--

INVESTIGATION NAME- UPPER ATMOSPHERE WINDS AND WEATHER DATA RELAY SYSTEM

NSSDC ID- 71-071A-01 INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)

PERSONNEL

PI - W.R. BANDEEN	NASA-GSFC
OI - A. KASAHARA	NATL CTR FOR ATMOS RES
OI - J. ANGELL	NOAA
OI - Y. MINTZ	U OF CALIF, LA
OI - P. MOREL	CNRS

BRIEF DESCRIPTION

The EOLE 1 upper atmospheric winds and weather data relay system consisted of equipment designed primarily to collect various meteorological data from balloons in the Southern Hemisphere floating at pressure altitudes of about 200 mb. A secondary objective was to develop techniques for accurately determining balloon positions from an orbiting spacecraft. The satellite carried a modified Doppler system on board, which, when combined with satellite-acquired range measurements, could locate a balloon's horizontal position to within plus or minus 3 km. As many as 500 3.66-m, helium-filled, 30-day-lifetime constant density balloons were launched at the rate of three per day from three sites in Argentina, with an additional 250 held in reserve to replace those that failed. Each balloon had a frangible 9.75-m instrumentation line carrying temperature and pressure sensors, solar cells and batteries for power supplies, a telemetry receiver operating at 464.4864 MHz, and a 4-W, 401.71796-MHz transmitter using a linear sleeve antenna. The spacecraft interrogated the balloons both day and night, individually, in sequence, or in a programmed group (up to 64 at a time). The balloon position and sensor data were relayed to the ground and were fed into a computer program that provided, for operational use, wind speed and direction, ambient temperature, ambient pressure, and balloon superpressure. Each balloon was also equipped with an explosive charge for self-destruction, which could be triggered by ground command if the balloon drifted beyond the experiment's latitudinal limits (30 deg S to 60 deg S). On September 11, 1971, 71 of the 115 balloons in operation were accidentally destroyed when ground personnel inadvertently sent up a general destruct command instead of the interrogation command. The number of balloons gradually decreased during the experiment lifetime (due to icing, leakage, etc.). The last balloons were intentionally destroyed in January 1973. The experiment was subsequently used for tracking and collecting data from ocean buoys, icebergs, and ships.

**************************** PEOLE 1 ****************************

SPACECRAFT COMMON NAME- PEOLE 1
ALTERNATE NAMES- PEOLE, PRELIMINAIRE EOLE
04801, DIAMANT-B NO 2

NSSDC ID- 70-109A

LAUNCH DATE- 12/24/70 WEIGHT- 70. KG
LAUNCH SITE- KOUROU (CENTRE SPATIAL GUYANAIS), FRENCH GUIANA
LAUNCH VEHICLE- DIAMANT

SPONSORING COUNTRY/AGENCY

FRANCE	CNES

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 12/12/70
ORBIT PERIOD- 96.9 MIN	INCLINATION- 14.98 DEG
PERIAPSIS- 514. KM ALT	APOAPSIS- 749. KM ALT

PERSONNEL

PM - UNKNOWN	UNKNOWN
PS - UNKNOWN	UNKNOWN

BRIEF DESCRIPTION

PEOLE 1 (Preliminaire EOLE) was the first French experimental meteorological satellite and the first launched by the Centre National d'Etudes Spatiales (CNES) from the Centre Spatial Guyanais near Kourou, French Guiana. The satellite was placed into a near-circular, near-equatorial orbit. Launched before the initiation of France's operational meteorological satellite program, PEOLE 1 was designed to test the feasibility of acquiring data, including wind velocity, by reception of telemetry and tracking data from independent earth-circling, constant-altitude, and meteorological balloons. Qualifying tests were made of a gravity-gradient stabilization and attitude system, onboard engineering, and meteorological experimental equipment that were later used on the EOLE meteorological satellite. In addition, studies were made of the effects of the space radiation environment on solar cells composed of thin layers of cadmium sulfide and cadmium telluride. The satellite was in the form of a regular octahedron 0.70 m across opposite corners and 0.55 m long with eight solar panels containing 5920 solar cells, which were deployed 45 deg from the spacecraft's upper octagonal structure after orbital insertion. A 136.350-MHz (1 command receiver handled the command and programming telemetry. The satellite-balloon and satellite-earth interrogation systems were tested with a 400.190-MHz (4-W) transmitter that operated through an earth-oriented canted turnstile antenna mounted on the satellite base. PEOLE 1 was a success, and nearly all of its systems were incorporated into the design of EOLE 1.

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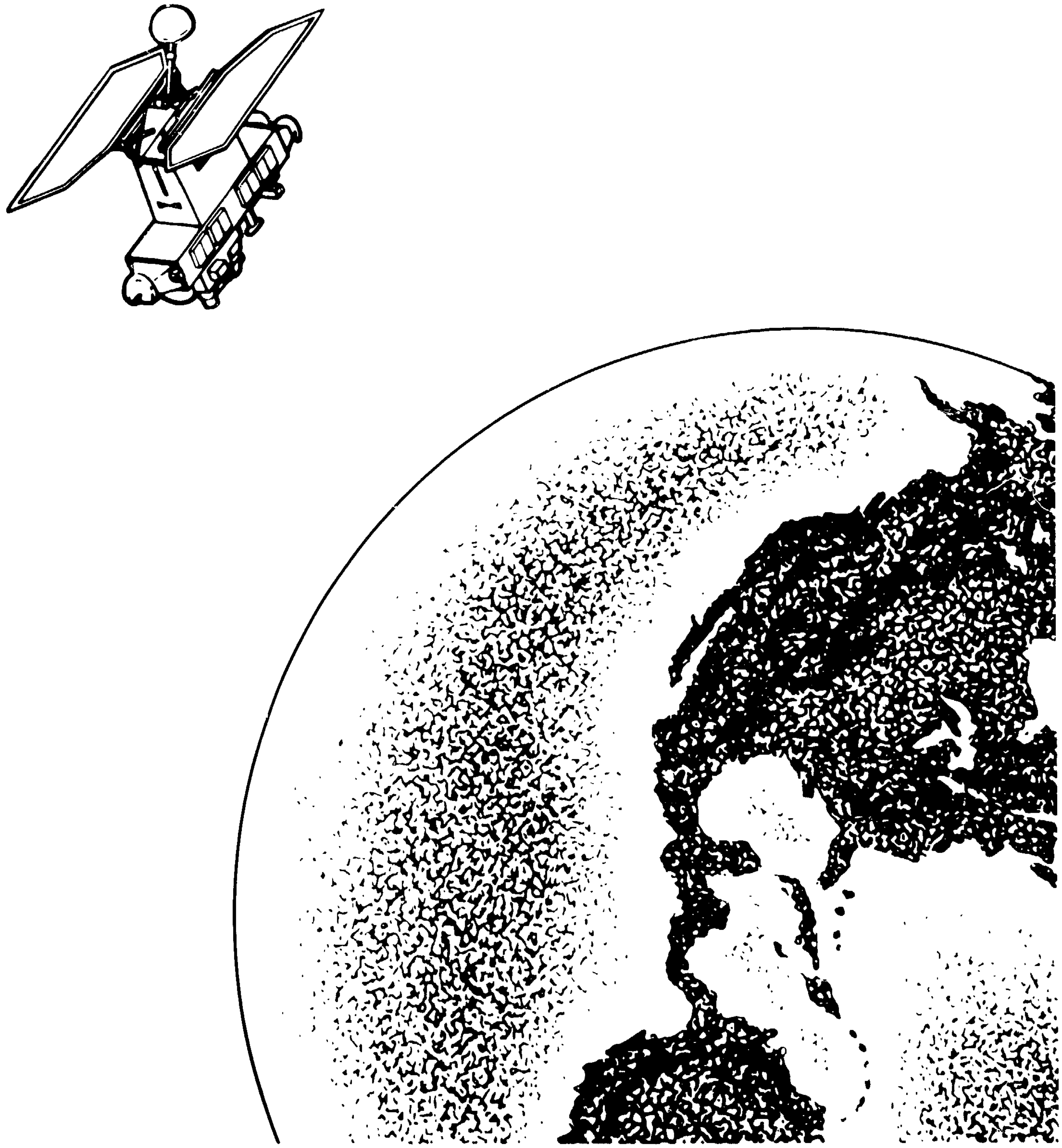
ERBE



EARTH RADIATION BUDGET EXPERIMENT (ERBE) PROGRAM

The Earth Radiation Budget Experiment (ERBE) program was designed for observations of the earth's radiation budget on global and regional scales in relation to long-term processes of the earth's weather and climate. The ERBE system allows the entire earth to be observed at some time of each day, and most of the earth at all times of day during every month. It consists of three satellites. Two of the satellites are the NOAA 9 and 10, advanced TIROS-N-class operational meteorological satellites, which are placed in 830-km polar, sun-synchronous orbits. The third satellite is NASA's Earth Radiation Budget Satellite (ERBS), which was launched in 1984 by a Shuttle into a 610-km circular, 57 deg-inclined orbit, covering nearly all parts of the earth from 57 deg S to 57 deg N latitude.

Each of the three spacecraft carries an ERBE nonscanner (ERBE-NS) instrument and a scanner (ERBE-S) instrument for measuring incident and reflected solar energy, and the earth's emitted radiation at different wavelengths, ranging from 0.2 to 50 micrometers. In addition, the ERBS satellite carried a Stratospheric Aerosol and Gas Experiment (SAGE II) sun-scanning radiometer for measuring solar radiation attenuation caused by atmospheric constituents. Mapped vertical and horizontal distributions of stratospheric aerosol and ozone were related to the radiation budget study. The SAGE II instrument was the fourth in a series of spaceborne stratospheric aerosol monitors. Earlier models of the sensor were flown on the Apollo/Soyuz Test Project, Nimbus 7, and SAGE (AEM-B).

For satellite and experiment descriptions of the other two ERBE experiments, see NOAA 9 and 10. A special issue of Rev. Geophys., v. 24, 1986, contains more details on the ERBE program and some preliminary results.

############################ ERBS ############################

SPACECRAFT COMMON NAME- ERBS
ALTERNATE NAMES- EARTH RAD BUDGET SAT, ERBS-A
15354

NSSDC ID- 84-108B

LAUNCH DATE- 10/05/84 WEIGHT- 2250. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SHUTTLE

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 12/ .1/84
ORBIT PERIOD- 96.8 MIN	INCLINATION- 57. DEG
PERIAPSIS- 598. KM ALT	APOAPSIS- 609. KM ALT

PERSONNEL

PM - C.L.	WAGNER, JR.	NASA-GSFC
PS - M.D.	KING	NASA-GSFC

BRIEF DESCRIPTION

The Earth Radiation Budget Satellite (ERBS) was designed to be a 2-yr mission to gather required radiation budget data, aerosol data, and ozone data to assess climate change and ozone depletion. The two experiments were the Earth Radiation Budget Experiment (ERBE) and the Stratospheric Aerosol and Gas Experiment II (SAGE II). An ERBE is also carried on two TIROS-N series (NOAA 9 and NOAA-G) missions.

------- ERBS, BARKSTROM---

INVESTIGATION NAME- EARTH RADIATION BUDGET EXPERIMENT (ERBE)

NSSDC ID- 84-108B-01

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
ATMOSPHERIC PHYSICS

PERSONNEL

EM - J.E.	COOPER	NASA-LARC
TL - B.R.	BARKSTROM	NASA-LARC

BRIEF DESCRIPTION

The Earth Radiation Budget Experiment (ERBE) was designed to measure the energy exchange between the earth-atmosphere system and space. The measurements of global, zonal, and regional radiation budgets on monthly time scales helped in climate prediction and in the development of statistical relationships between regional weather and radiation budget anomalies. The ERBE consisted of two instrument packages: the non-scanner (ERBE-NS) instrument and the scanner (ERBS-S) instrument. The ERBE-NS instrument had five sensors, each using cavity radiometer detectors. Four of them were primarily earth-viewing. Two wide field-of-view (FOV) sensors viewed the entire disk of the earth from limb to limb, approximately 135 deg. Two medium FOV sensors viewed a 10-deg region. The fifth sensor was a solar monitor that measured the total radiation from the sun. Of the four earth-viewing sensors, one wide and one medium FOV sensor made total radiation measurements; the other two measured reflected solar radiation in the shortwave spectral band between 0.2 and 5 micrometers by using Suprasil-W filters. The earth-emitted longwave radiation component was determined by subtracting the shortwave measurement from the total measurement. The ERBE-S instrument was a scanning radiometer which contained three narrow FOV channels. One channel measured reflected solar radiation in the shortwave spectral interval between 0.2 and 5 micrometers. Another channel measured earth-emitted radiation in the longwave spectral region from 5 to 50 micrometers. The third channel measured total radiation with a wavelength between 0.2 and 50 micrometers. All three channels were located within a continuously rotating scan drum which scanned the FOV across track sequentially from horizon to horizon. Each channel made 74 radiometric measurements during each scan, and the FOV of each channel was 3 by 4.5 deg that cov ''d about 40 km at the earth's surface. The ERBE-S also viewed the sun for calibration. Additional information can be obtaine. f'om the "Earth Radiation Budget Experiment (ERBE): An Overview," J. Energy, v. 6, pp. 141-146 (1982), by B. R. Barkstrom and J. B. Hall, Jr. See Appendix B3 for a list of ERBE investigators.

------- ERBS, MCCORMICK---

INVESTIGATION NAME- STRATOSPHERIC AEROSOL AND GAS (SAGE)

NSSDC ID- 84-108B-02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH
ATMOSPHERIC PHYSICS

PERSONNEL

PI - M.P.	MCCORMICK	NASA-LARC
OI - L.	MCMASTERS	NASA-LARC
OI - W.	VAUGHAN	NASA-LARC

BRIEF DESCRIPTION

The SAGE sensor was a multi-spectral channel radiometer which measured the extinction of solar radiation intensity during solar occultation. As the spacecraft emerged from the earth's shadow during each orbit, the sensor acquired the sun and measured the solar intensity in seven wavelength bands centered between 0.385 and 1.0 micrometers as it scanned the sun vertically. As the spacecraft continued in orbit, the line of sight from the spacecraft to the rising sun scanned the earth's atmosphere, resulting in a measurement of the attenuated solar intensity at different atmospheric layers. The procedure was then repeated in a reverse sense during spacecraft sunset. Each sunrise or sunset event was monitored from the top of the clouds to approximately 150 km above the earth's surface. The sensor had an instantaneous field of view of approximately 0.5 km measured at the horizon for a 600-km orbit. The dynamic range of each radiometric channel was approximately 4000, and the uncertainty in any radiometric measurement was specified to be less than 0.1% of the unattenuated solar intensity (the sensor was partially self-calibrating in that a measurement of the unattenuated solar intensity was made prior to each spacecraft sunset and following each spacecraft sunrise). Furthermore, zero intensity levels were reached every time the elevation mirror scanned off the sun. The instrument module consisted of optical and electronic subassemblies mounted side by side. The optical subassembly consisted of a flat scanning mirror, Cassegrain optics, and a detector package. The entire optical subassembly was gimbaled in azimuth. The azimuth servo employed sun sensors driven to null on the center of the sun to a tolerance of plus or minus 1 arc-min. At the beginning of a sunrise or sunset event, the instrument slewed in azimuth to a position to acquire the sun. Upon acquisition in azimuth, the mirror servo scanned in elevation until the sun was acquired. The scan range was then reduced to scanning back and forth across the solar image only. The solar input was reflected from the scan mirror through the Cassegrain telescope, which produced a solar image upon the science detector aperture. This image was scanned across the aperture by the motion of the scan mirror. The radiation through the aperture was dispersed, and the beams representing the wavelength bands were then collected and applied to silicon pin diode detectors. The outputs of the detectors were fed to signal-conditioning amplifiers whose outputs went to the PCM encoder. The PCM encoder multiplexed and digitized the signals and then transferred the digital data to the ERBS data system. The radiometric data for each wavelength channel were sampled 64 times per second or approximately four times per kilometer of tangent altitude, and they were digitized to 12 bits. These data, plus science supporting data and instrument module housekeeping data, totalled approximately 6 kbps. See Appendix B for a list of SAGE-II investigators.

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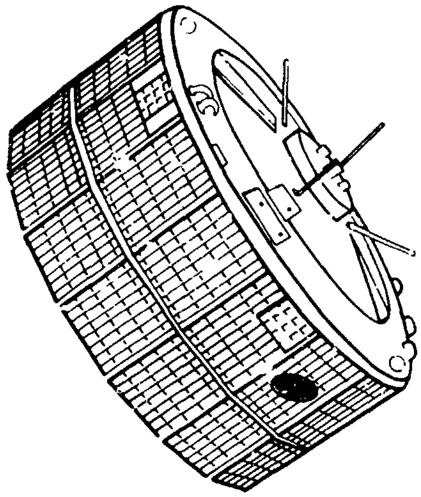
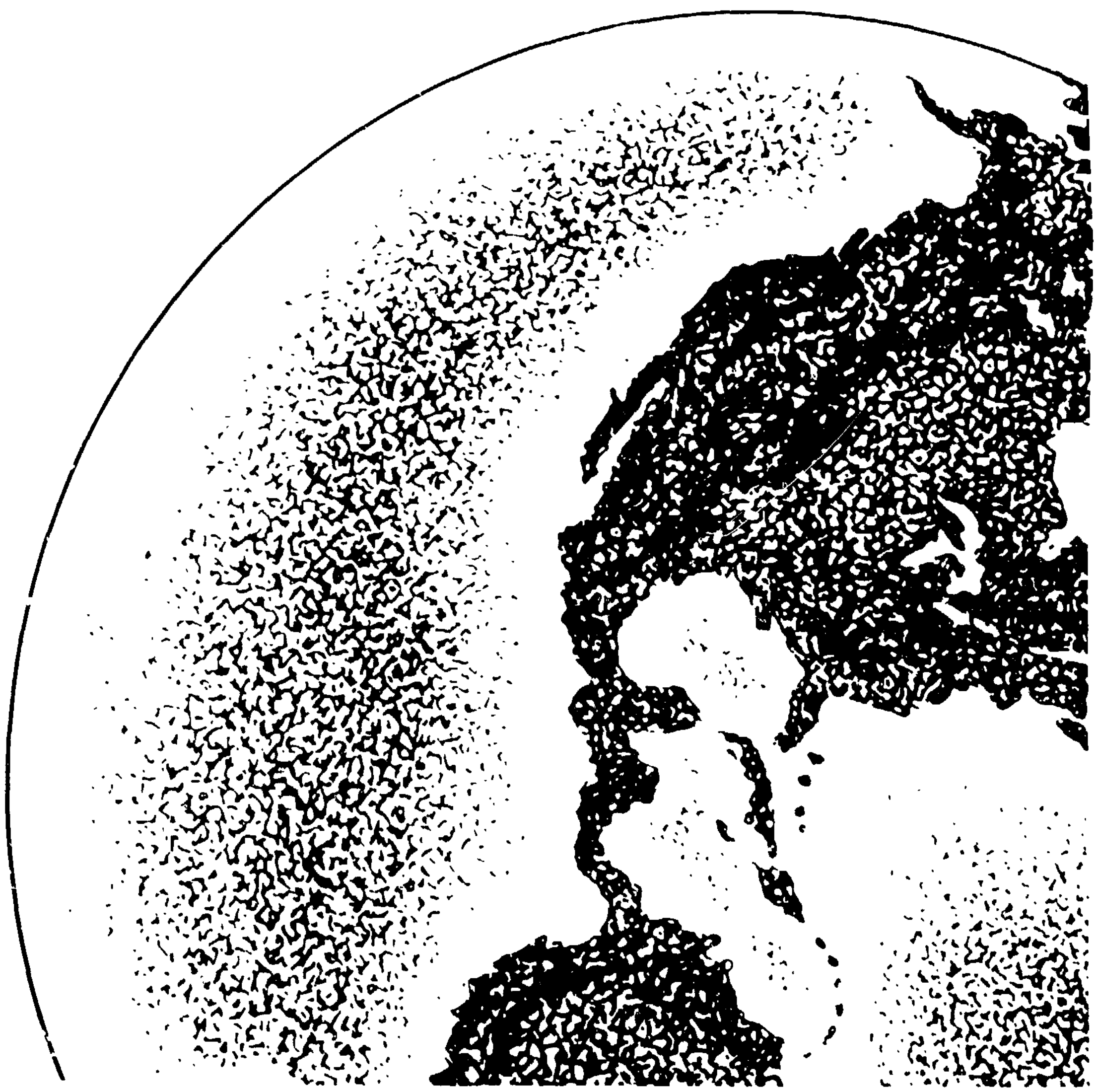
ESSA





ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION (ESSA) SATELLITE PROGRAM

The Operational TIROS (OT) and TIROS Operational Satellite (TOS), more commonly known as the ESSA program (Environmental Science Services Administration), grew out of the experience in space technology gained through the TIROS R&D program. Built and launched by NASA and operated and financed by ESSA, these satellites were designed to provide both local and global daytime coverage of the earth's surface and cloud cover on a daily basis, and to obtain global heat-balance data.

The program operation was initiated on February 3, 1966, with the launch of OT 3 from the Eastern Test Range by a Delta rocket into the successful orbit of ESSA 1. Later spacecraft in the series were launched from the Western Test Range using an improved Delta rocket. A total of nine ESSA spacecraft were successfully placed in orbit with a tenth (TOS-H) built and placed in storage.

All OT and TOS spacecraft were launched into circular, near-polar, sun-synchronous orbits, and were spin stabilized in a cartwheel mode. Improved attitude configuration, higher orbits, and better camera resolution gave ESSA spacecraft significantly improved photographic capabilities over the previously launched TIROS spacecraft. ESSA 2, 4, 6, and 8 were equipped with two identical 2.54-cm diameter, 800-line, vidicon APT cameras to provide direct readout of daytime cloud cover over specified locations. ESSA 3, 5, 7, and 9 were fitted with two redundant 2.54-cm diameter, 800-line, Advanced Vidicon Camera System (AVCS) cameras and a dual tape recorder for photographing and storing global cloud-cover data for subsequent transmission to ground acquisition stations at Wallops Island, VA, and Fairbanks, AK. The cameras on ESSA 1 were identical to the vidicons used on TIROS satellites. With the exception of ESSA 1, the cameras were mounted perpendicular to the spin axis. All odd-numbered ESSA spacecraft after ESSA 1 also carried two low-resolution infrared Flat Plate Radiometers (FPRs) that were mounted on the satellite baseplate and used to monitor the intensity of emitted and reflected radiation from the earth-atmosphere system on a global scale.

The operating system consisted of two ESSA satellites functioning simultaneously: one AVCS-equipped spacecraft and one APT-equipped spacecraft. The system provided full daytime global imagery of cloud systems on a daily basis. These spacecraft proved extremely reliable. Over 140,000 useful meteorological photographs were received from the AVCS experiment on ESSA 9, before it was placed in an operationally off mode in November 1972. The APT experiment was a great aid to operational meteorology at the local level; by 1971 nearly 600 stations throughout the world were capable of receiving real-time, cloud-cover photographs from APT-equipped ESSA spacecraft. Although no historical APT data are available, the experiment brief description is included here for completeness.

Spacecraft Name - ESSA 1-9

S/C	Alternate Name	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd.. (min)
ESSA 1	OT 3	66-008A	02/03/66	97.9	702	845	100.4
ESSA 2	OT 2	66-016A	02/28/66	101.0	1356	1418	113.6
ESSA 3	TOS-A	66-087A	10/02/66	101.1	1383	1493	114.6
ESSA 4	TOS-B	67-006A	01/26/67	102.0	1328	1443	113.5
ESSA 5	TOS-C	67-036A	04/20/67	102.0	1361	1423	113.6
ESSA 6	TOS-D	67-114A	11/10/67	102.1	1410	1488	114.8
ESSA 7	TOS-E	68-069A	08/16/68	101.7	1432	1476	115.0
ESSA 8	TOS-F	68-114A	12/15/68	101.9	1410	1473	114.7
ESSA 9	TOS-G	69-016A	02/26/69	101.8	1427	1508	115.3

S/C	PM	PS
ESSA 1	R. M. Rados (Retired) NASA/GSFC	Aero. and Meteo. Div. NASA/GSFC
ESSA 2-9	W. W. Jones (NLA) NASA/GSFC	

Brief Description

ESSA 1-9 (Environmental Science Services Administration) were spin-stabilized operational meteorological spacecraft designed to take daytime cloud-cover pictures and solar and terrestrial radiation on a global basis. They were also known as Operational TIROS (OT) and TIROS Operational Satellites (TOS). ESSA 1 had a redundant vidicon camera system. Later odd-number ESSA satellites were equipped with two Advanced Vidicon Camera System (AVCS) cameras. Even-numbered ESSA satellites had two Automatic Picture Transmission (APT) cameras. The AVCS satellites also carried a Flat Plate Radiometer (FPR) system. The satellites had essentially the same configuration as that of the TIROS series; i.e., an 18-sided right prism, 107 cm across opposite corners and 56 cm high, with a reinforced baseplate carrying most of the subsystems and a cover assembly (HAT). Electrical power was provided by approximately 10,000 1- by 2-cm solar cells that were mounted on the cover assembly and by 21 nickel-cadmium batteries. A pair of crossed-dipole command and receiving antennas projected out and down from the baseplate. A monopole telemetry and tracking antenna extended up from the top of the cover assembly. Each satellite was placed in a cartwheel orbital mode, with its spin axis maintained normal to the orbital plane. The satellite spin rate and attitude were determined primarily by a magnetic attitude spin coil (MASC). The MASC was a current-carrying coil mounted in the cover assembly. The magnetic field induced by the current interacted with the earth's magnetic field to provide the necessary torque maintaining a desired spin rate of 9.225 rpm for odd-numbered ESSA and 10.9 rpm for even-numbered ESSA. Five small solid-fuel thrusters mounted around the baseplate provided a secondary means of controlling the spacecraft spin rate.

-- ESSA 1-9, NESS Staff --

Investigation Name - Advanced Vidicon Camera System (AVCS)

Flown on - ESSA 3, 5, 7, 9

NSSDC ID - 66-087-01, 67-036A-01, 68-069A-01, 69-016A-01

PI - NESS Staff NOAA/NESS

Brief Description

This system was a camera, tape recorder, and transmitter combination that could record and store a series of remote daytime cloud-cover pictures for subsequent playback to a ground data acquisition facility. The cameras and tape recorder system were essentially the same as those on Nimbus 1 and 2. The ESSA AVCS system consisted of two redundant wide-angle cameras with 2.54-cm vidicons. The cameras were mounted 180 deg apart on the side of the spacecraft, with their optical axes perpendicular to the spin axis. The camera optical system employed a 180 deg lens with a focal length of 6.0 mm. Each camera was independently triggered into action only when it came into view of the earth. A video frame consisted of 0.25 s of blanked video followed by 6.25 s of vidicon scan (833 lines) and a final 0.25-s period of blanked video. Concurrent with shutter actuation, a 16-increment gray scale was included at the edge of each picture frame as a contrast check. A four-track tape recorder could store up to 36 pictures. The data could be read out between picture-taking cycles without losing a picture or interrupting a sequence. Six or 12 AVCS pictures per orbit could be programmed. At nominal attitude and altitude (approximately 1450 km), a picture covered a 3100- by 3100-km square with a horizontal resolution of about 3 km at nadir. There was a 50% overlap along the track between successive pictures to ensure complete coverage. The experiment was a success. Data from this experiment are available through SDSD. For an index of available data, see the "Catalog of Meteorological Satellite Data - ESSA 3 Television Cloud Photography," and the "Catalog of Meteorological Satellite Data - ESSA 3 and ESSA 5 Television Cloud Photography," etc., for sale from the U.S. Superintendent of Documents.

-- ESSA 1-9, NESS Staff --

Investigation Name - Vidicon Camera System

Flown on - ESSA 1

NSSDC ID - 66-008A-01

PI - NESS Staff NOAA/NESS

Brief Description

This system was a camera, tape recorder, and transmitter combination that could record and store a series of remote daytime cloud-cover pictures for subsequent playback to a ground data acquisition facility. The system was similar to those flown on previous TIROS missions, consisting of two redundant 500-scan-line TV cameras with 1.27-cm vidicons. The cameras were mounted 180 deg apart on the side of the spacecraft and were canted 75 deg from the spacecraft spin axis. The cameras were triggered into action only when they came into view of the earth. Each tape recorder had two separate channels, one for storing video signals and one for sun-angle data, which served as a time reference. Up to 32 pictures consisting of five levels of gray could be stored for subsequent playback. At nominal attitude and altitude (approximately 1450 km), the cameras covered a 1200- by 1200-km square with a spatial resolution of about 3 km at nadir. The experiment was a success. Data from this experiment are available through SDSD. For a complete index of data, see parts 1 and 2 of the "Catalog of Meteorological Satellite Data - ESSA 1 Television Cloud Photography," for sale from the U.S. Superintendent of Documents.

--- ESSA 1-9, Suomi ---

Investigation Name - Flat Plate Radiometer (FPR)

Flown on - ESSA 3, 5, 7, 9

NSSDC ID - 66-087A-02, 67-036A-02, 68-069A-02, 69-016A-02

PI - V. E. Suomi — U. of Wisconsin
OI - R. S. Parent — U. of Wisconsin

Brief Description

This experiment was designed to provide a measurement of the global distribution of reflected solar and long-wave radiation leaving the earth. The FPR system was composed of four infrared sensors, an analog-to-digital converter, a commutator, and a tape recorder. Two pairs of radiometers were mounted on opposite sides of the spacecraft, with their axes perpendicular to the spin axis. A cone shield was employed on two of the radiometers to isolate or reduce any response due to direct solar radiation. The field of view on the other two instruments was unrestricted. Both types of radiometers used a coated (either black or white) aluminum disk as the sensing element. The disk temperature was measured by two thermistors mounted on the back surface of the disk. The black-coated disk responded to the sum of the reflected solar, direct solar, and emitted long-wave radiation. The white disk reflected in the visual range but absorbed in the infrared (7- to 30-micrometer) range. Data from this experiment are available through SDSD.

-- ESSA 1-9, NESS Staff --

Investigation Name - Automatic Picture Transmission (APT)

Flown on - ESSA 2, 4, 6, 8

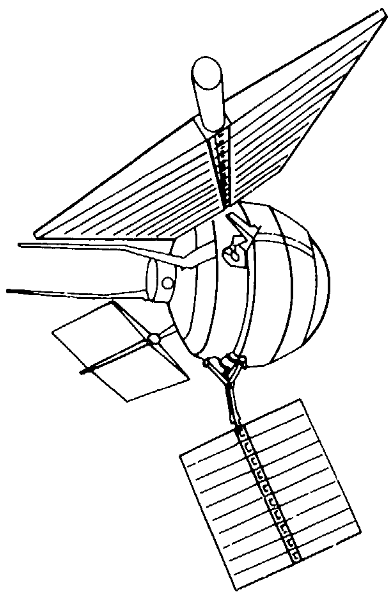
NSSDC ID - 66-016A-01, 67-006A-01, 67-114A-01, 68-114A-01

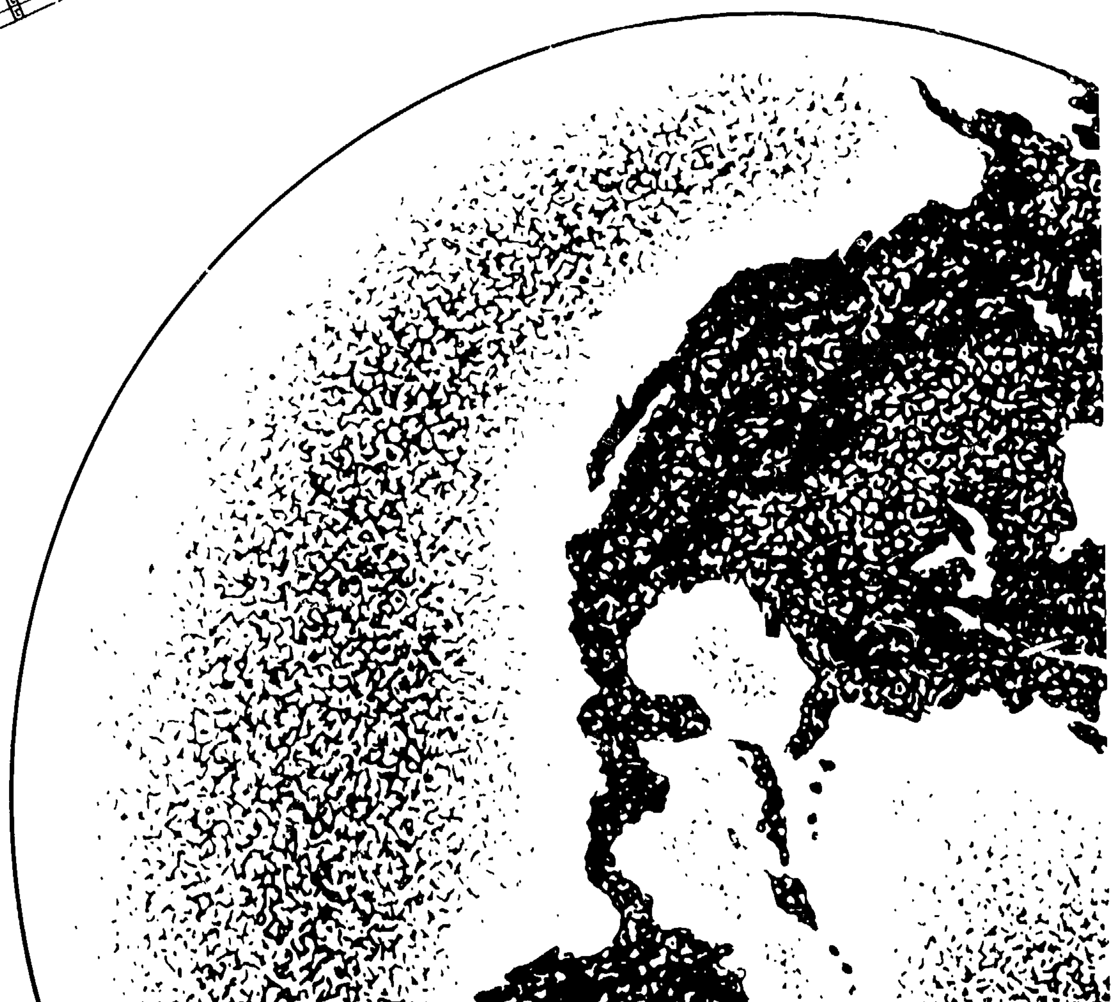
PI - NESS Staff NOAA/NESS

Brief Description

This experiment was a camera and transmitter combination designed to transmit real-time, daylight, slow-scan television pictures of cloud cover to any properly equipped ground receiving station. The camera system consisted of two redundant APT cameras with 2.54-cm-diameter vidicons. Each camera had a 108-deg wide-angle f/1.8 objective lens with a focal length of 5.7 mm. The cameras were mounted 180 deg apart on the side of the spacecraft, with their optical axes perpendicular to the spacecraft spin axis. The cameras were programmed to take four or eight APT pictures per orbit. The actual photography required 8 s and the transmission 200 s. Earth-cloud images retained on the photosensitive surface of the vidicon were read out at four lines per second to produce on 800-line picture. Two 5-W TV transmitters (137.5 MHz) relayed the pictures to local APT stations within the communication range. The faceplate of the vidicon had reticle marks that appeared on the picture format to aid in relating the picture to its geographical position on the earth's surface. At nominal satellite attitude and altitude (approximately 1450 km), a picture covered a 3100- by 3100-km square with a horizontal resolution of about 4 km at nadir. There was a 30% overlap between pictures along the track to ensure complete coverage. APT data were primarily intended for operational use within the local APT acquisition station.

EXPLORER





EXPLORER SATELLITE PROGRAM

The Explorer program had its beginnings as a joint effort by the U.S. Army and Navy under project "Orbiter." These efforts were terminated with approval of the Navy Vanguard program in September 1955. On November 8, 1957, 35 days after the Sputnik 1 success and 28 days prior to the first Vanguard launch attempt, DOD announced Army participation in the satellite launch efforts for the 1959 IGY. The resultant efforts based upon the project Orbiter experience and the Redstone rocket as a first stage led to a successful launch of Explorer 1 by a four-stage (Jupiter C) launch vehicle on February 1, 1958. The Explorer series continues to be used as a name for small, usually rather specialized research satellites primarily for astrogeophysical studies. Approximately 56 Explorer satellites had been launched as of 1985. Explorer 6 carried a cloud-cover experiment similar to that on Vanguard 2, and Explorer 7 carried a radiometry experiment to observe both incoming and outgoing thermal radiation. Further U.S. research work for meteorological applications was done primarily on the TIROS, Nimbus, and SMS/GOES satellite series.

**************************** EXPLORER 6 ************************

SPACECRAFT COMMON NAME- EXPLORER 6
ALTERNATE NAMES- ABLE 3, 1959 DELTA 1
00015

NSSDC ID- 59-004A

LAUNCH DATE- 08/07/59 WEIGHT- 64. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY

UNITED STATES	NASA-OSSA
UNITED STATES	DOD-USAF

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 12/19/59
ORBIT PERIOD- 754. MIN	INCLINATION- 47.0 DEG
PERIAPSIS- 237.000 KM ALT	APOAPSIS- 41900.0 KM ALT

PERSONNEL

PM - J.C. LINDSAY(DECEASED)	NASA-GSFC
PS - J.C. LINDSAY(DECEASED)	NASA-GSFC

BRIEF DESCRIPTION

Explorer 6 was a small, spheroidal satellite designed to study trapped radiation of various energies, galactic cosmic rays, geomagnetism, radio propagation in the upper atmosphere, and the flux of micrometeorites. It also tested a scanning device designed for photographing the earth's cloud cover. The satellite was launched into a highly elliptical orbit with an initial local time of apogee of 2100 h. The satellite was spin stabilized at 2.8 rps, with the direction of the spin axis having a right ascension of 217 deg and a declination of 23 deg. Four solar cell paddles mounted near its equator recharged the storage batteries while in orbit. Each experiment except the television scanner had two outputs, digital and analog. A UHF transmitter was used for the digital telemetry and the TV signal. Two VHF transmitters were used to transmit the analog signal. The VHF transmitters were operated continuously. The UHF transmitter was operated for only a few hours each day. Only three of the solar cell paddles fully erected, and this occurred during spin up rather than prior to spin up as planned. Consequently, initial operation of the payload power supply was 63% nominal, and this decreased with time. The decreased power caused a lower signal-to-noise ratio affecting most of the data especially near apogee. One VHF transmitter failed on September 11, 1959, and the last contact with the payload was made on October 6, 1959, at which time the solar cell charging current had fallen below that required to maintain the satellite equipment. A total of 827 h of analog and 23 h of digital data was obtained.

------- EXPLORER 6, BAKER-------------------------------------

INVESTIGATION NAME- TV OPTICAL SCANNER

NSSDC ID- 59-004A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - K.D. BAKER	UTAH STATE U

BRIEF DESCRIPTION

The TV optical scanner flown on Explorer 6 was an improved version of the TV system first employed on Pioneer 2. The experiment consisted of an optical unit containing a concave spherical mirror and phototransistor, a video amplifier, timing and logic circuits, and telemetry. The experiment was designed to test the feasibility of using such instrumentation to obtain low-resolution daylight cloudcover photographs. The Explorer 6 scanner also served as a forerunner to TV camera systems carried on later, more advanced satellites. The scanner's optical axis was directed 45 deg away from the spacecraft spin axis, which was parallel to the orbital plane. The vehicle's spin furnished the line scanning, and the spacecraft's forward motion along its trajectory provided the frame scanning. During a scan (one spacecraft revolution), a single scan spot (element) on earth was viewed and transmitted back to earth. During the next spacecraft revolution, an adjacent spot was scanned. This procedure was repeated until a line of 64 such spots was formed. Then the process was repeated to form an adjacent line of elements, and so on, until a frame, or picture, was obtained. The system could produce useful photographs only when the spacecraft's velocity and orbital position were such that successive lines overlapped. (At apogee, for example, the TV lines were separated by a distance about equal to their length, and hence no meaningful picture could be obtained.) Data obtained from this experiment are limited and of extremely poor quality. Proper spacecraft orientation was never achieved, resulting in a considerable amount of blank space between successive scan lines. The scanner's logic circuits also failed to operate normally (only every fourth scan spot could be successfully reproduced), further reducing the resolution. The last useful data were obtained on August 25, 1959.

**************************** EXPLORER 7 ************************

SPACECRAFT COMMON NAME- EXPLORER 7
ALTERNATE NAMES- 1959 IOTA 1, S 1A
00022

NSSDC ID- 59-009A

LAUNCH DATE- 10/13/59 WEIGHT- 41.50 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- JUNO

SPONSORING COUNTRY/AGENCY

UNITED STATES	DOD-ARMY

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 10/21/59
ORBIT PERIOD- 101.38 MIN	INCLINATION- 50.27 DEG
PERIAPSIS- 573. KM ALT	APOAPSIS- 1073. KM ALT

PERSONNEL

PM - H.E. LAGOW(RETIRED)	NASA-GSFC
PS - H.E. LAGOW(RETIRED)	NASA-GSFC

BRIEF DESCRIPTION

Explorer 7 was designed to measure solar X-ray and Lyman-alpha flux, trapped energetic particles, and heavy primary cosmic rays (Z>5). Secondary objectives included collecting data on micrometeoroid penetration and molecular sputtering and studying the earth-atmosphere heat balance. The spin-stabilized satellite's external structure consisted of two truncated conical fiberglass shells joined by a cylindrical aluminum center section. The spacecraft was 75 cm wide at its equator and about 75 cm high. The spacecraft was powered by approximately 3000 solar cells mounted on both the upper and lower shells. Additional power was provided by 15 nickel-cadmium batteries that were positioned on its equator near the outer skin as an aid in maintaining a proper spin rate. Two crossed dipole (1 W, 20 MHz) telemetry antennas projected outward from the center section, and a 108-MHz antenna used for tracking was mounted on the bottom of the lower shell. Located around the periphery of the center section were five bolometers for thermal radiation measurements and three cadmium sulfide micrometeoroid detector cells. A cylindrical ion chamber (lithium flourid window) and a beryllium window X-ray chamber were located on opposite sides of the upper cone, and a cosmic-ray Geiger counter was located on the very top. A primary cosmic-ray ionization chamber was located within the center portion of the upper cone. Useful real-time data were transmitted from launch through February 1961 and intermittently until August 24, 1961.

------- EXPLORER 7, SUOMI-------------------------------------

INVESTIGATION NAME- THERMAL RADIATION

NSSDC ID- 59-009A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - V.E. SUOMI	U OF WISCONSIN

BRIEF DESCRIPTION

The Explorer 7 thermal radiation experiment was designed to measure incident and reflected solar UV radiation and terrestrial IR radiation in order to obtain a better understanding of the driving forces of the earth-atmosphere system. The primary instrumentation consisted of five bolometers in the form of hollow silver hemispheres that were thermally insulated from, but in close proximity to specially aluminized mirrors. The hemispheres thereby behaved very much like isolated spheres in space. Two of the hemispheres had black coatings and responded about equally to solar and terrestrial radiation. A third hemisphere, coated white, was more sensitive to terrestrial radiation than to solar radiation. A fourth, which had a gold metal surface, was more sensitive to solar radiation than to terrestrial radiation. The fifth hemisphere, protected from direct sunlight, was used to measure the reflected sunlight. A glass-coated bead thermistor was mounted on the top of each hemisphere to measure the temperature. A complete set of four temperature observations and one reference sample required 30 s. Thus, in each orbit, about 180 temperature measurements could be obtained. The experiment was a success, and usable data were obtained from launch until February 28, 1961.

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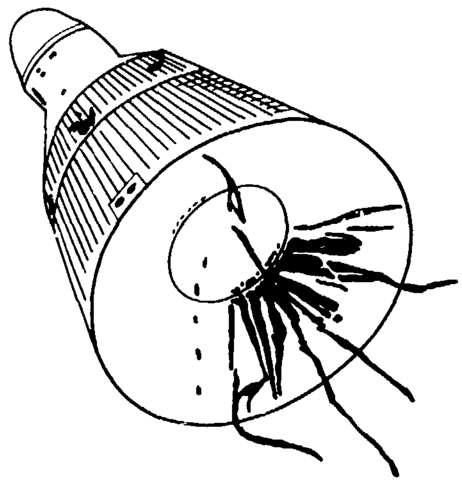
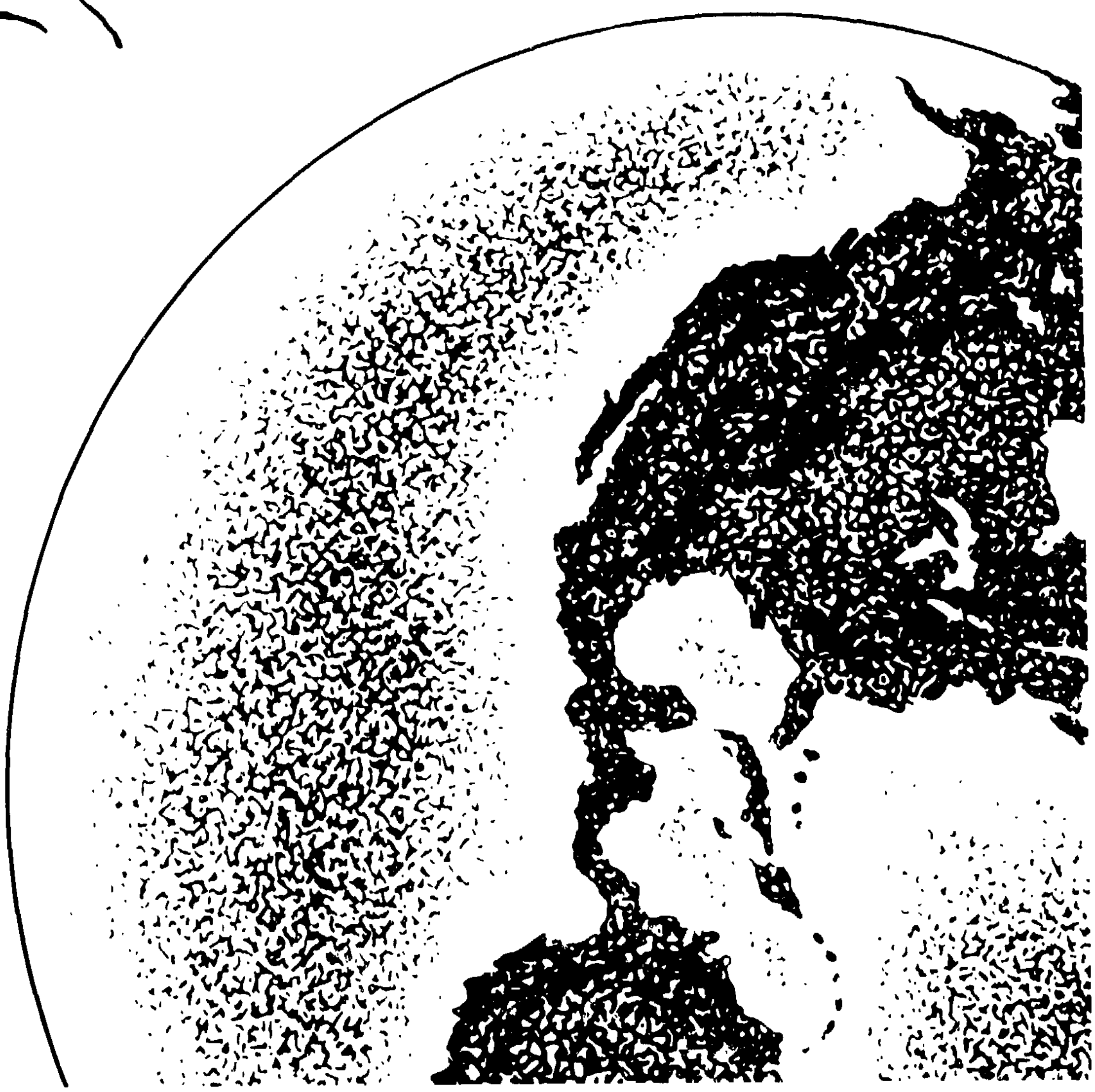
OF POOR QUALITY

GEMINI





GEMINI PROGRAM

The Gemini program (designed to carry two astronauts) was the second U.S. manned program and was the follow-on to the Mercury manned program (one astronaut capability). Objectives of this program were to develop long-duration manned flight and rendezvous capabilities, to develop precise reentry control, to attain flight and ground crew proficiency, to develop extravehicular capability, and to carry out selected scientific experiments.

The program was first approved in November 1961, with orbital flights occurring from April 1964 through November 1966. Gemini orbits were near 30 deg inclination with apogee/perigee approximately 320/160 miles with the exception of excursions to 765 km by Gemini 10 and to 1370 km by Gemini 11. Four dockings and nine EVAs were successfully carried out. All objectives were achieved.

Among the scientific experiments included were a cloudtop spectroscopy experiment to determine cloudtop heights by oxygen absorption between 0.075 and 0.078 micrometer (on Gemini 5 and 8) and a space object radiometry experiment to study the spectral irradiance of various targets such as airglow, cloud cover, and selected terrain objects (on Gemini 5 and 7). A synoptic weather terrain photography experiment was also conducted on Gemini 8-12. On Gemini 3 through 9, a Hasselblad 500C, 80-mm/f2.8 camera was used. For the Gemini 7 flight, a 250-mm/f4.5 lens was added. For the Gemini 9 through 12 flights, two cameras (three for Gemini 9) were used: a super wide-angle Hasselblad 70-mm camera with a 38-mm/f4.5 lens and a specially designed Maurer 70-mm camera with an 80-mm/f2.8 lens. All cameras were hand-held. The same cameras were used for both the synoptic terrain and synoptic weather (S005 and S006) experiments.

A complete index and a generous sample of prints from the Gemini photographs are contained in NASA SP 129 (Gemini 3-5) and NASA SP 171. Over 2400 photographs were taken and are available from the EROS Data Center. In addition to spacecraft and experiment descriptions, a summary table of the Gemini Program is appended (see Table 6).

TABLE 6

GEMINI PROGRAM

Gemini Vehicle Number*	NSSDC ID	Launch Date	Flight Duration (DDHHMM)	Docking/Rendezvous/EVA	Earth Photography†	Crew/Remarks
1	64-018A	04-08	03, 23, 15			Structural test
2		01-19	00, 00, 18			Systems and structural test
3	65-024A	03-23	00, 04, 52		H	Grissom, Young
4	65-043A	06-03	04, 01, 56	E	H	McDivitt, White
5	65-068A	08-21	07, 22, 56		H	Cooper, Conrad
6	GEM6	10-25				Flight cancelled - target failure
7	65-100A	12-04	13, 18, 35		H	Borman, Lovell
6A	65-104A	12-15	01, 01, 53	R	H	Schirra, Stafford
8	66-020A	03-16	00, 10, 41	D	H	Armstrong, Scott
9TA	GEM9TA	05-16				Target failure
9	GEM9	05-17				Flight cancelled - target failure
9TB	66-046A	06-01				
9A§	66-047A	06-03	03, 01, 04	R, E	H, H2, M	Stafford, Cernan
10T	66-064A	07-18				
10	66-066A	07-18	02, 22, 46	D, E	H2, M	Young, Collins
11T	66-080A	09-12				
11	66-081A	09-12	02, 23, 17	D, E	H2, M	Conrad, Gordon
12T	66-103A	11-11				
12	66-104A	11-11	02, 22, 37	D, E	H2, M	Lovell, Aldrin

* A = Rescheduled flight
TA, TB = Target vehicle
† H = Hasselblad 500c, 80 mm, f2.8 (also 250 mm, f4.5 on Gemini 7)
H2 = Hasselblad Super wide-angle-C, 38 mm, f4.5
M = Maurer 80 mm, f2.8
§ Gemini 9A is often referred to as Gemini 9.

********************************** Gemini 3-12 **********************************

Spacecraft Name - Gemini 3-12

S/C	NSSDC ID	Launch Date	Incl. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
Gemini 3	65-024A	03/23/65	33.0	160	240	88.6
Gemini 4	65-043A	06/04/65	32.5	162	281	88.8
Gemini 5	65-068A	08/21/65	32.6	197	303	89.4
Gemini 6A	65-104A	12/15/65	28.9	258	271	89.6
Gemini 7	65-100A	12/04/65	28.9	292	298	90.3
Gemini 8	66-020A	03/16/66	28.9	285	298	90.2
Gemini 9	66-047A	06/03/66	28.9	270	272	89.8
Gemini 10	66-066A	07/18/66	28.9	391	400	92.3
Gemini 11	66-081A	09/12/66	28.8	161	280	88.8
Gemini 12	66-104A	11/11/66	28.8	243	310	89.9

PM - W. C. Schneider (Retired) NASA Headquarters
PM - C. W. Mathews (Retired) NASA/JSC

Brief Description

The specific objectives of the Gemini missions were (1) to determine how man performs in the space environment on flights of as much as 2 weeks; (2) to develop the capability to rendezvous with another craft and dock with it; (3) to maneuver the combined vehicles; (4) to provide a platform for scientific, engineering, and medical experiments; (5) to develop methods of controlling reentry flight paths to selected landing areas; and (6) to develop astronaut spaceflight experience, including extravehicular activity. The experiments conducted during manned flights derived from a variety of disciplines including aeronomy, astronomy, biology, physiology, geography, geology, meteorology, and space physics. The Gemini missions were highly successful and produced some significant experimental results.

-- Gemini 3-12, Lowman --

Investigation Name - Synoptic Terrain Photography

Flown on - Gemini 3-12

NSSDC ID - 65-024A-03, 65-043A-01, 65-068A-02, 65-104A-01,
65-100A-01, 66-020A-01, 66-047A-05, 66-066A-02,
66-081A-06, 66-104A-02

PI - P. D. Lowman, Jr. NASA/GSFC

Brief Description

This experiment was designed to take high-quality color photographs of selected land and near-shore areas of the earth by hand-held cameras for geologic, geographic, and oceanographic studies. For Gemini 3-9, a 70-mm Hasselblad 500C camera with a Zeiss Planar 80-mm f/2.8 lens was used to obtain the photographs. The Gemini 7 had another Zeiss Sonnar 250-mm f/4.5 lens. For Gemini 9-12, two cameras were used. (Thus, with these two cameras plus the Hasselblad camera mentioned above, Gemini 9 had three cameras.) One camera was a super wide-angle Hasselblad 70-mm with a Zeiss Biogon 38-mm f/4.5 lens, and the other one was a specially designed Maurer camera with a Xenotar 80-mm f/2.8 lens. Haze filters were used on all cameras to reduce the intensity of blue light scattering from the atmosphere. This experiment was not formally scheduled on Gemini 3, but useful pictures were taken by the astronauts. Data from this experiment are available from the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD. The index of photographs can be found in "Earth Photographs from Gemini III, IV, and V" (NASA SP-129) and "Earth Photographs from Gemini VI through XII" (NASA SP-171).

-- Gemini 3-12, Nagler --

Investigation Name - Synoptic Weather Photography

Flown on - Gemini 3-12

NSSDC ID - 65-043A-02, 65-068A-03, 65-104A-02, 65-100A-02,
66-020A-07, 66-047A-06, 66-066A-03, 66-081A-07,
66-104A-03

PI - K. Nagler NOAA/NMC
OI - S. Soules NOAA/NWS

Brief Description

The synoptic weather photographs were taken by the same cameras used for the synoptic terrain photography experiment. Color photographs of selected areas were taken when the spacecraft were in a nearly vertical position. For Gemini 3-9, a 70-mm Hasselblad 500C camera with a Zeiss Planar 80-mm f/2.8 lens was used to obtain the photographs. Gemini 7 had another Zeiss Sonnar 250-mm f/4.5 lens. For Gemini 9-12, two cameras were used. (Thus, with these two cameras plus the Hasselblad camera mentioned above, Gemini 9 had three cameras.) One camera was a super wide-angle Hasselblad 70-mm with a Zeiss Biogon 38-mm f/4.5 lens, and the other one was a specially designed Maurer camera with a Xenotar 80-mm f/2.8 lens. Haze filters were used on all cameras to reduce the intensity of blue light scattering from the atmosphere. This experiment was not formally scheduled on Gemini 3, but useful pictures were taken by the astronauts. The photographs are archived at the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD; the index can be found in "Earth Photographs from Gemini III, IV, and V" (NASA SP-129) and "Earth Photographs from Gemini VI through XII" (NASA SP-171).

-- Gemini 3-12, Saiedy --

Investigation Name - Cloud Top Spectrometer

Flown on - Gemini 5, 8

NSSDC ID - 65-068A-04, 66-020A-04

PI - F. Saiedy U. of Maryland
OI - J. C. Alishouse NOAA/NESDIS

Brief Description

A hand-held spectrograph was used by astronauts to photograph clouds and, simultaneously, to record an image of the spectrum of sunlight reflected from these clouds in the wavelength interval from 0.75 to 0.78 micrometer. The spectra were recorded on high-speed infrared film. The objective of the experiment was to deduce the cloudtop heights from the absorption of light by the oxygen A band, which is centered at 0.7619 micrometer. By comparing the radiance at a certain wavelength within the band 0.7631 micrometer for low- and medium-level clouds, 0.7606 micrometer for high clouds) to the radiance in an atmospheric window outside the band, the transmittance of oxygen in the atmosphere above the cloud was obtained. (The transmittance of oxygen is a function of the pressure altitude of the cloud.) The instrument functioned well and was operated properly. Twenty-six good photograph-spectrograms were obtained by Gemini 5. No data were obtained by Gemini 8 due to an early termination of the flight.

-- Gemini 3-12, Brentnall --

Investigation Name - Space Object Radiometry

Flown on - Gemini 5, 7

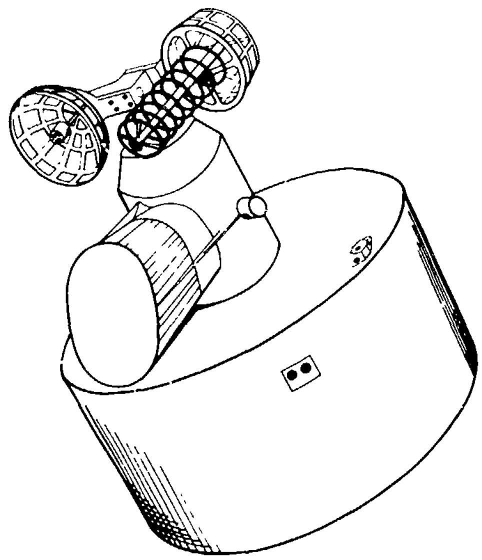
NSSDC ID - 65-068A-06, 65-100A-05

PI - B. Brentnall NOAA/NMC

Brief Description

The space object radiometry experiment was designed to study the spectral irradiance from numerous earth and atmospheric objects at wavelengths from 0.2 to 15 micrometers. The instrumentation consisted of two interferometer spectrometers and a multichannel spectroradiometer, each with a 2-deg field of view. This same instrumentation was used in experiment 65-068A-05 to study celestial subjects. The radiometer system consisted of a 0.2- to 0.6-micrometer band photomultiplier tube, a 1- to 3-micrometer band lead sulfide detector, and a 4- to 15-micrometer band bolometer detector. One spectrometer was a dual channel instrument patterned after the Michaelson Interferometer. It consisted of a lead sulfide detector (1 to 3 micrometers) and a bolometer detector (3 to 15 micrometers) that provided correlative information to the two similar channels of the spectroradiometer. The other interferometer spectrometer utilized a mercury-doped germanium detector that operated in the 8- to 12-micrometer range. It was cooled with liquid neon to maintain a temperature of -397 deg F for approximately 15 h. Some data from the experiment were stored on the spacecraft. Real-time FM data were telemetered to selected ground stations. Measurements of nighttime IR radiation were obtained from water, cloud tops, various types of terrain and ground cover, and several missile launches. Although there were mechanical problems during both missions, 3 h and 10 min, and 3 h and 11 min of data were gathered, respectively.

GMS



GEOSTATIONARY METEOROLOGICAL SATELLITE PROGRAM (GMS)

The GMS program consisted of three geostationary spin-stabilized satellites stationed near 140 deg E longitude. The first was launched in 1977, the second in 1981 as a replacement, and the third in March 1984. The GMS satellites originated as Japan's contribution to the international Global Atmospheric Research Program (GARP) and to the World Weather Watch (WWW), and they occupied one of the five longitudinal positions defined for the program. A major objective of GARP was to obtain synoptic global data sets for use in research directed toward meteorological modeling improvement. The GMS are similar in configuration and instrumentation to the other four geosynchronous satellites in GARP. Other participants were the European Space Agency with Meteosat near the prime meridian and NOAA/NASA with SMS/GOES series satellites near 55 deg E, 75 deg W, and 135 deg W longitude.

The primary instrumentation on the GMS was a Visible and IR Spin-Scan Radiometer (VISSR) similar to the GOES VISSR, and secondary ones included a weather communication facility (WEFAX) and a space environment monitor (SEM). Both day and night IR (10.5 to 12.5 microm-eters) and day visible (0.5 to 0.7 micrometer) radiometric images of the full earth disk were made by the VISSR at 30-min intervals with a resolution of about 1 km in the visible channel and 5 km in the IR channel at nadir. Images are used for cloud-cover location, wind determination, and sea surface temperature derivations. Data and information are available from NASDA, Japan.

**************************** GMS ****************************

SPACECRAFT COMMON NAME- GMS
ALTERNATE NAMES- GEOSTATION.METEOROL.SAT., HIMAWARI

NSSDC ID- 77-065A

LAUNCH DATE- 07/14/77 WEIGHT- 647. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
JAPAN NASDA
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 07/17/77
ORBIT PERIOD- 1429.4 MIN INCLINATION- 1.2 DEG
PERIAPSIS- 35531. KM ALT APOAPSIS- 35779. KM ALT

PERSONNEL
PM - N. KODAIRA METEOROL SATELLITE CTR
PS - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Geostationary Meteorological Satellite (GMS) was Japan's contribution to the international GARP (Global Atmospheric Research Program). One major objective of GARP was to obtain synoptic global meteorological data sets for 1 year's duration (to include two optimized observing periods of a few weeks each). These data served as raw material to optimize computer models for meteorological prediction. It was hoped that determination could be made of the time limitation for short-term modeling. This spacecraft was roughly cylindrical with a height of 345 cm and a diameter of 216 cm. The cylindrical surface was covered with solar cells which could provide 225 W. The satellite was spin-stabilized with a despun earth-pointing antenna. The satellite was positioned near 140 deg E. Designed to operate for 5 years, the satellite was turned off in 1981 after 4 1/2 years in orbit.

------- GMS, JMA STAFF---

INVESTIGATION NAME- VISIBLE AND INFRARED SPIN-SCAN RADIOMETER (VISSR)

NSSDC ID- 77-065A-01 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Visible and IR Spin-Scan Radiometer (VISSR) was similar to VISSR experiments on other GARP (Global Atmospheric Research Program) satellites such as GOES 1. The objectives were to make observations of the earth cloud cover location, land surface temperature, sea surface temperature, and cloud top temperature. It made both night IR (10.5 to 12.5 micrometers) and day IR, plus visible (0.5 to 0.75 micrometer) photometric observations of the subsatellite area at 30-min intervals. The visible channel had a resolution of about 1.25 km and the IR channel had a resolution of about 5 km at nadir. Real-time transmission was available to the data acquisition station in Japan, with additional data transmission to other meteorological users as needed.

*************************** GMS 2 ***************************

SPACECRAFT COMMON NAME- GMS 2
ALTERNATE NAMES- GEOSTATION.METEORO.SAT.2, HIMAWARI 2

NSSDC ID- 81-076A

LAUNCH DATE- 08/10/81 WEIGHT- 653. KG
LAUNCH SITE- TANEGASHIMA, JAPAN
LAUNCH VEHICLE- N-2

SPONSORING COUNTRY/AGENCY
JAPAN NASDA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 08/26/81
ORBIT PERIOD- 1435.9 MIN INCLINATION- 0.2 DEG
PERIAPSIS- 35776. KM ALT APOAPSIS- 35792. KM ALT

PERSONNEL
PM - N. KODAIRA METEOROL SATELLITE CTR
PS - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Geostationary Meteorological Satellites (GMS) were Japan's contribution to the international Global Atmospheric Research Program (GARP). The spacecraft was roughly cylindrical with a height of 345 cm and a diameter of 216 cm. The cylindrical surface was covered with solar cells which provided 225 W. The satellite was spin-stabilized with a despun earth-pointing antenna. The satellite was positioned near 140 deg E and was designed to operate for 5 years. This was a follow-on GMS type spacecraft launched and controlled by NASDA of Japan. The spacecraft was turned off in September 1984.

------- GMS 2, JMA STAFF---

INVESTIGATION NAME- VISIBLE AND INFRARED SPIN-SCAN RADIOMETER (VISSR)

NSSDC ID- 81-076A-01 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Visible and Infrared Spin-Scan Radiometer (VISSR) was similar to VISSR experiments on other GARP (Global Atmospheric Research Program) satellites such as GOES 1 and GMS. The objectives were to make observations of the earth cloud cover location, land surface temperature, sea surface temperature, and cloud top temperature. It made both night IR (10.5 to 12.5 micrometers) and day IR measurements, plus visible (0.5 to 0.75 micrometer) photometric observations of the subsatellite area at 30-min intervals. The visible channel had a resolution of about 1.25 km, and the IR channel had a resolution of about 5 km at nadir. Real-time transmission was available to the data acquisition station in Japan, with additional data transmission to other meteorological users as needed. Because of optical failure since 1983, the experiment was subsequently replaced by its successor on GMS 3.

*************************** GMS 3 ***************************

SPACECRAFT COMMON NAME- GMS 3
ALTERNATE NAMES- HIMAWARI 3, 15152

NSSDC ID- 84-080A

LAUNCH DATE- 08/02/84 WEIGHT- 681. KG
LAUNCH SITE- TANEGASHIMA, JAPAN
LAUNCH VEHICLE- N-2

SPONSORING COUNTRY/AGENCY
JAPAN NASDA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 09/17/84
ORBIT PERIOD- 1450.2 MIN INCLINATION- 1.86 DEG
PERIAPSIS- 35783. KM ALT APOAPSIS- 36340. KM ALT

PERSONNEL
PM - Y. ICHIKAWA NASDA
PS - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Geostationary Meteorological Satellites (GMS) were Japan's contribution to the international Global Atmospheric Research Program (GARP). The spacecraft was roughly cylindrical with a height of 345 cm and a diameter of 216 cm. The cylindrical surface was covered with solar cells which provide 263 W. The satellite was spin-stabilized with a despun earth-pointing antenna. The satellite was positioned near 140 deg E and was designed to operate for 5 years. This was a follow-on GMS type spacecraft launched and controlled by NASDA of Japan.

------- GMS 3, JMA STAFF---

INVESTIGATION NAME- VISIBLE AND INFRARED SPIN-SPAN RADIOMETER (VISSR)

NSSDC ID- 84-080A-01 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - JMA STAFF JAPANESE METEOROL AGCY

BRIEF DESCRIPTION
The Visible and Infrared Spin-Scan Radiometer (VISSR) was similar to VISSR experiments on other GARP (Global Atmospheric Research Program) satellites such as GOES 1 and GMS. The objectives were to make observations of the earth cloud cover location, land surface temperature, sea surface temperature, and cloud top temperature. It made both night IR (10.5 to 12.5 micrometers) and day IR measurements, plus visible (0.5 to 0.75 micrometer) photometric observations of the subsatellite area at 30-min intervals. The visible channel had a resolution of about 1.25 km, and the IR channel had a resolution of about 5 km at nadir. Real-time transmission was available to the data acquisition station in Japan, with additional data transmission to other meteorological users as needed.

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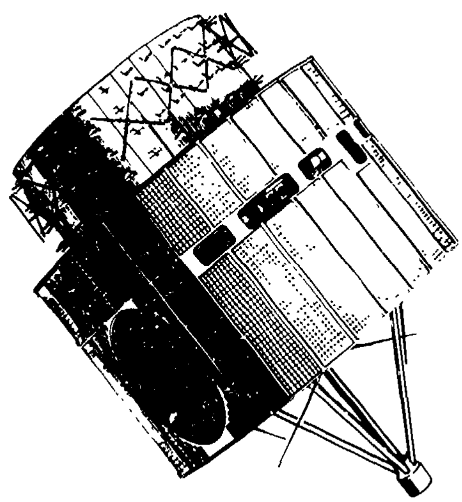
GOES/SMS



GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE/ SYNCHRONOUS METEOROLOGICAL SATELLITE (GOES/SMS) SYSTEM

The GOES/SMS system of satellites is part of the National Operational Meteorological Satellite System (NOMSS) that was originally funded by the United States in September 1961 to provide continuous cloud-cover observations. In 1970 a contract was awarded to Philco-Ford, Inc. (now Aeronutronics Ford, Inc.) for the production of three satellites, using the NASA Applications Technology Satellites ATS 1 and ATS 3 as a basis for design. Two of the three satellites were commissioned by NASA and were called Synchronous Meteorological Satellites (SMS); the third and subsequent satellites were ordered by NOAA and were termed Geostationary Operational Environmental Satellites (GOES). Since the launch of SMS 1 in May 1974, these satellites have provided continuous meteorological observations over the Western Hemisphere.

SMS 1 and GOES 1, 2, and 3 had been critical in the continuing success of the Global Atmospheric Research Program (GARP). SMS 1 was originally located at 45 deg W for support of the GARP Atlantic Tropical Experiment (GATE). Upon completion of GATE, the satellite was moved by NOAA to 75 deg W for operational observations of the eastern U.S. and the Atlantic Ocean. GOES 1 was originally positioned at 75 deg W but was moved to 55 deg E longitude in November 1978, to provide Indian Ocean coverage in support of the First GARP Global Experiment (FGGE), a joint project under the auspices of the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU). Together with Japan's Geostationary Meteorological Satellite (GMS) and Europe's Meteorological Satellite (Meteosat), GOES 1, GOES 3 (the west coast satellites), and GOES 2 (the east coast satellite) provided global coverage from approximately 60 deg N to 60 deg S for FGGE between November 1978 and November 1979.

Since then, more GOES satellites have been launched to maintain an operational, two-satellite system. GOES-East is located near 75 deg W and GOES-West is positioned near 135 deg W. A third satellite, GOES-Central, is located near 107 deg W and is used for weather facsimile broadcasts. Table 7 shows the current and past operational locations, and the current status of the GOES/SMS satellites.

TABLE 7

SMS/GOES LOCATIONS 1975-1984

Approximate Longitudes

Year	75 deg W	90 deg W	110 deg W	135 deg W
1975	S1(01-12)75		S2(03-11)105	
1976	G1(01-12)75		S1(02-12)105	S2(01-12)135
1977	G1(01-08)75 G2(08-12)75		S1(01-12)105	S2(01-12)135
1978	G2(01-12)75	S1(08-10)105	S1(01-07)105 S2(07-12)110	S1(04-06)135 S2(01-03)135 G3(07-12)135
1979	S1(02-09)69-75 S2(04-12)75 G2(01)75		G2(01-12)100-110	G3(01-12)135
1980	S2(01-12)75	G1(03-08)89-90 G4(09-12)98	G2(01-12)105-110	S1(03-12)130 G3(01-12)135
1981	S2(01-07)75 G5(08-12)75		G2(01-12)107	G1(01-12)126-131 G3(01-03)135 G4(03-12)135
1982	G5(01-12)75	G3(01-12)89-91	S2(04-07)107 G2(01-12)106	G1(01-12)117-130 G4(01-12)135
1983	G5(01-12)75	G3(01-12)91	G2(01-12)106-107	G1(01-12)129-130 G4(01-12)135-140 G6(05-12)135
1984	G5(01-12)75	G3(01-08)91	G2(01-12)107-114 G6(08-12)97-108	G1(01-12)130 G4(01-12)138-139 G6(01-07)135

Legend: SS(MM)LL

SS = Satellite
(S2=SMS 2, G4=GOES 4, etc.)

MM = Months on that location
(01=Jan., 02=Feb., etc.)

LL = Longitude

The GOES/SMS spacecraft were cylindrical and weighed 578 kg (1384 lb) at launch. Spacecraft were placed in a geosynchronous orbit at about 35,800 km (19,318 nautical miles). The spacecraft were controlled for proper earth imaging by an attitude control subsystem, which maintained the spin rate at 100 rpm and aligned the spacecraft spin axis parallel to the earth's polar axis so that spacecraft spin accomplished the scan function required for imaging.

These spin-stabilized spacecraft carried (1) a Visible-IR Spin-Scan Radiometer (VISSR) to provide high-quality, day/night cloud-cover data and to provide radiance temperatures of the earth/atmosphere system; (2) a Space Environment Monitor (SEM) to measure proton, electron, and solar X-ray fluxes and magnetic fields; and (3) a meteorological Data Collection System (DCS) to collect and distribute environmental data measured from remote data collection platforms. This DCS also relayed processed data from central weather facilities to small APT-equipped regional stations. Later spacecraft configurations (beginning with GOES 4) carried an improved version of the VISSR, the VISSR Atmospheric Sounder (VAS), which had an added capability for atmospheric sounding.

The VISSR was a two-channel scanning radiometer. The visible channel (0.55 to 0.75 micrometer) scanned with eight detectors to provide a resolution of 900 m at nadir. The IR channel (10.5 to 12.5 micrometers) provided resolution of 9 km at nadir and measured radiance temperatures between 180 deg and 315 K to a thermal resolution of better than 1.4 K. A full scan cycle required 20.2 minutes. The VAS capability provided IR radiance observations at 12 wavelengths between 3.9 and 14.7 micrometers, and added two imaging modes and a sounding mode to the VISSR. The VAS also made possible IR resolution of 6.9 or 13.8 km in the imaging modes, and 13.8 km in the sounding mode. Meteorological parameters derived from the VISSR include cloud cover, earth/cloud temperatures, cloud type, cloud-motion derived winds, and stereo-derived cloudtop heights. Parameters added from the VAS capability include, for clear and partly cloudy areas, (1) water vapor fields, (2) temperature fields, (3) improved surface temperatures, (4) improved cloud type specification, and (5) temperature/moisture profiles. For cloudy areas, cloud type identification is improved. The VAS improvement for VISSR is an experimental effort by NASA/GSFC, and work is presently in progress to adapt the new capabilities of VAS to operational applications.

******************************GOES 1-7, SMS 1, 2****************************

Spacecraft Name - SMS 1, 2; GOES 1-6

S/C	Alternate Name	NSSDC ID	Launch Date	Incl. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
SMS 1	SMS-A	74-033A	05/17/74	1.9	32345	35439	1340
SMS 2	SMS-B	75-011A	02/06/75	1.0	35778	35799	1436
GOES 1	GOES-A	75-100A	10/16/75	1.0	34165	36458	1412
GOES 2	GOES-B	77-048A	06/16/77	0.9	35266	36304	1436
GOES 3	GOES-C	78-062A	06/16/78	1.7	35469	36679	1450
GOES 4	GOES-D	80-074A	09/09/80	0.2	35776	35800	1436
GOES 5	GOES-E	81-049A	05/22/81	0.3	35715	35769	1434
GOES 6	GOES-F	83-041A	04/28/83	0.3	35775	35796	1436
GOES 7	GOES-H	87-022A	02/26/87	0.2	35788	35788	1440

S/C	PM	PS
SMS 1,2	T. J. Karras NOAA/NESDIS A. Butera NOAA/NESDIS D. V. Fordyce (Retired) NASA/GSFC	W. E. Shenk NASA-GSFC
GOES 1-3	G. W. Longanecker NASA/GSFC R. H. Pickard (NLA) NASA/GSFC D. V. Fordyce (Retired) NASA/GSFC	W. E. Shenk NASA-GSFC
GOES 4-6	G. W. Longanecker NASA/GSFC R. H. Pickard (NLA) NASA/GSFC	W. E. Shenk NASA-GFSC

Brief Description

The Synchronous Meteorological Satellite (SMS) and the Geostationary Operational Environmental Satellites (GOES) were geostationary and spaced in longitude over the equator to provide near-continuous, timely, high-quality observations of the earth and its environment. SMS 1 and 2 were developed by NASA, and follow-on spacecraft GOES 1-6 were funded by NOAA. Each spin-stabilized, earth-synchronous spacecraft carried three experiments: (1) a Visible Infrared Spin-scan Radiometer (VISSR), or a VISSR Atmospheric Sounder (VAS), (2) a meteorological Data Collection System (DCS), and (3) a Space Environment Monitor (SEM) system containing an energetic charged particle monitor, a magnetometer, and a solar X-ray monitor. The cylindrically shaped spacecraft measured 190.5 cm in diameter and 230 cm in length, exclusive of a magnetometer that extended an additional 83 cm beyond the cylinder shell. The primary structural members were a honeycombed equipment shelf and thrust tube. The VISSR telescope was mounted on the equipment shelf and viewed the earth through a special aperture in the spacecraft's side. A support structure extended radially from the thrust tube and was affixed to the solar panels, which formed the outer walls of the spacecraft and provided the primary source of electrical power. Located in the annulus-shaped space between the thrust tube and the solar panels were station keeping and dynamics control equipment, batteries, and most of the SEM equipment. The spacecraft spun at approximately 100 rpm with a spin axis nearly perpendicular to the equatorial plane. The spacecraft used both UHF-band and S-band frequencies in its telemetry and command subsystem. A low-power VHF transponder provided telemetry and command during launch and then served as a backup for the primary subsystem once the spacecraft had attained synchronous orbit. The satellites were relocated from time to time to support specific programs or to replace one that was failing. SMS 1 was initially located at 45 deg W to support the Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE). After completion of GA[illegible] in September 1974, it was moved to 75 deg W. The follow-on spacecraft joined the SMS [illegible] ate at 75 deg W and 135 deg W, which were known as GOES-East and GOES-West, r[illegible] During the FGGE (First GARP Global Experiment) Operational Year, December 1978 November 1979, the GOES-East coverage was provided by GOES 2, SMS 1, and SM[illegible] GOES-West coverage was provided by GOES 3. GOES 1 served as the GOES-Indian at [illegible] during May–August 1979. Beginning in 1979, a Weather Facsimile (WEFAX) experimental se[illegible]vice was provided by a satellite located at 107 deg W, which was known as GOES-Central. This service used earlier GOES spacecraft that were no longer suitable for imaging to retransmit GOES image sectors to ground receivers.

--------------------------------------GOES 1-7, SMS 1, 2, NESDIS Staff--------------------------------

Investigation Name - Visual Infrared Spin-Scan Radiometer (VISSR)

Flown on - SMS 1,2; GOES 1-3

NSSDC ID - 74-033A-01, 75-011A-04, 75-100A-01, 77-048A-01, 78-062A-01

PI - NESDIS Staff — NOAA/NESDIS
OI - W. E. Shenk — NASA/GSFC

Brief Description

The Visible Infrared Spin-Scan Radiometer (VISSR) provided day/night observations of cloud cover and earth/cloud radiance temperatures for use in operational weather analysis and forecasting. The 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 normal angle of 45 deg 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 was oriented parallel with the earth's axis. The latitudinal scan was accomplished by sequentially tilting the scanning mirror north to south at the completion of each spin. A full picture took 18.2 min to complete and about 2 min 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 nadir. Two Hg-Cd-Te detectors (redundant) sensed the infrared portion of the spectrum with a horizontal resolution of approximately 9 km at nadir. The infrared detectors measured radiance temperatures between 180 and 315 K, with a sensitivity of 1.2 K at 200 K. The VISSR output was digitized and transmitted to the National Oceanic and Atmospheric Administration (NOAA) Command Data Acquisition (CDA) Station, Wallops Island, VA. There the signal was fed into a "line stretcher" where it was stored and time-stretched for transmission back to the satellite at reduced bandwidth for rebroadcast to data utilization stations (DUS). The VISSR data, as with all operational type data, were handled by NOAA, and the majority of data were archived by SDSD. NSSDC also has the data processed by the Image Processing Facility, NASA/GSFC. A more detailed description can be found in "The GOES/SMS User's Guide," available from NSSDC and SDSD.

Investigation Name - VISSR Atmospheric Sounder (VAS)

Flown on - GOES 4-7

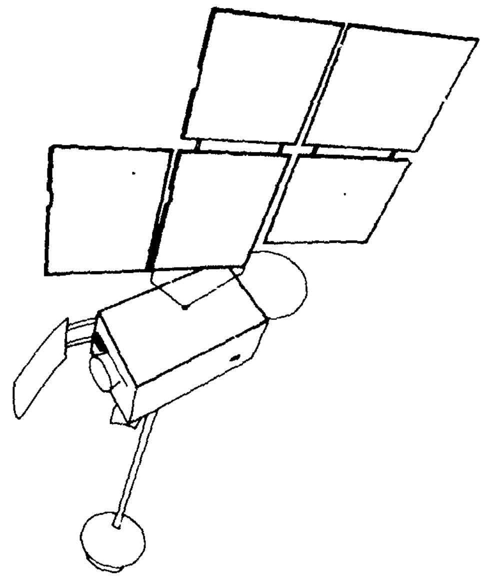
NSSDC ID - 80-074A-01, 81-049A-01, 83-041A-01, 87-022A-01

PI - NESDIS Staff NOAA/NESDIS
OI - W. E. Shenk NASA/GSFC

Brief Description

The Visible Infrared Spin-Scan Radiometer Atmospheric Sounder (VAS) operated in three distinct modes to provide parameter flexibility, spectral band selection, geographic location, and signal-to-noise (S/N) ratio. The VAS had the original VISSR imaging capability plus additional thermal bands in H_2O and CO_2 absorption regions for the determination of water vapor and temperature profiles. The VISSR mode was the same as the VISSR system on board GOES 1-3 except that the FOV for the VAS infrared imaging was 6.9 km. The dwell-sounding mode used 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 was dwelling on a single N-to-S scan line. The filter wheel could be programmed so that each spectral band filter could dwell on a single scan line for from 0 to 255 spacecraft spins. Either the 6.9-km or 13.8-km resolution detectors could 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 were used. Selectable frame size, position, and scan direction were also programmable via ground command. For the VAS demonstration, 10-bit reduced resolution (3.5-km) visible data were provided for imaging. In some of the spectral regions, multiple-line data were required to enhance the S/N ratio. Typically, 167 satellite spins at the same N-to-S scan line position were required to obtain the desired sounding data with a 30-km x 30-km resolution. The multispectral imaging (MSI) mode could provide either (1) four spectral channel observation (the visible at 0.9-km resolution, the 11-micrometer window at 6.9-km resolution, and any two selected spectral bands at 13.8-km resolution), or (2) five spectral channel observation (the visible at 0.9-km resolution and any four infrared spectral channels at 13.8-km resolution). Unlimited N-to-S frame size and position selection, within the maximum N-to-S FOV scan direction, could be selected. The VAS output was digitized and transmitted to the NOAA Command Data Acquisition (CDA) Station, Wallops Island, VA. There the VISSR data were fed into a "line stretcher," where the data were stored and time-stretched for transmission back to the satellite at reduced bandwidth for rebroadcast to APT user stations. Data can be obtained through SDSD.

INSAT



INDIAN SATELLITE (INSAT) PROGRAM

The operational INSAT 1 satellite program was designed to be a two-spacecraft system that consisted of three-axis-stabilized spacecraft located in geostationary orbit near 74 deg E and 94 deg E longitude with a host of ground stations throughout India. The objective of the missions was to provide a combined telecommunications, direct TV broadcast, and meteorological service to India's civilian community over a planned seven-year, in-orbit lifespan. The telecommunications and TV packages provided two-way, long-distance telephone circuits and direct radio and TV broadcasting to even the most remote areas of India.

The meteorology package was composed of a scanning, two-channel, Very High Resolution Radiometer (VHRR) to provide full-frame, full-earth coverage every 30 minutes. The visible channel (0.55 to 0.75 micrometer) had a 2.75-km resolution while the IR channel (10.5 to 12.5 micrometers) had an 11-km resolution. Using the INSAT TV capability, early warnings of impending disasters, i.e., floods, storms, etc., directly reached the civilian population even in remote areas. The INSAT 1 satellites also had a data channel for relaying meteorological, hydrological, and oceanographic data from unattended land or ocean data collection and transmission platforms.

Launched in April 1982, INSAT 1A was never operational. The solar sail that was used to balance the spacecraft could not be deployed. Control of the spacecraft was lost in October 1982. INSAT 1B was launched by the Space Shuttle in August 1983 and has been operating as planned. INSAT 1C is scheduled for launch in 1988.

########################### INSAT 1A ###########################

SPACECRAFT COMMON NAME- INSAT 1A
ALTERNATE NAMES- INDIAN NATIONAL SAT., 13129

NSSDC ID- 82-031A

LAUNCH DATE- 04/10/82 WEIGHT- 1152. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
INDIA ISRO
UNITED STATES NASA-OSTO

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 04/11/82
ORBIT PERIOD- 631.5 MIN INCLINATION- 28.1 DEG
PERIAPSIS- 225. KM ALT APOAPSIS- 35784. KM ALT

PERSONNEL
PM - P.P. KALE INDIA DEPT OF SPACE

BRIEF DESCRIPTION
The Insat-1 satellite program incorporated two three-axis stabilized spacecraft in geostationary orbit (Insat-1A at 74 degrees E and Insat-1B at 94 degrees E) with a host of ground stations throughout India. The Insat-1A satellite, built by the Ford Aerospace and Communications Corporation, was designed to provide combined telecommunications, direct TV broadcast, and meteorological service to India's civilian community over a 7-year-in-orbit lifespan. The telecommunications package provided two-way, long distance telephone circuits and direct radio and TV broadcasting to the remotest areas of India. The meteorology package was composed of a scanning very-high-resolution, two-channel radiometer (VHRR) to provide full-frame, full-earth coverage every 30 minutes. The visual channel (0.55-0.75 micrometer) had a 2.75-km resolution while the IR channel (10.5-12.5 micrometers) had an 11-km resolution. Using the Insat TV capability, early warnings of impending disasters (i.e., floods, storms, etc.) could directly reach the civilian population, even in remote areas. The Insat-1A also had a data channel for relaying meteorological, hydrological, and oceanographic data from unattended land-based or ocean-based data collection and transmission platforms.

------- INSAT 1A, UNKNOWN--

INVESTIGATION NAME- VERY HIGH RESOLUTION RADIOMETER (VHRR)

NSSDC ID- 82-031A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - UNKNOWN

BRIEF DESCRIPTION
The Very High Resolution Radiometer (VHRR) was a two-channel scanning instrument. Both channels gave full earth coverage with a full frame image every 30 minutes. The visible channel (10.5-12.5 micrometers) had a 2.75-km resolution, and the IR channel had an 11-km resolution. The half-hourly observations were used for monitoring weather systems over land and sea, i.e., observing cyclones and measuring sea surface and cloud top temperatures.

########################### INSAT 1B ###########################

SPACECRAFT COMMON NAME- INSAT 1B
ALTERNATE NAMES- INDIAN NATIONAL SAT., 14318

NSSDC ID- 83-089B

LAUNCH DATE- 08/31/83 WEIGHT- 1152. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SHUTTLE

SPONSORING COUNTRY/AGENCY
INDIA ISRO

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 10/15/83
ORBIT PERIOD- 1440. MIN INCLINATION- 0.0 DEG
PERIAPSIS- 35680. KM ALT APOAPSIS- 35680. KM ALT

PERSONNEL
PM - P.P. KALE INDIA DEPT OF SPACE

BRIEF DESCRIPTION
The Insat 1B was the second spacecraft in the first generation Indian National Satellite System. The three-axis stabilized spacecraft, originally launched as an on-orbit backup, replaced Insat 1A, which failed in late 1982. It was positioned in a geosynchronous orbit at 74 deg E with a host of ground stations throughout India. The Insat 1B satellite, built by the Ford Aerospace and Communications Corporation, was designed to provide combined telecommunications, direct TV broadcast, and meteorological service to India's civilian community over a 7-year-in-orbit lifespan. The telecommunications package provided two-way, long-distance telephone circuits and direct radio and TV broadcasting to the remotest areas of India. The meteorology package was comprised of a scanning very-high-resolution, two-channel radiometer (VHRR) to provide full-frame, full-earth coverage every 30 min. The visual channel (0.55-0.75 micrometer) had a 2.75-km resolution while the IR channel (10.5-12.5 micrometers) had an 11-km resolution. Using the Insat TV capability, early warnings of impending disasters (i.e., floods, storms, etc.) can directly reach the civilian population, even in remote areas. The Insat 1B also had a data channel for relaying meteorological, hydrological, and oceanographic data from unattended land-based or ocean-based data collection and transmission platforms.

------- INSAT 1B, IMD STAFF--

INVESTIGATION NAME- VERY HIGH RESOLUTION RADIOMETER (VHRR)

NSSDC ID- 83-089B-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - IMD STAFF INDIA METEOROLOG. DEPT

BRIEF DESCRIPTION
The Very High Resolution Radiometer (VHRR) was a two-channel scanning instrument. Both channels gave full earth coverage with a full frame image every 30 min. The visible channel (10.5-12.5 micrometers) had a 2.75-km resolution, and the IR channel had an 11-km resolution. The half-hourly observations were used for monitoring weather systems over land and sea, i.e., observing cyclones and measuring sea surface and cloud top temperatures.

########################### INSAT-1C ###########################

SPACECRAFT COMMON NAME- INSAT-1C
ALTERNATE NAMES- INDIAN NATIONAL SAT.

NSSDC ID- INSAT1C

LAUNCH DATE- 06/00/88 WEIGHT- 1152. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SHUTTLE

SPONSORING COUNTRY/AGENCY
INDIA ISRO

PLANNED ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC
ORBIT PERIOD- 1436. MIN INCLINATION- 0.0 DEG
PERIAPSIS- 36000. KM ALT APOAPSIS- 36000. KM ALT

PERSONNEL
PM - P.P. KALE INDIA DEPT OF SPACE

BRIEF DESCRIPTION
The Insat-1C is the third spacecraft in the first generation Indian National Satellite system. The geostationary (at 94 deg E), three-axis stabilized spacecraft is functionally identical to Insat 1A and 1B, and is designed to provide combined telecommunications, direct TV broadcast, and meteorological service to India's civilian community over a 7-year-in-orbit life span. The telecommunications package provides two-way, long-distance telephone circuits and direct radio and TV broadcasting to the remotest areas of India. The meteorology package is comprised of a scanning very-high-resolution, two-channel radiometer (VHRR) to provide full-frame, full-earth coverage every 30 min. The visual channel (0.55-0.75 micrometer) has a 2.75-km resolution while the IR channel (10.5-12.5 micrometers) has an 11-km resolution. Using the Insat TV capability, early warnings of impending disasters (i.e., floods, storms, etc.) can directly reach the civilian population, even in remote areas. The Insat-1C also has a data channel for relaying meteorological, hydrological, and oceanographic data from unattended land-based or ocean-based data collection and transmission platforms.

------- INSAT-1C, IMD STAFF--

INVESTIGATION NAME- VERY HIGH RESOLUTION RADIOMETER (VHRR)

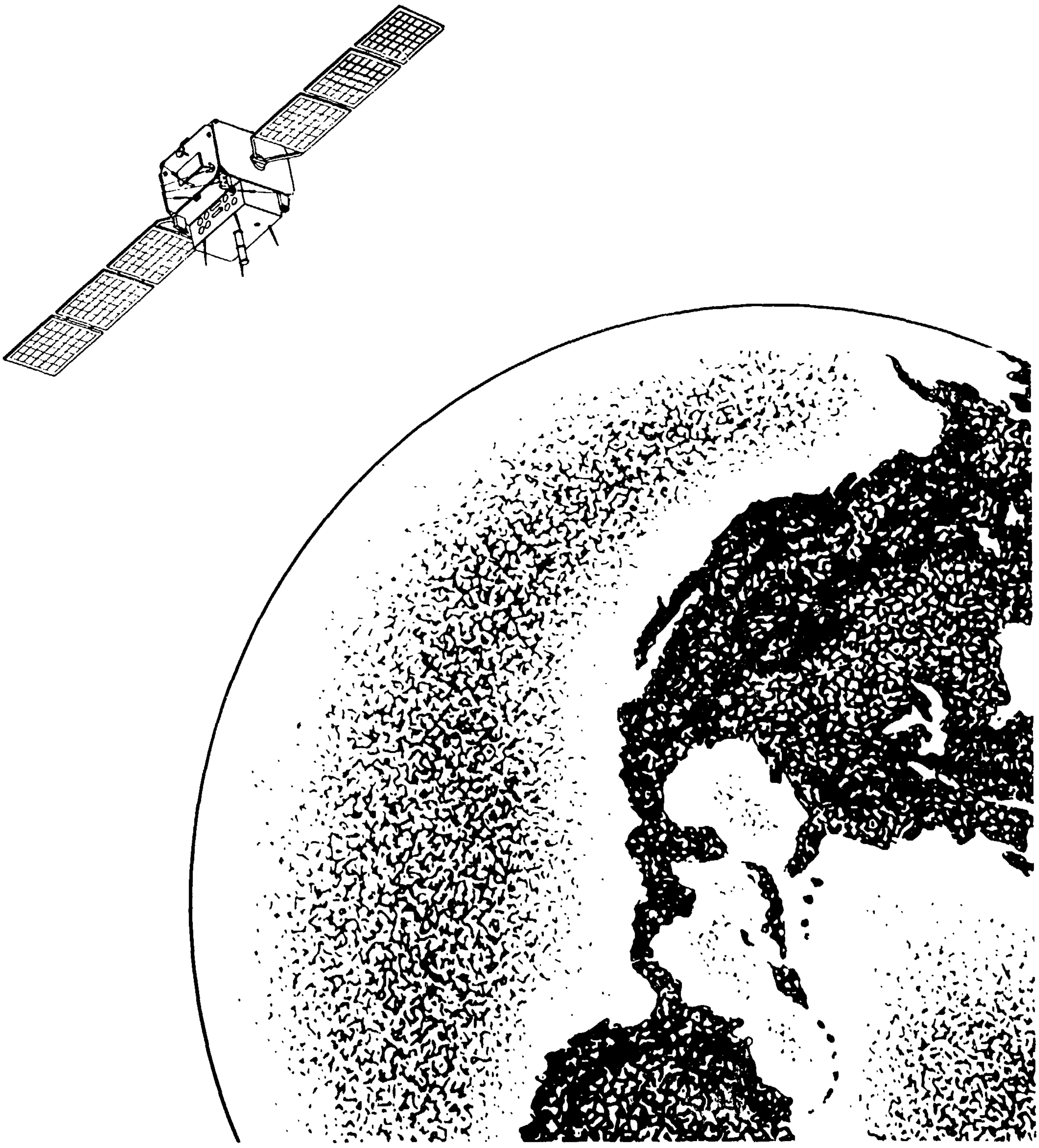
NSSDC ID- INSAT1C-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - IMD STAFF INDIA METEOROLOG. DEPT

BRIEF DESCRIPTION
The Very High Resolution Radiometer (VHRR) is a two-channel scanning instrument. Both channels give full earth coverage with a full frame image every 30 min. The visible channel (10.5-12.5 micrometers) has a 2.75-km resolution, and the IR channel has an 11-km resolution. The half-hourly observations are used for monitoring weather systems over land and sea, i.e., observing cyclones and measuring sea surface and cloud top temperatures.

IRS



INDIAN REMOTE SENSING (IRS) SATELLITE PROGRAM

The Indian Remote Sensing (IRS) satellite system represents a major step for the Indian Space Research Organization (ISRO) in its transition from an experimental (Bhaskara) to an operational, satellite-based remote sensing system. A series of three axis-stabilized satellites will be launched into near-polar, sun-synchronous orbits to acquire images for earth resources applications. The first mission, IRS 1A, is designated for a 1987 launch.

Each IRS 1 series spacecraft carries three push-broom cameras, called Linear Imaging Self-Scanning Sensors (LISS), that operate in four spectral ranges: 0.45 to 0.52 micrometer, 0.52 to 0.59 micrometer, 0.62 to 0.68 micrometer, and 0.77 to 0.86 micrometer. LISS I has a spatial resolution of 73 m and a swath of 148 km. The two LISS II have a spatial resolution of 36.5 m and a swath of 74 km each.

In terms of spatial and spectral resolutions, the IRS 1A sensors are meant to be compatible and complementary with other remote sensing satellites, such as the U.S. Landsat and the French SPOT. Higher resolution (15 to 20 m) and more spectral channels are being considered for IRS 1B. It is likely that some IR channels are included in the IRS 2 series.

Although the IRS system is mainly designed to contribute to the generation of resource information in agriculture, forestry, geology, and hydrology, and images with heavy cloud coverage are mostly eliminated, some data may still be useful for meteorological studies, such as monitoring pollution and severe storms and determining snow cover. Data products will probably be disseminated through the Space Application Centre, Ahmedabad, India.

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**************************** IRS-1A****************************

SPACECRAFT COMMON NAME- IRS-1A
ALTERNATE NAMES- INDIAN REMOTE SENSNG SAT

NSSDC ID- IRS-1A

LAUNCH DATE- 10/00/87                    WEIGHT- 850. KG
LAUNCH SITE- UNKNOWN, U.S.S.R.
LAUNCH VEHICLE- UNKNOWN

SPONSORING COUNTRY/AGENCY
   INDIA                        ISRO

PLANNED ORBIT PARAMETERS
   ORBIT TYPE- GEOCENTRIC
   ORBIT PERIOD-  103.2 MIN          INCLINATION-      99. DEG
   PERIAPSIS-     904. KM ALT        APOAPSIS-     904. KM ALT

PERSONNEL
   PD - K.     KASTURIRANGAN           ISRO SATELLITE CENTER
   PS - R.R.   NAVALGUND               SPACE APPLICATIONS CTR
   PS - V.     JAYARAMAN               ISRO SATELLITE CENTER
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BRIEF DESCRIPTION

The Indian Remote Sensing Satellite-1A (IRS-1A) is the first of a series of semi-operational/operational remote sensing satellites developed by India for land-based applications such as agriculture, forestry, geology, and hydrology. The three-axis-stabilized sun-synchronous satellite carries two linear imaging self-scanned sensors (LISS) which perform "pushbroom" scanning in visible and near IR bands to acquire images of the earth. Local equatorial crossing time is fixed at around 10 a.m. The spacecraft platform, measuring 1.56 m x 1.66 m x 1.10 m, has the payload module attached on the top and a deployable solar array stowed on either side. Attitude control is provided by four momentum wheels, two magnetic torques, and a thruster system. Together they give an estimated accuracy of better than plus or minus 0.10 deg in all three axes. Further information can be found in "The Indian Remote Sensing Satellite: a Program Overview," Proc. Indian Acad. Sci. v. 6, pp. 313-336, 1983, by R. R. Navalgund and K. Kasturirangan.

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------- IRS-1A, JOSEPH-----------------------------------------

INVESTIGATION NAME- LINEAR IMAGING SELF-SCAN SENSORS
                    (LISS I & II)

NSSDC ID-  IRS-1A -01        INVESTIGATIVE PROGRAM
                               APPLICATIONS

                             INVESTIGATION DISCIPLINE(S)
                               OCEANOGRAPHY
                               EARTH RESOURCES SURVEY

PERSONNEL
   PI - G.     JOSEPH                  ISRO SATELLITE CENTER
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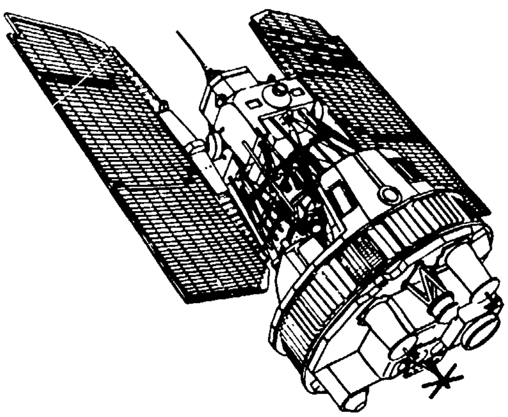
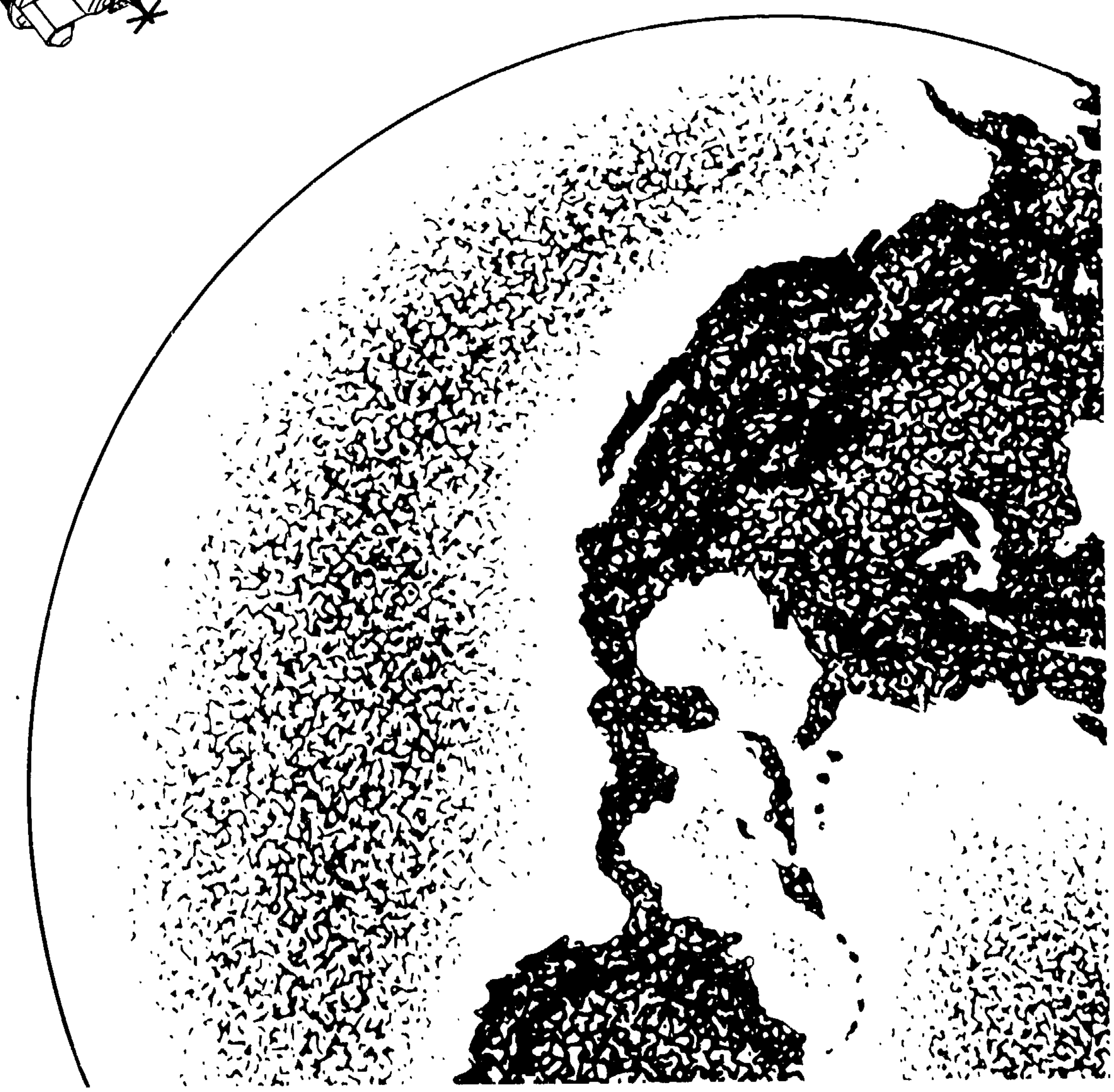
BRIEF DESCRIPTION

The IRS-1A Linear Imaging Self-Scanned Sensors (LISS) provide repetitive multispectral images of the earth's surface on a global basis for earth resources studies. One type of sensor is designated as LISS-I, which yields a low spatial resolution of 73 m. The other type, LISS-II, has two identical cameras, each of which has a medium resolution of 37 m. Both types of push-broom scanning sensors operate in the four spectral bands: 0.45-0.52, 0.52-0.59, 0.62-0.68, and 0.77-0.86 micrometer. Incoming radiation is electronically scanned by a linear array of detectors of the charge-coupled device (CCD) type with 2048 elements, which are located in the focal plane of the system. The along-track scan is produced by the orbital motion of the spacecraft. The instantaneous field of view for LISS-I is 80 microradians and the swath width is 148 km; for LISS-II they are each 40 microradians and 74 km, respectively. Data from both LISS-I and LISS-II are transmitted in real time to the data reception system at the National Remote Sensing Agency, Hyderabad, India.

LANDSAT





LANDSAT/ERTS (EARTH RESOURCES TECHNOLOGY SATELLITE) PROGRAM

The U.S. Landsat Program began with the launch of ERTS on July 23, 1972; ERTS was later renamed Landsat 1. Landsat 2 through 5 were subsequently launched for additional earth resources studies. The Landsat spacecraft serve as stabilized, earth-oriented platforms to obtain information on earth resources in a near-polar orbit from altitudes of about 900 km for Landsat 1, 2, and 3, and 700 km for Landsat 4 and 5.

On Landsat 1, 2, and 3, visible and IR photographic images were provided by Return Beam Vidicon (RBV) cameras. Landsat 1 and 2 used a three-camera system, one camera for each spectral band: blue-green (0.47 to 0.575 micrometer), yellow-red (0.58 to 0.68 micrometer), and near-IR (0.69 to 0.83 micrometer). Landsat 3 used a two-camera system covering the spectral band from 0.53 to 0.75 micrometer.

Each spacecraft (Landsat 1 through 5) also used a Multispectral Scanner (MSS) to obtain radiometric images of the earth with a ground resolution of 86 m over a 185 km swath. Landsat 1, 2, and 4 used a four-channel MSS at frequencies in the visible band (0.50 to 1.1 micrometers). Landsat 3 had an improved MSS that included a fifth channel in the IR band to give nighttime radiometric sensing capabilities for the first time. This IR channel failed soon after the launch, and little data were produced.

Both Landsat 4 and 5 were equipped with an improved radiometric sensor called the Thematic Mapper (TM). It was a second-generation, multispectral scanning radiometer that had seven earth-looking bands (six narrow frequency bands from 0.45 to 2.35 micrometers and one from 10.40 to 12.50 micrometers) with a 30-m ground resolution and a 185-km swath width.

Landsat 1, 2, and 3 had a Data Collection System (DCS) to collect and relay surface observed data from remote, individually equipped ground stations to central acquisition centers. Two wide-band videotape recorders provided 30 minutes of scanner or camera data storage to give the spacecraft sensors a near-global coverage capability. Both Landsat 1 and 2 systematically provided earth resources data over each of their more than 5-year lifetimes. Landsat 1 was retired on January 6, 1978, Landsat 2 on January 22, 1980, and Landsat 3 on September 7, 1983, after providing a combined total of more than one million images. Landsat 4 and 5 provided a transition for both foreign and domestic users of MSS data to the higher resolution and data rate of the TM. The spacecraft and sensors were operated through the Tracking and Data Relay Satellite System (TDRSS) to provide real-time acquisition of earth data worldwide. The Landsat 4 and 5 spacecraft were also Shuttle compatible for refurbishing and relaunch. Due to delays and problems in the deployment of the TDRSS, Landsat 4 relied on ground transmissions after the launch in June 1982. Two months later, the TM direct ground link (X-band transmitter) failed, but the MSS data were routinely collected. While waiting for the TDRSS to become operational and to resume the receipt of TM data (through the Ku-band transmitter), two power cables failed and reduced the spacecraft power to half. In anticipation of losing additional power and spacecraft control, Landsat 5 was launched in March 1984, one year ahead of schedule.

While the Landsat program was designed primarily to obtain information for earth resources studies on agriculture, forestry, geology, hydrology, and cartography, the spacecraft sensors can also be used to conduct meteorological studies, i.e., monitoring environmental pollution, determining snow cover, or monitoring severe storms. Most of the archived data at the Earth Resources Data Center in Sioux Falls, SD, were chosen with a priority for minimum cloudiness; thus, data taken in cloudy situations was not normally retained.

The Landsat program was the first spacecraft program transferred from the U.S. Government to the private sector in compliance with the Land Remote Sensing Commercialization Act of 1984 (U.S. Public Law 98-365). Operation of Landsat 4 and 5 was assumed by the Earth Observation Satellite Company (EOSAT), which is also responsible for the distribution of data. In addition, the company is funded to construct the next generation, commercial Landsat spacecraft to be launched in the late 1980's.

***********************************Landsat 1-3**********************************

Spacecraft Name - Landsat 1-3

S/C	Alternate Name	NSSDC ID	Launch Date	Incl. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
Landsat 1	ERTS-A	72-058A	07/23/72	99.1	897	917	103.1
Landsat 2	ERTS-B	75-004A	01/22/75	99.1	907	918	103.3
Landsat 3	Landsat-C	78-026A	03/05/78	99.1	897	914	103.1

S/C	PM	PS
Landsat 1,2	C. M. MacKenzie NASA/GSFC	S. C. Freden
	R. K. Browning NASA/GSFC	W. P. Nordberg (Deceased) NASA/GSFC
	S. Sargent (Retired) NASA/GSFC	
	S. Weiland (Retired) NASA/GSFC	
Landsat 3	C. M. MacKenzie NASA/GSFC	S. C. Freden NASA/GSFC
	R. K. Browning NASA/GSFC	

Brief Description

Landsat 1-3 were modified versions of the Nimbus series of meteorological satellites. The near-polar orbiting spacecraft served as a stabilized, earth-oriented platform for obtaining near-global coverage of data on agricultural and forestry resources, geology and mineral resources, hydrology and water resources, geography, cartography, environmental pollution, oceanography and marine resources, and meteorological phenomena. To accomplish these objectives, each spacecraft was equipped with (1) a two- or three-camera Return Beam Vidicon (RBV) to obtain visible and near IR photographic images of the earth, (2) a four- or five-channel Multispectral Scanner (MSS) to obtain radiometric images of the earth, and (3) a Data Collection System (DCS) to collect information from remote, individually equipped ground stations and to relay the data to central acquisition stations. Landsat 1-3 carried two Wide-Band Video Tape Recorders (WBVTR) capable of storing up to 30 min of scanner or camera data. An advanced attitude control system consisting of horizon scanners, sun sensors, and a command antenna combined with a Freon gas propulsion system permitted the spacecraft's orientation to be maintained within plus or minus 0.7 deg in all three axes. Spacecraft communications included a command subsystem operating at 154.2 and 2106.4 MHz, and a PCM narrow-band telemetry subsystem operating at 2287.5 and 137.86 MHz for spacecraft housekeeping, attitude, and sensor performance data. Video data from the RBV system were transmitted in both real-time and tape-recorder modes at 2265.5 MHz, while information from the MSS was constrained to a 20-MHz bandwidth at 2229.5 MHz. More information can be found in the "Landsat Data Users Handbook," available from the U.S. Geological Survey, Arlington, VA.

---Landsat 1-3, Arluskas, Balla-------------------------------------

Investigation Name - Multispectral Scanner System (MSS)

S/C	NSSDC ID	PI
Landsat 1	72-058A-02	J. Arluskas NASA/GSFC
Landsat 2, 3	75-004A-02 78-026A-02	J. A. Balla NASA/GSFC

Brief Description

The 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 22.86-cm double reflector-type telescope, scanning mirror, filters, detectors, and associated electronics. The scanner on Landsat 1 and 2 operated in the following spectral intervals: (1) 0.5 to 0.6 micrometer, (2) 0.6 to 0.7 micrometer, (3) 0.7 to 0.8 micrometer, and (4) 0.8 to 1.1 micrometers. (These bands were designated as bands 4, 5, 6, and 7, respectively.) The Landsat 3 MSS had an additional band in the 10.4- to 12.6-micrometer thermal region (band 8). This thermal band failed on July 11, 1978, and produced little useful data. Incoming radiation was collected by the scanning mirror, which oscillated 2.89 deg to either side of nadir and scanned cross-track swaths 185-km wide. The along-track scan was produced by the orbital motion of the spacecraft. The primary image produced at the image plane of the telescope was relayed by fiber optic bundles to detectors where conversion to an electronic signal was accomplished. Optical filters were used to produce the desired spectral separation. Six detectors were employed in each of the four spectral bands: bands 4 through 6 used photomultiplier tubes as detectors, and band 7 used silicon photodiodes. Band 8 on Landsat 3 had two Hg-Cd-Te detectors. A multiplexer included in the MSS system processed the scanner's 24 (26 for Landsat 3) channels of data. The data were time-multiplexed and then converted to a pulse-code modulated signal by an A/D converter. The data were then transmitted (at 2229.5 MHz) directly to an acquisition station or, in the case of remote areas, stored on magnetic tape for subsequent playback the next time the spacecraft came within the communication range of an acquisition station. The ground resolutions were 80 m for bands 4 to 7 and 240 m for band 8. Data are archived at the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD.

---Landsat 1-3, Weinstein---

Investigation Name - Return Beam Vidicon Camera System

S/C	NSSDC ID	PI	OI
Landsat 1	72-058A-01	O. Weinstein NASA/GSFC	T. M. Raglan NASA/GSFC
Landsat 2, 3	75-004A-01 78-026A-01	O. Weinstein NASA/GSFC	

Brief Description

The Landsat 1 and 2 Return Beam Vidicon (RBV) camera system contained three independent cameras taking pictures of earth scenes simultaneously during the daytime in three different spectral bands from blue-green (0.47 to 0.575 micrometer) through yellow-red (0.58 to 0.68 micrometer) to near IR (0.69 to 0.83 micrometer). While designed primarily to obtain information for earth resource type studies, the RBV camera system also conducted meteorological studies, i.e., to investigate atmospheric attenuation and to observe mesoscale phenomena, winter monsoon clouds (Japan), snow cover, etc. The three earth-oriented cameras were mounted to a common base, which was structurally isolated from the spacecraft to maintain accurate alignment. Each camera contained an optical lens, a 5.08-cm RBV, a thermoelectric cooler, deflection and focus coils, a mechanical shutter, erase lamps, and sensor electronics. The cameras were similar except for the spectral filters contained in the lens assemblies that provided separate spectral viewing regions. The viewed ground scene, 185 by 185 km in area, was stored on the photosensitive surface of the camera tube, and, after shuttering, the image was scanned by an electron beam to produce a video signal output. Each camera was read out sequentially, requiring about 3.5 s for each of the spectral images. The cameras were operated every 25 s to produce overlapping images along the direction of spacecraft motion. Video data from the RBV were transmitted (at 2265.5 MHz) in both real-time and tape recorder modes. From a nominal spacecraft altitude of 900 km, the RBV had a ground resolution of about 80 m. The Landsat 3 RBV system, consisting of two panchromatic cameras, produced two side-by-side images rather than three overlapping images of the same scene. Each camera had the same spectral band of 0.505 to 0.750 micrometer. The two cameras were aligned to view adjacent 98-km square ground scenes which overlapped slightly so that the total width of the swath was 185 km. The cameras were operated every 12.5 s to produce overlapping images along the direction of spacecraft motion. After shuttering, the image was scanned by an electron beam to produce a video output signal. A 3.5-s offset was introduced between the readouts of the two cameras, permitting sequential readout, and allowing the same tape recorder and communications channel to be used. The Landsat 3 RBV had a better ground resolution of 40 m. Data from this experiment are archived at the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD.

********************************** Landsat 4, 5 ******************************

Spacecraft Name - Landsat 4, 5

S/C	Alternate Name	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min.)
Landsat 4	Landsat-D	82-072A	07/16/82	98.3	678	699	98.5
Landsat 5	Landsat-D Prime	84-021A	03/01/84	98.3	683	698	98.6

PM - L. Gonzales NASA/GSFC
PM - J. R. Busse NASA/GSFC
PM - E. E. Speaker NASA/GSFC
PM - C. M. MacKenzie NASA/GSFC
PM - R. K. Browning NASA/GSFC
PS - V. V. Salomonson NASA/GSFC

Brief Description

The Landsat 4 was an earth resources monitoring system with the new powerful remote-sensing capabilities of the Thematic Mapper (TM), and provided a transition for both foreign and domestic users from the Multispectral Scanner (MSS) data to the higher resolution and data rate of the TM. It had a complete end-to-end highly automated data system, which was designed to be a new generation system, and was a major step forward in global remote-sensing applications. The Landsat 4 mission consisted of an orbiting satellite (flight segment) with the necessary wide-band data links and support systems, and a ground segment. The Landsat 4 flight segment consisted of two major systems: (1) the instrument module, containing the two sensing instruments together with the mission unique subsystems, such as the solar array and drive, the Tracking and Data Relay Satellite (TDRS) antenna the Wide Band Module (WBM), and the Global Positioning System (GPS); and (2) the Multimission Modular Spacecraft (MMS) that contained the modularized and standardized power, propulsion, attitude control, and communications and data handling sub-systems. The flight segment was designed with 3 years nominal lifetime in orbit that could be extended through in-orbit replacement when the Shuttle became operational. The spacecraft was placed into an orbit having a descending node with equatorial crossing between 9:30 and 10:00 a.m. local time. The spacecraft and attendant sensors were operated through the GSTDN stations before the Tracking and Data Relay Satellite System (TDRSS) became available. Landsat 4 experienced failures of X-band transmission, primary command, and data handling computer, and two of its four solar array panels after launch. Landsat 5 was forced to be launched earlier. Landsat 5 was identical to Landsat 4 in all aspects, but with those anomalies repaired.

--Landsat 4, 5, Banks --

Investigation Name - Multispectral Scanner System (MSS)

NSSDC ID - 82-072A-02, 84-021A-01

PI - G. F. Banks NASA/GSFC

Brief Description

The 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 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 22.86-cm 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 (the band numbering was different from Landsat 1-3). The Landsat 4 MSS was similar to the Landsat 1-3 MSS except for changes necessary to accommodate the lower orbital altitude. The swath width of 185 km remained the same by increasing the FOV of the sensors from 11.56 to 14.92 deg. The ground resolution was approximately 83 m for all four bands. The primary image produced at the image plane of the telescope was relayed by use of fiber optic bundles to detectors where conversion to an electronic signal was accomplished. Optical filters were used to produce the desired spectral separation. Six detectors were employed in each of the four spectral channels: bands 1 through 3 used photomultiplier tubes as detectors, band 4 used silicon photodiodes. A multiplexer included in the MSS system processed the scanner's video data. The data were time-multiplexed and then converted to a pulse-code modulated signal by an A/D converter. The data were then transmitted via the Tracking and Data Relay Satellites (TDRS) and/or direct readout to local receiving stations. Data are archived at the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD.

---Landsat 4, 5, Linstrom------------------ --------------------

Investigation Name - Thematic Mapper (TM)

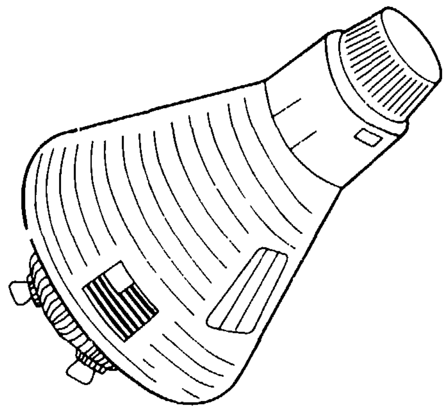
NSSDC ID - 82-072A-01

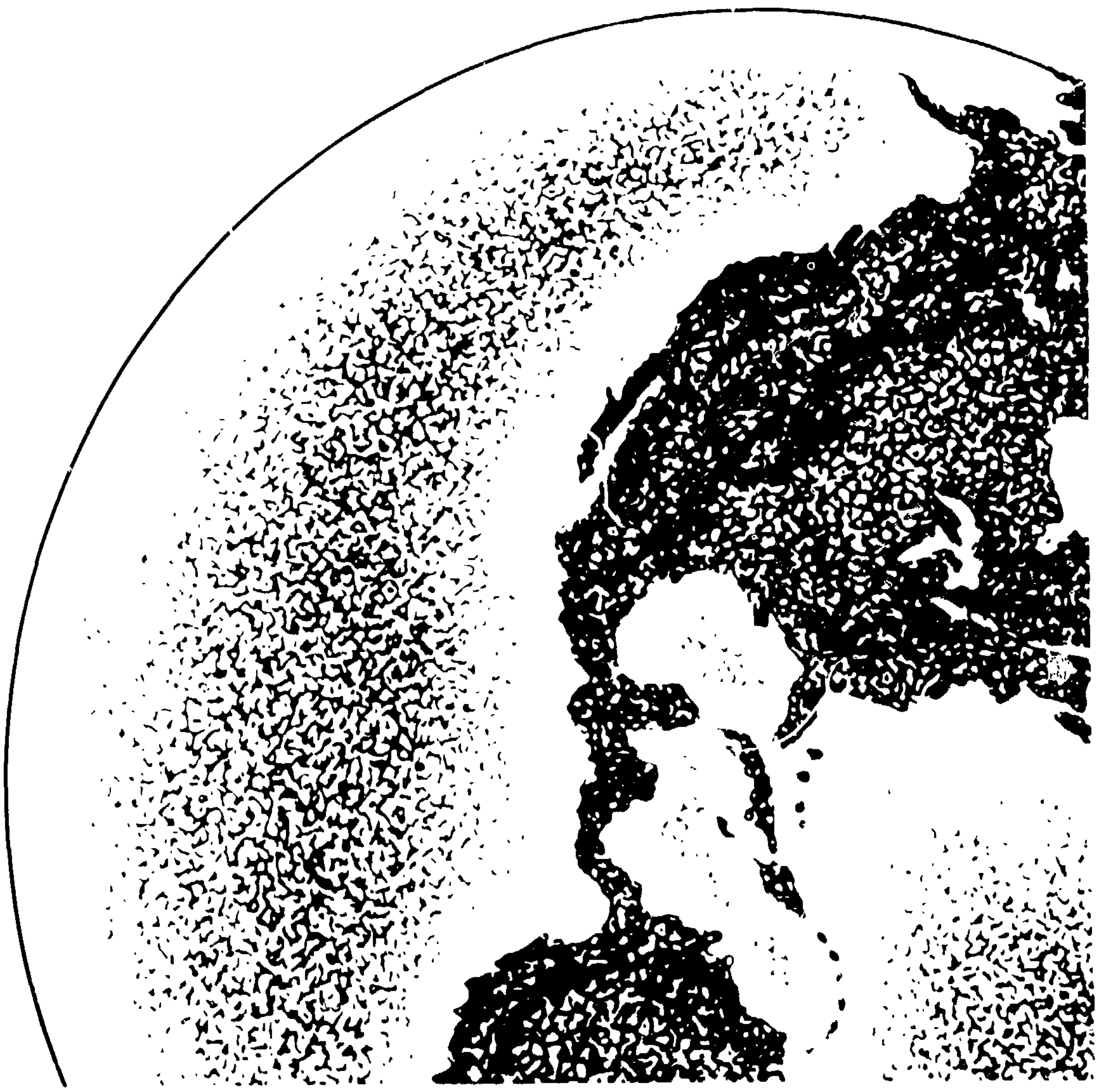
PI- 0. Weinstein — Hughes Aircraft, El Segundo, CA

Brief Description

The Thematic Mapper (TM) was 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 consisted of primary imaging optics, scanning mechanism, spectral band discrimination optics, detector arrays, radiative cooler, inflight calibrator, and required operating and processing electronics. The scanning mechanism provided the cross-track scan, while the progress of the spacecraft provided the scan along the track. The optical system imaged the earth's surface on a field stop or a detector sized to define an area on the earth's surface 30-m square. Several lines were 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 were used to provide the spectral signature capability of the instrument: band 1, 0.45-0.52 micrometer; band 2, 0.52-0.60 micrometer; band 3, 0.63-0.69 micrometer; band 4, 0.76-0.90 micrometer; band 5, 1.55-1.75 micrometers; band 6, 10.40-12.50 micrometers; and band 7, 2.08-2.35 micrometers. The information outputs from the detector channels were processed in the TM multiplexer for transmission via the Tracking and Data Relay Satellites (TDRS) and/or direct readout to local receiving stations. Data from this experiment are archived at the EROS Data Center, U.S. Geological Survey, Sioux Falls, SD.

MERCURY





MERCURY PROGRAM

The Mercury program was the first U.S. manned spaceflight program and was somewhat analogous to the U.S.S.R. Vostok program. The Mercury spacecraft was bell shaped, with a convex disk-shaped ablative reentry base on a cone-shaped body. On the conical apex was mounted a short cylinder used to house the descent parachutes. The spacecraft was designed for one astronaut and included a reclining seat, a downward looking (relative to the astronaut) periscope in a central position on the console, and a small window above the console. The capsule height was 2.9 m (9.5 ft) high, and its maximum diameter was 1.8 m (6 ft). The primary objective of the program was to solve the engineering, technical, and support problems involved in placing/recovering a man in space and to study the effects of a space environment on man.

Program approval was given on October 7, 1958. There were seven boilerplate (dummy) tests, six from August 21, 1959, to January 21, 1960, and another on March 24, 1961. Twenty-one spacecraft were built, of which 5 were not used and 16 were used in 19 flights or tests. (Three were used twice.) Thirteen tests/flights were suborbital (May 19, 1960 - July 21, 1961) and six were placed in orbit (September 13, 1962 - May 15, 1963). Orbit inclinations were 32.5 to 32.8 deg, and apogees/perigees were 237-285/153-161 km. Flights made were launched by Little Joe, Redstone, and Atlas launch vehicles.

Since manned flight was the primary emphasis, only biological experiments were given high priority. Physical science experimentation, however, did include cameras for earth and cloud photography. Photography was accomplished with slightly modified, standard 16-mm movie and 35- or 70-mm cameras with a limited number of supplementary filters and lenses. A specially designed TV camera mounted near the window for additional photographs was included on the last (MA-9 or 63-015A) flight. The Mercury program produced over 750 photographs that may have a potential for meteorological use. Most were from MA-4 (or 61-025A, unmanned, 350 pictures) and from MA-7 (or 62-019A, Carpenter, 200 pictures). No brief descriptions have been written, but further summary information is found on pages 221 and 335 of NASA SP 45 "Mercury Project Summary."

The project flights made with a Mercury spacecraft are listed in Table 8 and are commonly named with the launch vehicle. The number "7" was included with the spacecraft name and is used in reference to the first seven U.S. astronauts. (Slayton was one of the seven but did not fly during the Mercury program.)

TABLE 8
MERCURY PROGRAM

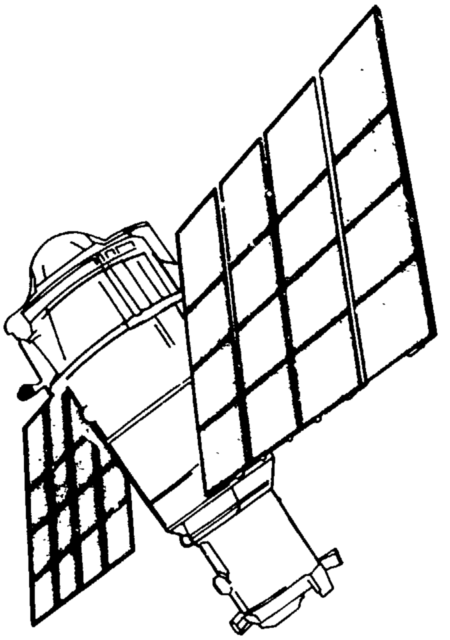
Mercury Vehicle Number*	Common Name (Launch Vehicle†)	NSSDC ID	Launch Date (MMDDYY)	Duration (HHMM)	Photography§	Crew/Remarks
1	BA-1		05-09-60	00-01		Abort systems test
4	MA-1		07-29-60	00-03		Exploded after 1 min
3	LJ-5		11-08-60	00-02		Flight abort after 15 sec
2	MR-1		11-21-60	00-00		Launch failure
2A	MR-1A		12-19-60	00-16	H	235 mi suborbital launch
5	MR-2		01-31-61	00-17	H	Flight abort w/chimp Ham after 137 sec
6	MA-2		02-21-61	00-18		18 min flight
14	LJ-5A		03-18-61	00-24		Malfunction after 20 sec
BP	MR-BD		03-24-61	00-08		307 mi suborbital launch
8	MA-3	MERCA3	04-25-61	00-07		Aborted after 40 sec
14A	LJ-5B		04-28-61	00-05		Aborted after 33 sec
7	MR-3		05-05-61	00-15	H	Shepard, Freedom 7
11	MR-4		07-21-61	00-15		Grissom, Liberty Bell 7
8A	MA-4	61-025A	09-13-61	01-49	H	Robot astronaut
14B	MS-1		11-01-66	00-01		Destroyed after 43 sec
9	MA-5	61-033A	11-29-61	03-21	H	Chimp Enos aboard
13	MA-6	62-003A	02-20-62	04-56	A	Glenn, Friendship 7
18	MA-7	62-019A	05-24-62	04-56	R	Carpenter, Aurora 7
16	MA-8	62-052A	10-03-62	09-14	H	Schirra, Sigma 7
20	MA-9	63-015A	03-15-63	34-20	H	Cooper, Faith 7

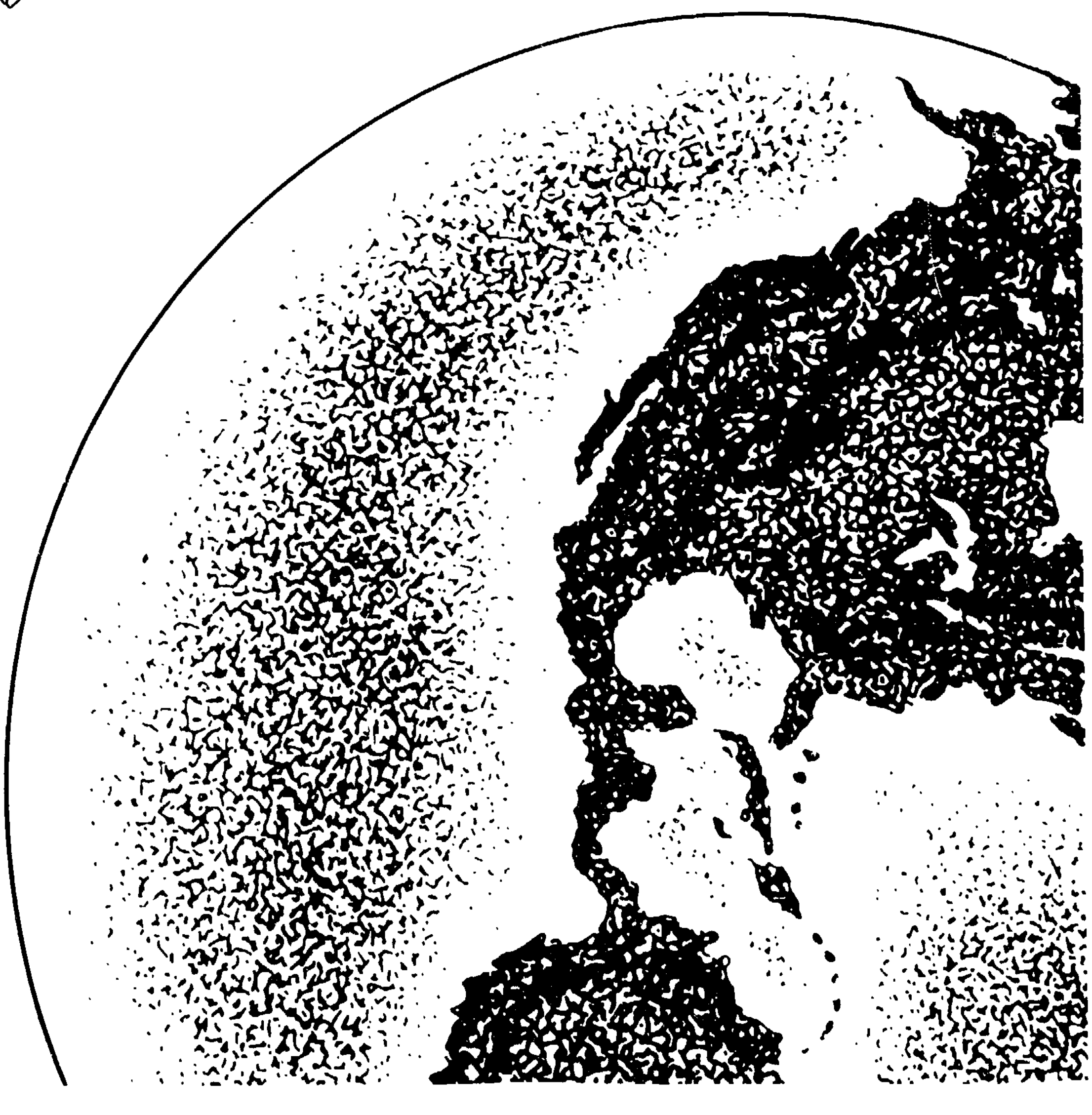
* A/B = Additional spacecraft usage
BP = Boiler Plate

§ H = Hasselblad, 70 mm
A = Ansco Autoset, 35 mm
R = Robot Recorder, 35 mm

† M = Mercury
A = Atlas
LJ = Little Joe (WI Launch)
R = Redstone
BA = Beach Abort
BD = Booster Development
S = Scout

METEOR 1





METEOR 1 PROGRAM

The operational phase of the U.S.S.R. meteorological satellite program began in March 1969, and consists of 31 launches of Meteor 1 and 15 launches of Meteor 2. The satellites were under operational control of the Soviet Hydrometeorological Service. They were follow-on operational spacecraft resulting from design development made on experimental Cosmos spacecraft. All spacecraft were similar in appearance, i.e., of cylindrical form (1.5-m diameter, 5 m-length), with two solar-cell-equipped vanes, and weighing about 2200 kg.

Meteor spacecraft provided day and night imaging and radiation sensing capabilities. Meteors 1-1 through 1-7 were each equipped with a dual vidicon camera system, a scanning High-Resolution Infrared Radiometer (HRIR), and an actinometric instrument, all of which were developed and tested on Cosmos flights. Meteors 1-8 through 1-17 had an additional instrument: an atmospheric sounder for obtaining atmospheric temperature and water vapor profiles.

In addition to the above experiments, Meteor 10 through 13, 18, and 19 were each equipped with an Automatic Picture Transmission (APT) system. The system was controlled by ground command and was operated only when the satellite was within communication range of APT receiving stations within the Soviet Union. Infrared imagery could also be transmitted in real time by using the APT capabilities.

All the Meteor launches prior to 1-29 were from the Plesetsk site, and the A-1 launch vehicle was used to launch them into near-circular, near-polar, prograde orbits with apogees between 555 and 932 km, and inclined at approximately 81 deg. Meteor 5, 9, and 14 through 30 were placed in higher orbits (perigee>853 and apogee>903 km) to provide wider coverage. The cameras were improved to prevent any loss in resolution with the expanded coverage.

Because of nonoverlapping coverage, at least two spacecraft were required to provide a complete view of the earth-atmosphere system every 24 hours. The acquired data were either recorded for later transmission or transmitted directly to one of the three ground acquisition stations: Obninsk (near Moscow), Khabarovsk (near Vladivostok), or Novosibirsk (about halfway between) when within communication range.

An essentially new satellite development, in terms of mission, equipment and orbital path, made its appearance with the launch of Meteor 1-28 on June 29, 1977, followed by the launch of Meteor 1-29 on January 25, 1979, from Tyuratam, U.S.S.R. While also serving as a meteorological satellite, its primary mission was to provide an earth resources observation platform. New types of onboard sensors, using either a 2- or 4-band scanning radiometer, were employed to record the infrared radiation of the earth for evaluation of the earth's subsurface layers. These earth resources type of Meteor satellites were launched into sun-synchronous orbits at an inclination near 98 deg. The last Meteor 1 was flown in July 1981. Since there is considerable similarity between the Meteor 1 series satellites and limited descriptive information has been found, a listing of the launches (see Table 9) and a sample brief description (Meteor 1-10) are included here instead of descriptions for each spacecraft.

TABLE 9

METEOR 1 PROGRAM

NSSDC ID	METEOR NUMBER	LAUNCH DATES	ORBIT inc (deg)	ORBIT a/p (km)	ORBIT pd (min)
69-029A	1-1	03-26-69	81	687-633	98
69-084A	1-2	10-06-69	81	681-613	98
70-019A	1-3	03-17-70	81	635-537	96
70-037A	1-4	04-28-70	81	710-625	98
70-047A	1-5	06-23-70	81	888-831	102
70-085A	1-6	10-15-70	81	648-626	97
71-003A	1-7	01-20-71	81	656-629	98
71-031A	1-8	04-17-71	81	633-610	97
71-059A	1-9	07-16-71	81	642-614	97
71-120A	1-10	12-29-71	81	874-859	102
72-022A	1-11	03-30-72	81	891-868	103
72-049A	1-12	06-30-72	81	905-889	103
72-085A	1-13	10-27-72	81	891-869	103
73-015A	1-14	03-20-73	81	892-873	103
73-034A	1-15	05-29-73	81	920-852	102
74-011A	1-16	03-05-74	81	894-832	102
74-025A	1-17	04-24-74	81	894-865	103
74-052A	1-18*	07-09-74	81	893-865	103
74-083A	1-19	10-28-74	81	907-843	102
74-099A	1-20	12-17-74	81	897-842	102
75-023A	1-21	04-01-75	81	893-867	103
75-087A	1-22	09-18-75	81	901-838	102
75-124A	1-23	12-25-75	81	902-942	102
76-032A	1-24	04-07-76	81	918-827	102
76-043A	1-25	05-15-76	81	895-846	102
76-102A	1-26	10-16-76	81	892-857	102
77-024A	1-27	04-05-77	81	897-854	103
77-057A	1-28	06-29-77	98†	670-601	97
79-005A	1-29	01-25-79	98	645-622	97
80-051A	1-30	06-18-80	98	667-584	97
81-065A	1-31	07-10-81	98	671-610	98

* Carried an orbit adjustment motor
† First Meteor in sun-synchronous orbit

******************************* METEOR 1 (71-120A)*****************

SPACECRAFT COMMON NAME- METEOR 1 (71-120A)
ALTERNATE NAMES- METEOR 1-10, METEOR 10

NSSDC ID- 71-120A

LAUNCH DATE- 12/29/71 WEIGHT- KG
LAUNCH SITE- PLESETSK, U.S.S.R.
LAUNCH VEHICLE- A-1

SPONSORING COUNTRY/AGENCY
U.S.S.R. SHS

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 12/30/71
ORBIT PERIOD- 102.7 MIN INCLINATION- 81.2 DEG
PERIAPSIS- 880. KM ALT APOAPSIS- 905. KM ALT

PERSONNEL
PM - SHS STAFF SOVIET HYDROMET SVC
PS - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
Meteor 1-10 was the tenth fully operational Russian meteorological satellite launched from the Plesetsk site. The satellite was placed in a near-circular, near-polar prograde orbit to provide near-global observations of the earth's weather systems, cloud cover, ice and snow fields, vertical profiles of temperature and moisture, and reflected and emitted radiation from the dayside and nightside of the earth-atmosphere system for operational use by the Soviet Hydrometeorological Service. This was the second satellite of the Meteor series to be placed in a high orbit, about 240 km higher than most other Meteor launches (the first was Meteor 1-5). The spacecraft was equipped with two vidicon cameras and APT cameras for dayside photography, a scanning high-resolution IR radiometer with APT capability for dayside and nightside photography, an actinometric instrument for measuring the earth's radiation field in the visible and infrared regions, and a medium-resolution scanning diffraction spectrometer for determining indirectly the vertical profiles of atmospheric temperature and humidity. The satellite was in the form of a cylinder 5 m long and 1.5 m in diameter with two large solar panels attached to the sides. The solar panels were automatically oriented toward the sun to provide the spacecraft with the maximum amount of solar power. The spacecraft was oriented toward the earth by a gravity-gradient triaxial stabilization system consisting of flywheels whose kinetic energy was dampened by the use of controlled electromagnets on board that interacted with the magnetic field of the earth. The instruments were housed in the base of the satellite, which pointed toward the earth, while the solar sensors were mounted in the top section. The operational Meteor weather satellite system ideally consisted of at least two satellites spaced at 90-deg intervals in latitude to observe a given area of the earth every 6 h. This allowed the monitoring of the formation, development, and movement of major weather systems. When within communication range, the data acquired were transmitted directly to the ground-receiving centers near Moscow, Novosibirsk, and Vladivostok or to APT-equipped stations within the U.S.S.R. Over regions beyond communication range, Meteor 1-10 recorded the TV and IR pictures, spectrometer data, and actinometric data and stored them on board until the satellite passed over the receiving centers. The meteorological data received at these centers were processed, reduced, and sent to the Hydrometeorological Center in Moscow, where they were analyzed and used to prepare various forecast and analysis products. Some of the TV and IR pictures and analyzed actinometric data were then distributed to various meteorological centers around the world. Some of these data were transmitted from Moscow to the National Environmental Satellite Service (NESS). It is believed that Meteor 1-10 was deactivated in June 1972, as indicated by the termination of data being transmitted to NESS.

------- METEOR 1 (71-120A), SHS STAFF--------------------------

INVESTIGATION NAME- DUAL VIDICON CAMERAS

NSSDC ID- 71-120A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
The Meteor 1-10 dual vidicon camera system provided daytime pictures of the earth's cloudcover distribution, local storms, and near-global weather systems for operational use by the Soviet Hydrometeorological Service. The instrumentation consisted of two identical vidicon cameras that were mounted in the satellite base and were directed toward the earth. Meteor 1-10 had slightly modified equipment with a vision bandwidth 50 percent greater than the lower orbiting satellites of the Meteor series. Each camera viewed a 750- by 750-km area, one to the left and the other to the right of nadir, with a resolution of 1.25 km at nadir from a satellite altitude of about 870 km. The cameras took a one-frame image of the earth's cloud cover with slight overlapping of successive frames to provide continuous coverage. The cameras switched on automatically any time the sun was more than 5 deg above the horizon. Because the earth illumination varied so much, automatic sensors adjusted the camera apertures to produce high-quality pictures under a variety of illumination conditions. The image formed by each vidicon tube either was transmitted directly to the ground if the satellite was in radio contact with one of the ground stations or was recorded on magnetic tape for later transmission if the satellite was beyond the zone of radio communication. The TV images received by these ground stations were processed and transmitted to the Hydrometeorological Center in Moscow where they were analyzed and used in various forecast and analysis products. The pictures were archived at the Hydrometeorological Center. Although the Meteor 1-10 cameras had about four times the resolution at nadir of those carried on the ESSA satellites, they could not provide continuous overlapping global coverage as did the ESSA cameras owing to the lower orbit of the Meteor 1 satellites (870 km compared to 1400 km). To close these gaps in coverage, at least two satellites were used in the Meteor system. In addition, cloudcover mosaics were produced from 10 or more individual cloudcover pictures at the Hydrometeorological Center to provide a more comprehensive view of near-global weather systems. Some of the individual pictures and the cloud mosaics were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received these pictures at the National Environmental Satellite Service (NESS) in Suitland, Maryland, via the "cold line" facsimile link with Moscow. These pictures were kept at NESS for 1 yr and then, unless of unusual interest, were discarded. The system had a scan rate of two lines per second, or half the ESSA rate, and scanned from right to left instead of left to right. The experiment was probably deactivated in June 1972, as indicated by the termination of data transmissions to NESS.

------- METEOR 1 (71-120A), SHS STAFF-----------------------

INVESTIGATION NAME- SCANNING HRIR

NSSDC ID- 71-120A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
The Meteor 1-10 high-resolution scanning IR radiometer made operational measurements of cloud distribution and snow and ice cover on the dayside and nightside of the earth. The radiometer measured the outgoing radiation from the earth-atmosphere system in the 8- to 12-micrometer atmospheric window. Measurements made in this spectral region permitted brightness patterns of the thermal relief to be constructed and equivalent radiation temperatures of the earth's surface and cloud to be determined. The instrument was a narrow-angle scanning radiometer with an instantaneous viewing angle of 1.5 by 1.5 deg. It was mounted in the base of the satellite in a sealed instrument compartment with its optical axis directed along the local vertical and toward nadir. The radiometer measured the intensity of the outgoing radiation by comparing the earth's radiation flux with the radiation flux from space. Each type of radiation entered the radiometer through separate windows, which were oriented in mutually perpendicular directions. The radiation from the earth-atmosphere system fell on a plane scanning mirror that was mounted at an angle of 45 deg to the satellite velocity vector and scanned through an angle of plus or minus 50 deg from nadir. The radiation was reflected from the scanning mirror through a stationary modulating disk and filter window onto a parabolic mirror, which focused the parallel beam through a movable modulating disk onto a thermistor bolometer. The stationary and movable modulating disks provided the channel switching, sending first the earth-atmosphere radiation and then the space radiation to the parabolic mirror and finally to the bolometer. The bolometer converted the radiant flux into variable electric voltages (0 to 6 V) whose frequency was equal to the modulator frequency and whose magnitudes were proportional to the differences in the radiant flux intensities between earth and space developed at the bolometer output. During the movement of the scanning mirror through a plus or minus 40-deg sector, line scanning (40 lines/min) of the target area was accomplished in a plane normal to the orbital plane using a forward and back path, while scanning along the flight path was provided by the relative motion of the satellite with respect to the earth. In each scan, with the increased viewing and scanning angles from the satellite's orbital altitude, the radiometer recorded the mean radiation intensities from a band about 1650 km wide with a resolution of about 15 km at nadir to about 24 to 27 km at the edges. The radiometer was capable of measuring radiation temperatures within 0.5 to 0.6 deg for temperatures of 293 to 298 deg K and 1.5 to 2 deg for temperatures around 223 deg K. The video signals were amplified and sent either to the satellite memory unit for later transmission or to the radio telemetry unit for direct transmission to earth depending on whether the satellite was beyond or within the zone of radio communication with a ground receiving station or an APT-equipped station within the U.S.S.R., respectively. The ground receivers recorded the transmitted data in digital form on magnetic tape and simultaneously on 80-mm photographic film in the form of a brightness image of the thermal relief of the earth-atmosphere

system. The data on magnetic tape were processed by computers at the Hydrometeorological Center and were used to produce a digital map of the equivalent radiation temperature field with a superposed geographic grid. The photographic film was developed and processed into an IR picture also with a superposed grid. The pictures were archived at the Hydrometeorological Center. Some of these pictures were transmitted to various foreign meteorological centers as part of an international meteorological data exchange program. The United States received these pictures at the National Environmental Satellite Service (NESS), Suitland, MD, via the "cold line" facsimile link with Moscow. These IR pictures were kept at NESS for 1 yr and then, unless of unusual interest, they were discarded. The experiment was probably deactivated in June 1972, as indicated by the termination of data transmissions to NESS.

------- METEOR 1 (71-120A), SHS STAFF-------------------------

INVESTIGATION NAME- ACTINOMETRIC INSTRUMENT

NSSDC ID- 71-120A-03 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S) METEOROLOGY

PERSONNEL
PI - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
The Meteor 1-10 actinometric instrument measured (1) the outgoing longwave radiation (3 to 30 micrometers) from the earth-atmosphere system, (2) the outgoing near UV, visible, and near IR solar radiation (0.3 to 3 micrometers) reflected and backscattered by the earth-atmosphere system, and (3) the effective radiation temperature of the earth's surface and cloud tops (8 to 12 micrometers) for operational use by the Soviet Hydrometeorological Service. The instrumentation consisted of four radiometers: a pair of scanning, narrow-angle, two-channel radiometers, and a pair of nonscanning, wide-angle, two-channel radiometers. The narrow-angle (4 by 5 deg field of view) radiometers measured radiation in all three spectral bands, while the wide-angle (136 to 140 deg field of view) radiometers operated only in the 0.3- to 3- and 3- to 30-micrometer bands. In the narrow-angle radiometer, the 0.3- to 3-micrometer band was measured in one channel and the 8- to 12- and 3- to 30-micrometer bands were combined in the second channel. In the second channel, the two bands were separated by the exchange of corresponding filters as the radiometer scanned in alternate directions. The earth radiation entered the narrow-angle radiometer through a cylindrical fairing (KRS-5 crystal) and fell onto a conical scanning mirror. The radiation was reflected from the mirror through a three-lobed rotating mirror chopper that modulated the radiation flux at a frequency of 80 Hz. The chopper alternately reflected earth radiation and space radiation, which entered through a separate KRS-5 crystal window, onto one of three openings in a color filter wheel, one filter for each spectral band. The particular spectral band that was passed through then fell on an off-axis parabolic mirror that focused the radiation flux onto a bolometric receiver. Periodic calibration was made when the scanning mirror moved to a 90-deg angle from nadir with simultaneous turning on and viewing of a silicon standard lamp. The 0.3- to 3-micrometer channel did not use the two-beam system or filter switching. The output from the modulated flow of radiation on the bolometer was amplified, rectified, filtered, and fed into the radio telemetry system over eight channels. The wide-angle radiometers had identical optical systems for both channels. The earth radiation entered the radiometer through a hemispherical shell composed of quartz or KRS-5 crystal with a coating that determined the passband. The radiation was then modulated with a frequency of 64 Hz and fell on a bolometric receiver. As in the narrow-angle radiometers, the bolometer output was processed and fed into the radio telemetry system. The wide-angle radiometer was standardized simultaneously with the narrow-angle radiometer by inputting a standard 64-Hz calibrating frequency into the amplification circuit. The relative rms measuring error for both types of radiometers was about 0.5 percent. To provide a backup capability, one wide-angle and one narrow-angle radiometer were held in reserve and could be activated on command from the ground. The orientation of the Meteor 1-10 satellite insured that the primary optical axes of the radiometers were oriented vertically down toward nadir. The survey of the earth's surface by both radiometers was carried out by the motion of the satellite relative to the earth. In addition, the narrow-angle radiometer scanned 66 deg to either side of nadir in a plane normal to the orbital plane by rocking the scanning mirror about the optical axis. The radiometers covered a strip about 3500 km wide on the earth's surface and had a ground resolution of 50 km at nadir. The data were reduced at the ground stations and were transmitted to the Hydrometeorological Center in Moscow, where they were recorded in digital form on magnetic tape and were used to produce various analysis products such as earth-atmosphere albedo charts and radiation temperature maps. The data were archived at the Hydrometeorological Center. The experiment was probably deactivated in June 1972, as indicated by the termination of video and IR data transmissions to the United States via the "cold line" facsimile link with Moscow.

------- METEOR 1 (71-120A), SHS STAFF-------------------------

INVESTIGATION NAME- ATMOSPHERIC THERMAL SOUNDER

NSSDC ID- 71-120A-04 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S) METEOROLOGY

PERSONNEL
PI - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
The Meteor 1-10 atmospheric temperature sounder was an operational experiment designed to obtain vertical profiles of temperature and atmospheric humidity by indirect means under a variety of cloudcover conditions. The instrumentation consisted of a medium-resolution diffraction spectrometer that scanned continuously over a 20-s observing cycle in the 10.5- to 15-micrometer band. The resolving power of the spectrometer in this spectral range was within 4 to 5 mm. From an average satellite altitude of about 870 km, the instrument's field of view covered a 53- by 13-km area on the earth's surface with the long side oriented parallel to the satellite trajectory. The data were stored on board the spacecraft until a ground acquisition station came within communication range. The data were then relayed to the ground station, reduced and processed, and transmitted directly to the Soviet Hydrometeorological Center in Moscow, where they were analyzed. Temperature profiles were constructed from the spectral radiation data by means of mathematical inversion techniques for clear and overcast cloudcover conditions. The average error for these profiles was 2 to 4 deg celsius. Temperature profiles were also constructed for partly cloudy conditions and, while not as accurate as the clear and overcast results, proved promising. Atmospheric humidity profiles were statistically derived using measurements of the outgoing radiation in the 15-micrometer band. The experiment was probably deactivated in June 1972 as indicated by the termination of IR and video data transmissions to the United States via the "cold line" facsimile link with Moscow.

------- METEOR 1 (71-120A), SHS STAFF-------------------------

INVESTIGATION NAME- AUTOMATIC PICTURE TRANSMISSION (APT)

NSSDC ID- 71-120A-05 INVESTIGATIVE PROGRAM APPLICATIONS

INVESTIGATION DISCIPLINE(S) METEOROLOGY COMMUNICATIONS

PERSONNEL
PI - SHS STAFF SOVIET HYDROMET SVC

BRIEF DESCRIPTION
The automatic picture transmission (APT) system first flown on Meteor 1-10 provided Soviet meteorologists with real-time cloudcover photographs. The system was controlled by ground command and operated only when the spacecraft was within communication range of APT receiving stations within the USSR. Little was known about the experiment except that it employed line scanning: the ground scene was scanned continuously, a line at a time, and transmitted directly to ground, probably at 137.62 MHz. The experiment probably terminated operation in June 1972. Except for the operating frequencies, identical experiments appear to have been flown on Meteors 11, 12, 13, 18, 19, and others.

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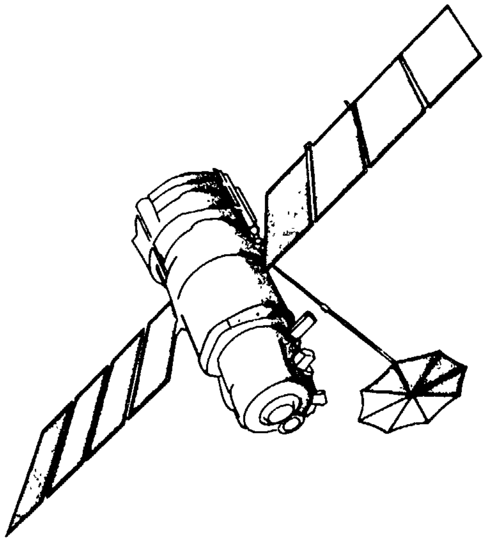
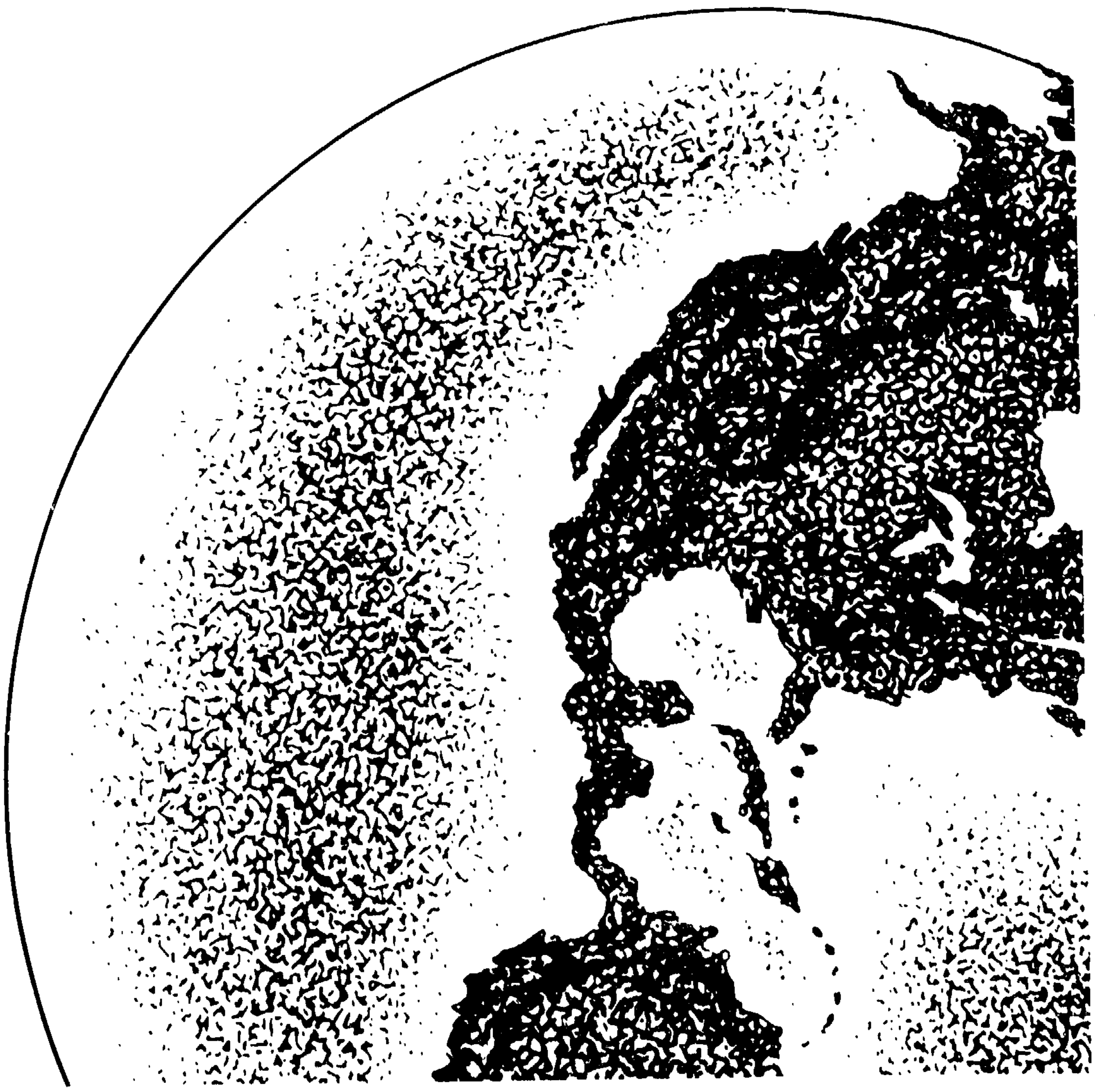
METEOR 2





METEOR 2 PROGRAM

The Meteor 2 satellites were designed to test and implement advanced weather sensors to become the second generation Soviet operational meteorological satellite series. Fifteen Meteor 2 experimental spacecraft have been launched since July 11, 1975. The Meteor 2 differs in external appearance from Meteor 1 by carrying a solar panel of new design, having substantial modifications to the sensor platform, and having a weight increase of 550 kg. The Meteor 2 spacecraft have been launched from Plesetsk into near-circular, near-polar prograde orbits with apogees approximately 900 km and inclination near 81 deg. A two- or three-spacecraft system is required for daily full global coverage. The data are processed and used by the U.S.S.R. Hydrometeorological Center and the State Scientific Research Center for the study of environment and natural earth resources.

All Meteor 2 spacecraft carry visible and infrared radiometers and Automatic Picture Transmission (APT) systems, comparable in many respects to NOAA's ITOS systems. The visible scanner (0.5 to 0.7 micrometer) has a ground resolution of 2 km over a 2100-km swath and the IR scanner (8 to 12 micrometers) has a ground resolution of 8 to 10 km over a 26,100-km swath. The APT system transmits its data stream in the international frequency range of 137 to 138 MHz, and any location that receives U.S. data should be able to receive Meteor 2 data. Two disadvantages of Meteor 2 spacecraft are the inability to process simultaneous visible and infrared products, and the low resolution of the IR product.

The spacecraft also have an interferometer spectrometer to measure the intensity of the atmospheric absorption of infrared radiation from the earth surface in the range of 6 to 25 micrometers.

Some Meteor 2 spacecraft carry a two- or four-band earth resources multispectral scanner that is probably also used for obtaining atmospheric sounding. The two-band sensor, operating in the 0.4- to 0.7- and 0.7- to 1.1-micrometer bands, has a 250-m ground resolution over a 2000-km swath. The four-band instrument, operating in the same spectral bands used by Landsat, provides a spatial resolution of 1000 m x 1600 m over a 2800-km swath. The resolution capabilities of these instruments are nowhere near the 80 m provided by Landsat, but they have the advantage of providing repetitive coverage every 2 to 3 days, instead of every 9 days as in the case for the U.S. two-spacecraft Landsat system.

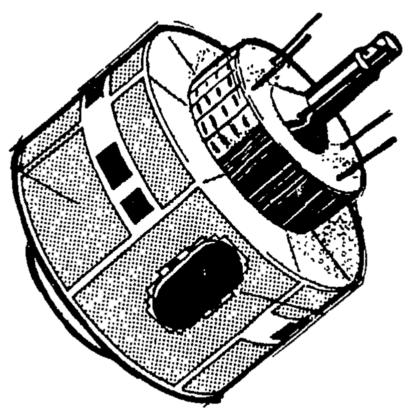
Few additional details are presently available concerning these spacecraft and their instrumentation. For this reason, separate spacecraft and experiment descriptions are not included here. Table 10 lists the known Meteor 2 spacecraft as of October 1985.

TABLE 10

METEOR 2 PROGRAM

NSSDC ID	METEOR NUMBER	LAUNCH DATES	ORBIT		
			inc (deg)	a/p (km)	pd (min)
75-064A	2-1	07-11-75	81	882-851	102
77-002A	2-2	01-06-77	81	897-883	102
77-117A	2-3	12-14-77	81	886-847	102
79-021A	2-4	03-01-79	81	890-830	102
79-095A	2-5	10-31-79	81	884-865	103
80-073A	2-6	09-09-80	81	890-839	102
81-043A	2-7	05-14-81	81	889-849	103
82-025A	2-8	03-25-82	82	960-035	104
82-116A	2-9	12-14-82	81	888-805	102
83-109A	2-10	10-28-83	81	897-740	101
84-072A	2-11	07-18-84	82	962-945	104
85-013A	2-12	02-06-85	82	958-936	104
85-119A	2-13	12-26-85	82	958-936	104
86-039A	2-14	05-27-86	82	958-936	104
87-001A	2-15	01-05-87	82	973-950	104

METEOSAT



METEOROLOGICAL SATELLITE (METEOSAT) PROGRAM

The European Space Agency (ESA), a consortium sponsored by several Western European countries, developed Meteosat as its contribution to the Global Atmospheric Research Program's (GARP) World Weather Watch observing network. This ESA satellite originated as a French project called Meteosat. When ESA took over the project, the name Meteosat was retained. The first ESA spacecraft was Meteosat 1 which was launched from Kennedy Space Center on November 12, 1977, into a geosynchronous orbit with an equator crossing near the prime meridian. A second spacecraft, Meteosat 2, was launched on March 19, 1981, from Kourou, French Guiana, as a replacement for Meteosat 1 (whose imager failed on November 24, 1979). A third spacecraft, Meteosat P2, will be launched in 1988 as a refurbished prototype of Meteosat 2. The Meteosat spacecraft are similar in design and capability to the U.S. GOES/SMS satellites. Meteosat, along with three U.S. GOES and one Japanese GMS, provides 24-hour global coverage from approximately 60 deg N to 60 deg S.

The primary instrument on board the spin-scan stabilized spacecraft was the five-channel visible-IR imaging radiometer. The two visible channels (0.5 to 0.9 micrometer) and the three IR channels (two in the 10.5- to 12.5-micrometer region and one in the 5.7- to 7.1-micrometer region) used a common optics system. The 5.7- to 7.1-micrometer IR water-vapor channel (similar to the water-vapor channel of the Nimbus THIR instrument) was flown for the first time on an operational meteorological satellite by Meteosat.

In addition to its normal payload, Meteosat 2 carried three special experiments. One, involving a Hexfet power transistor, was conceived as a technology demonstration. The other two experiments were the electron spectrometer (SSJ/3) and the Electrostatic Event Monitor (EEM) which were to seek the correlation between the environment of the spacecraft and the electromagnetic interference within it.

Meteosat also had a data collection and transmission platform (DCP) that collected data from various earth-based observing platforms and provided WEFAX type transmissions to the Western European users. The Meteosat 2 DCP malfunctioned four days after launch. Subsequent operations have used Meteosat 1 for its DCP capability and Meteosat 2 for its imaging experiment. Working in this cooperative mode, the spacecraft are maintained near 0 deg (Meteosat 2) and 10 deg E (Meteosat 1) longitude.

############################ METEOSAT 1 ########################

SPACECRAFT COMMON NAME- METEOSAT 1
ALTERNATE NAMES- METEOROLOGICAL SAT-A, METOSAT
10489

NSSDC ID- 77-108A

LAUNCH DATE- 11/23/77 WEIGHT- 625.8 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
INTERNATIONAL ESA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 11/24/77
ORBIT PERIOD- 1411.5 MIN INCLINATION- 0.7 DEG
PERIAPSIS- 34913. KM ALT APOAPSIS- 35692. KM ALT

PERSONNEL
PM - J. AASTED ESA-TOULOUSE

BRIEF DESCRIPTION
Meteosat 1 was a geostationary spacecraft that served as part of European Space Agency's (ESA) contribution to the Global Atmospheric Research Program (GARP). As part of GARP, the satellite helped to supply data required for global data sets used in improvement of machine weather forecasts. In general, the spacecraft design, instrumentation, and operation were similar to SMS/GOES. The spin-stabilized spacecraft carried (1) a visible-IR radiometer to provide high-quality day/night cloudcover data and to take radiance temperatures of the earth/atmosphere system, and (2) a meteorological data collection system to disseminate image data to user stations, to collect data from various earth-based platforms, and to relay data from polar-orbiting satellites. The cylindrically shaped spacecraft measured 210 cm in diameter and 430 cm in length, including the apogee boost motor. The primary structural members were an equipment platform and a central tube. The radiometer telescope was mounted on the equipment platform and viewed the earth through a special aperture in the side of the spacecraft. A support structure extended radially out from the central tube and was affixed to the solar panels, which formed the outer walls of the spacecraft and provided the primary source of electrical power. Located in the annulus-shaped space between the central tube and the solar panels were station-keeping and dynamics control equipment and batteries. Proper spacecraft attitude and spin rate (approximately 100 rpm) were maintained by jet thrusters mounted on the spacecraft and activated by ground command. The spacecraft used both UHF-band and S-band frequencies in its telemetry and command subsystems. A low-power VHF transponder provided telemetry and command during launch and then served as a backup for the primary subsystem once the spacecraft attained synchronous orbit. Meteosat 1 was originally placed in a geosynchronous orbit near the prime meridian and was positioned later between 9 and 11 deg E.

------- METEOSAT 1, PERA--

INVESTIGATION NAME- DATA COLLECTION PLATFORM (DCP)

NSSDC ID- 77-108A-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - L. PERA ESA-TOULOUSE

BRIEF DESCRIPTION
The data collection system was designed to (1) disseminate image data to user stations, (2) collect data from various earth-based platforms, and (3) provide for a space-to-space relay for data from polar-orbiting satellites. This experiment was similar to the meteorological data collection and transmission system (WEFAX) flown on SMS 1, SMS 2, and GOES series spacecraft. This experiment operated on S-band frequencies for WEFAX-type transmissions and UHF for data collection platform report and interrogation.

------- METEOSAT 1, SERENE---------------------------------------

INVESTIGATION NAME- IMAGING RADIOMETER

NSSDC ID- 77-108A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - B. SERENE ESA-TOULOUSE

BRIEF DESCRIPTION
The visible-IR radiometer flown on Meteosat 1 was capable of providing day/night observations of cloudcover and earth/cloud radiance temperature measurements from a synchronous, spin-stabilized satellite for use in (1) operational weather analysis and forecasting and (2) support of GARP. The five-channel instrument was able to take full pictures of the earth's disk. The three IR channels (two in the 10.5- to 12.5-micrometer region and one in the 5.7- to 7.1-micrometer region), and the two visible channels (0.4 to 1.1 micrometers) used a common optics system. Incoming radiation was received by a scan mirror and collected by an optical system. The scan mirror was set at a nominal angle of 45 deg to the radiometer 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-east scan motion when the spin axis of the spacecraft was oriented parallel with the earth's axis. The latitudinal scan was accomplished by sequentially tilting the scanning mirror at the completion of each spin. Resolutions at the subsatellite point were 2.5 km for the visible, and 5 km for the IR and water vapor channels. Data from this experiment are available through the European Space Operations Center (ESOC), Darmstadt, W. Germany.

############################ METEOSAT 2 ########################

SPACECRAFT COMMON NAME- METEOSAT 2
ALTERNATE NAMES- METEOROLOGICAL SAT-B, METEOSAT-B

NSSDC ID- 81-057A

LAUNCH DATE- 06/19/81 WEIGHT- 625.8 KG
LAUNCH SITE- KOUROU (CENTRE SPATIAL GUYANAIS), FRENCH GUIANA
LAUNCH VEHICLE- ARIANE

SPONSORING COUNTRY/AGENCY
INTERNATIONAL ESA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 06/27/81
ORBIT PERIOD- 1442.1 MIN INCLINATION- 1.01 DEG
PERIAPSIS- 35847. KM ALT APOAPSIS- 35973. KM ALT

PERSONNEL
PM - J. AASTED ESA-TOULOUSE

BRIEF DESCRIPTION
Meteosat 2 was a geostationary spacecraft which served as part of the European Space Agency's (ESA) contribution to the Global Atmospheric Research Program (GARP). As part of GARP, the satellite helped to supply data required for global data sets used in improvement of machine weather forecasts. In general, the spacecraft design, instrumentation, and operation were similar to SMS/GOES. The spin-stabilized spacecraft carried (1) a visible-IR radiometer that provided high-quality day/night cloudcover data and that took radiance temperatures of the earth/atmosphere system and (2) a meteorological data collection system that disseminated image data to user stations, collected data from various earth-based platforms, and relayed data from polar-orbiting satellites. The cylindrically shaped spacecraft measured 210 cm in diameter and 430 cm in length, including the apogee boost motor. The primary structural members were an equipment platform and a central tube. The radiometer telescope was mounted on the equipment platform and viewed the earth through a special aperture in the side of the spacecraft. A support structure extended radially out from the central tube and was affixed to the solar panels, which formed the outer walls of the spacecraft and provided the primary source of electrical power. Located in the annulus-shaped space between the central tube and the solar panels were stationkeeping and dynamics control equipment and batteries. Proper spacecraft attitude and spin rate (approximately 100 rpm) were maintained by jet thrusters mounted on the spacecraft and activated by ground command. The spacecraft used both UHF-band and S-band frequencies in its telemetry and command subsystems. A low-power VHF transponder provided telemetry and command during launch and then served as a backup for the primary subsystem after the spacecraft had attained synchronous orbit. Meteosat 2 was maintained on station between 1 deg E and 1 deg W.

------- METEOSAT 2, PERA--

INVESTIGATION NAME- DATA COLLECTION PLATFORM (DCP)

NSSDC ID- 81-057A-02 INVESTIGATIVE PROGRAM
COMMUNICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - L. [illegible] ESA-TOULOUSE

BRIEF DESCRIPTION
The data collection system was designed to (1) disseminate image data to user stations, (2) collect data from various earth-based platforms, and (3) provide for a space-to-space relay for data from polar orbiting satellites. This experiment was similar to the meteorological data collection and transmission system (WEFAX) flown on SMS 1, SMS 2, and GOES series spacecraft. This experiment operated on S-band frequencies for WEFAX-type transmissions and UHF for

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data collection platform report and interrogation.

-------- METEOSAT 2, SERENE----- --------------------------------

INVESTIGATION NAME- IMAGING RADIOMETER

NSSDC ID- 81-057A-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - B. SERENE ESA-TOULOUSE

BRIEF DESCRIPTION
The visible-IR radiometer flown on Meteosat 2 was capable of providing day/night observations of cloud cover and earth/cloud radiance temperature measurements from a synchronous, spin-stabilized satellite for use in (1) operational weather analysis and forecasting and (2) for support to GARP. The five-channel instrument was able to take full pictures of the earth's disk. The three IR channels (two in the 10.5- to 12.5-micrometer region and one in the 5.7- to 7.1-micrometer region), and the two visible channels (0.4- to 1.1-micrometers) used a common optics system. Incoming radiation was received by a scan mirror and collected by an optical system. The scan mirror was set at a nominal angle of 45 deg to the radiometer 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-east scan motion when the spin axis of the spacecraft was oriented parallel with the earth's axis. The latitudinal scan was accomplished by sequentially tilting the scanning mirror at the completion of each spin. Resolutions at the sub-satellite point were 2.5 km for the visible, and 5 km for the IR and water-vapor channels. Data from this experiment are available through the European Space Operations Center (ESOC), Darmstadt, W. Germany.

**************************** MTSATP2 ****************************

SPACECRAFT COMMON NAME- MTSATP2
ALTERNATE NAMES- METEOSAT-P2

NSSDC ID- MTSATP2

LAUNCH DATE- 00 00/87 WEIGHT- 625. KG
LAUNCH SITE- KOUROU (CENTRE SPATIAL GUYANAIS), FRENCH GUIANA
LAUNCH VEHICLE- ARIANE-4

SPONSORING COUNTRY/AGENCY
INTERNATIONAL ESA

PLANNED ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC
ORBIT PERIOD- 1436. MIN INCLINATION- 0.0 DEG
PERIAPSIS- 36000. KM ALT APOAPSIS- 36000. KM ALT

PERSONNEL
PM - J. AASTED ESA-TOULOUSE

BRIEF DESCRIPTION
Meteosat P2 is a refurbished protoype of Meteosat 2. In general, the spacecraft design, instrumentation, and operation are similar to SMS/GOES. The spin-stabilized, geostationary spacecraft carries (1) a visible-IR radiometer to provide high-quality, day/night cloud-cover data and to take radiance temperatures of the earth/atmosphere system, and (2) a meteorological data collection system to disseminate image data to user stations, to collect data from various earth-based platforms, and to relay data from polar-orbiting satellites. The cylindrically shaped spacecraft measures 210 cm in diameter and 430 cm in length, including the apogee boost motor. The primary structural members are an equipment platform and a central tube. The radiometer telescope is mounted on the equipment platform and views the earth through a special aperture in the side of the spacecraft. A support structure extends radially out from the central tube and is affixed to the solar panels, which form the outer walls of the spacecraft and provide the primary source of electrical power. Located in the annulus-shaped space between the central tube and the solar panels are station-keeping and dynamics control equipment and batteries. Proper spacecraft attitude and spin rate (approximately 100 rpm) are maintained by jet thrusters mounted on the spacecraft and activated by ground command. The spacecraft uses both UHF-band and S-band frequencies in its telemetry and command systems. A lower power VHF transponder provides telemetry and command during launch and then serves as a backup for the primary subsystem once the spacecraft attains synchronous orbit.

-------- MTSATP2, PERA--

INVESTIGATION NAME- DATA COLLECTION PLATFORM (DCP)

NSSDC ID- MTSATP2-02 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - L. PERA ESA-TOULOUSE

BRIEF DESCRIPTION
The data collection system is designed (1) to disseminate image data to user stations, (2) to collect data from various earth-based platforms, and (3) to provide for a space-to-space relay for data from polar-orbiting satellites. This experiment is similar to the meteorological data collection and transmission system (WEFAX) flown on SMS 1, SMS 2, and GOES series spacecraft. This experiment operates on S-band frequencies for WEFAX-type transmissions and UHF for data collection platform report and interrogation.

-------- MTSATP2, SERENE--

INVESTIGATION NAME- MULTISPECTRAL (VISIBLE AND INFRARED) IMAGING RADIOMETER

NSSDC ID- MTSATP2-01 INVESTIGATIVE PROGRAM
APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - B. SERENE ESA-TOULOUSE

BRIEF DESCRIPTION
The Meteosat P2 visible-IR radiometer is capable of providing day/night observations of cloud cover and earth/cloud radiance temperature measurements from a synchronous, spin-stabilized satellite for use in operational weather analysis and forecasting. The five-channel instrument is able to take pictures of the full earth's disk. The three IR channels (two in the 10.5- to 12.5-micrometer region and one in the 5.7- to 7.1-micrometer region), and the two visible channels (0.4 to 1.1 micrometers) use a common optics system. Incoming radiation is received by a scan mirror and collected by an optical system. The scan mirror is set at a nominal angle of 45 deg to the radiometer optical axis, which is aligned parallel to the spin axis of the spacecraft. The spinning motion of the spacecraft (approximately 100 rpm) provides a west-to-east scan motion when the spin axis of the spacecraft is oriented parallel with the earth's axis. The latitudinal scan is accomplished by sequentially tilting the scanning mirror at the completion of each spin. Resolutions at the sub-satellite point are 2.5 km for the visible, and 5 km for the IR and water-vapor channels. Data from this experiment are to be available through the European Space Operations Center (ESOC), Darmstadt, W. Germany.

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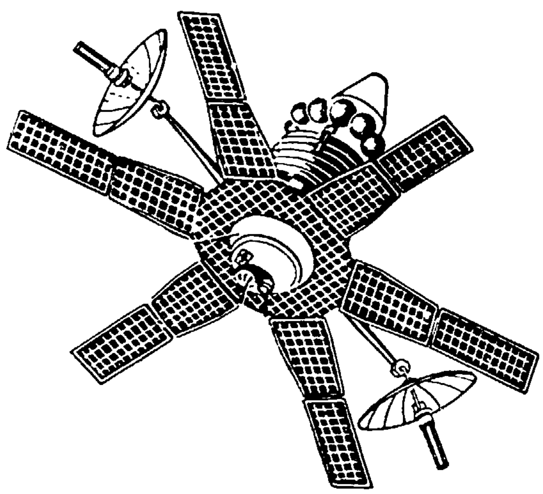
MOLNIYA



MOLNIYA I PROGRAM

The Molniya I (Lightning 1) series was a first generation communication satellite series that was designed primarily to test and perfect a radio, telephone, and television communication relay system using earth satellites as active transponders and to test the system for operational use. The satellites were all launched from Tyuratam by A-2-E launch vehicles into highly elliptical orbits with apogees near 40,000 km and having 12-h periods. Beginning in 1966, TV cameras were included on several of the Molniya I satellites to supplement the more detailed but smaller-scale pictures obtained by the lower-orbiting experimental Meteor system satellites. These cameras were equipped with interchangeable lenses and various light filters. They were carried on the third through the tenth satellites of this series.

Taken at satellite apogee, the pictures provided nearly full earth-disk coverage and gave Soviet meteorologists the opportunity to study large-scale cloud patterns over the Northern Hemisphere from a single photograph. With the initiation of the operational Meteor system satellites possessing global cloud cover monitoring capabilities, the TV camera system was not included on later launches in the Molniya I series.

The description of a typical Molniya spacecraft is appended.

**************************** MOLNIYA I, 1-3 through 1-10 ************************

Spacecraft Name - Molniya I, 1-3 to 1-10

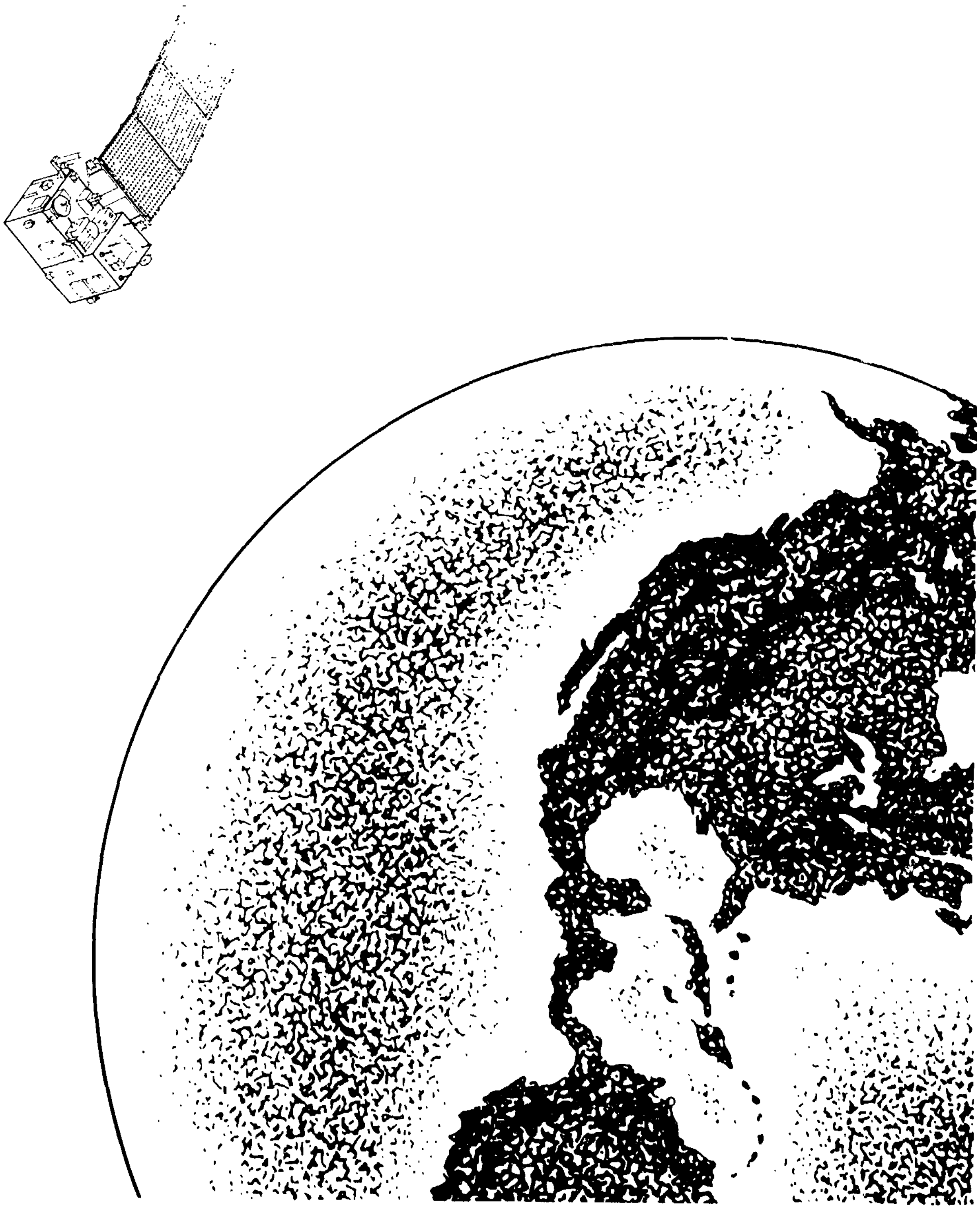
S/C		NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (hh/min)
Molniya	1-3	66-035A	04/25/66	65	499	39,500	11/50
	1-4	66-092A	10/20/66	65	489	39,700	11/53
	1-5	67-052A	05/24/67	65	460	38,810	11/55
	1-6	67-095A	10/03/67	65	465	39,600	11/52
	1-7	67-101A	10/22/67	65	456	39,740	11/54
	1-8	68-035A	04/21/68	65	460	39,700	11/53
	1-9	68-057A	07/05/68	65	470	39,770	11/55
	1-10	68-085A	10/05/68	65	490	39,600	11/52

S/C	PM	PS
Molniya 1-3 through 1-10	Unknown	Unknown

Brief Description

The Molniya I series was a first-generation U.S.S.R. communications satellite orbited to test and perfect a system of radio communications and television broadcasting using earth satellites as active transponders and to experiment with the system in practical use. The basic function of the satellite was to relay television programs and long-distance, two-way, multichannel telephone, phototelephone, and telegraph links from Moscow to the various standard ground-receiving stations in the "orbita" system. The satellite was in the form of a hermetically sealed cylinder with conical ends; one end contained the orbit-correcting engine and a system of microjets, and the other end contained externally mounted solar and earth sensors. Inside the cylinder were (1) a high-sensitivity receiver and three 800-MHz 40-W transmitters (one operational and two in reserve), (2) telemetering devices that monitored equipment operation, (3) chemical batteries that were constantly recharged by solar cells, and (4) an electronic computer that controlled wall equipment on board. Mounted around the central cylinders were six large solar battery panels and two directional, high-gain parabolic aerials mounted 180 deg apart. One of the aerials was directed continually toward the earth by the highly sensitive earth sensors. The second aerial was held in reserve. Signals were transmitted in a fairly narrow beam ensuring strong reception at the earth's surface. The satellite received telemetry at 1000 MHz. Television service was provided in a frequency range of 3.4 to 4.1 GHz at 40 W. Molniya 1-3, whose cylindrical body was 3.4 m long and 1.6 m in diameter, was much heavier than corresponding U.S. Comsats, and it had about 10 times the power output of the Early Bird satellites. In addition, it did not employ a geosynchronous equatorial orbit as have most U.S. communication satellites because such an orbit would not provide coverage for areas north of 70 deg N latitude. Instead, the satellite was boosted from a low-altitude parking orbit into a highly elliptical orbit with two high apogees daily over the Northern Hemisphere (one over the U.S.S.R. and one over North America) and relatively low perigees over the Southern Hemisphere. During its apogee, Molniya I series satellites moved very slowly with respect to the earth below for nearly 8 of every 12 h. By placing three or more Molniya I satellites in this type of orbit, spacing them suitably, and shifting their orbital planes relative to each other by 120 deg, a 24-h/day communication system was obtained. Molniya 1-3 relayed color TV transmissions from Moscow to France in a test of the French-Russian Secam-III television transmission system. In addition, Molniya 1-3 was the first of the series to carry a television camera to transmit cloud-cover pictures. The camera was externally mounted and was equipped with various filters and interchangeable wide- and narrow-angle lenses. From its high apogee over the Northern Hemisphere, the satellite transmitted detailed cloud-cover pictures of the entire disk of the earth that were similar to the ATS pictures. Such pictures from Molniya 1-3 through 10 were used in conjunction with cloud-cover pictures taken by the lower orbiting satellites of the Meteor weather satellite system to obtain a comprehensive and detailed view of global weather systems.

MOS



MARINE OBSERVATION SATELLITE (MOS) PROGRAM

MOS 1 is Japan's first earth observation satellite in a series of spacecraft to study the state of sea surface and atmosphere, and to establish the fundamental remote sensing technologies for both land and ocean observations. Launched in January 1987 into a near-polar and sun-synchronous orbit, MOS 1 provides repetitive coverage of an area every 17 days and crosses the equator in a descending node between 10 and 11 a.m. local time.

Three sensors are carried on each spacecraft: (1) the Multispectral Electronic Self-Scanning Radiometer (MESSR), (2) the Visible and Thermal Infrared Radiometer (VTIR), and (3) the Microwave Scanning Radiometer (MSR).

The MESSR measures sea surface colors in four spectral bands between 0.51 and 1.1 micrometers. Ground resolution of the earth images is 50 m x 50 m, and swath width is approximately 100 km along track. Since the MESSR instrument is not meteorologically oriented, no experiment description will be given.

The VTIR gathers information on sea surface temperatures and cloud cover. Both visible (0.5 to 0.7 micrometer) and infrared (6.0 to 7.0, 10.5 to 11.5, and 11.5 to 12.5 micrometers) radiometer images are produced with a swath width of 1500 km, and resolutions of 900 m (VIS) and 2700 m (IR), respectively. Observed image data by the VTIR are combined with the data from the MESSR into one data stream and transmitted in real time to the ground by a high speed data transmitter.

Measurements of sea ice, snowfall, and water vapor content at the ocean surface and in the atmosphere are made by the MSR in two microwave bands (24 and 31 GHz). Swath width is about 317 km along track, and ground resolutions are 32 km and 23 km, respectively. All data are transmitted in real time to ground stations in Japan and overseas.

With the launch of the MOS spacecraft, Japan is progressing toward the establishment of an operational earth resources satellite program.

****************************** MOS 1 ******************************

SPACECRAFT COMMON NAME- MOS 1
ALTERNATE NAMES- MARINE OBSERV. SAT. 1, MOS-A
17527

NSSDC ID- 87-018A

LAUNCH DATE- 02/19/87 WEIGHT- 750. KG
LAUNCH SITE- TANEGASHIMA, JAPAN
LAUNCH VEHICLE- N-II

SPONSORING COUNTRY/AGENCY
JAPAN NASDA

ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE-
ORBIT PERIOD- 103. MIN INCLINATION- 99.1 DEG
PERIAPSIS- 909. KM ALT APOAPSIS- 909. KM ALT

PERSONNEL
PM - Y. ISHIZAWA NASDA
PS - NASDA STAFF NASDA

BRIEF DESCRIPTION
The Marine Observation Satellite (MOS-1) was Japan's first earth observation satellite. The three-axis stabilized spacecraft carried (1) a Multispectral Electronic Self-scanning Radiometer (MESSR) that collected data from both land and sea, (2) a Visible and Thermal Infrared Radiometer (VTIR) to measure sea surface temperature, (3) a Microwave Scanning Radiometer (MSR) to provide information on sea ice, snowfall, water vapor content at the ocean and in the atmosphere, and (4) a Data Collection System (DCS) transponder to collect observation data from drifting buoys. The spacecraft had a box-type shape with deployable solar panels. It was composed of two cubes, a bus module and a mission module, on which the three sensors were mounted. The spacecraft followed a sun-synchronous orbit with equatorial crossings in the descending node maintained between 10:00 a.m. and 11:00 a.m. local time. The mission life was designed to be 2 years.

------- MOS 1, EARTH OBS CTR-----------------------------------

INVESTIGATION NAME- MULTISPECTRAL ELECTRONIC SELF-SCANNING RADIOMETER (MESSR)

NSSDC ID- 87-018A-01 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
EARTH RESOURCES SURVEY
OCEANOGRAPHY

PERSONNEL
PI - EARTH OBS CTR NASDA
PI - INVESTIGATION GROUP JAPANESE GOVT AGENCIES

BRIEF DESCRIPTION
The Multispectral Electronic Self-Scanning Radiometer (MESSR) experiment measured sea-surface color, the distribution of ice floes and chlorophyll, and the generation of red tides. It was also used to detect mineral and energy resources, crop inventories, and other on-land data. The push-broom scanning radiometer operated in four spectral bands: 0.51-0.59, 0.61-0.69, 0.72-0.80, and 0.80-1.10 micrometers. Incoming radiation was received by two optical systems. Each system was composed of a Gauss type telescope, a prism to divide the incident ray into two parts depending on wavelength, and two detectors of the charge-coupl d device (CCD) type with 2048 elements. The instantaneous FOV was 54.7 microradians (approximately 50-m ground resolution) and the swath width was 100 km along track. For increased reliability of data, two sets of MESSRs were used; thus the swath width totaled 200 km. Image data were converted by signal processors into digital format, and then were transmitted via 8000-MHz transmitters to the Earth Observation Center in Japan and to overseas ground stations.

------- MOS 1, EARTH OBS CTR-----------------------------------

INVESTIGATION NAME- VISIBLE AND THERMAL INFRARED RADIOMETER (VTIR)

NSSDC ID- 87-018A-02 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - EARTH OBS CTR NASDA
PI - INVESTIGATION GROUP JAPANESE GOVT AGENCIES

BRIEF DESCRIPTION
The Visible and Thermal Infrared Radiometer (VTIR) was a mechanical scanning radiometer that gathered information on clouds and sea-surface temperatures. Incoming radiation was collected by a reflecting mirror, which rotated with a rate of 7.3 rps and scanned cross-track swaths 1500-km wide. The along track scan was provided by the motion of the spacecraft. The primary image produced at the image plane was spectrally separated by optical filters and relayed to detectors for photo-electric conversion. Silicon pin diodes were selected for the visible band (0.5 to 0.7 micrometer), and Hg-Cd-Te elements were used for the three infrared bands (6.0 to 7.0, 10.5 to 11.5, and 11.5 to 12.5 micrometers). The instantaneous FOV of the sensors were 1 mrad for the visible region and 5 mrad for the infrared, which corresponded to ground resolutions of 900 m and 2700 m, respectively. Image data in digital format were transmitted by an 8000-MHz link to the Earth Observation Center in Japan and to other foreign stations for processing.

------- MOS 1, EARTH OBS CTR-----------------------------------

INVESTIGATION NAME- MICROWAVE SCANNING RADIOMETER (MSR)

NSSDC ID- 87-018A-03 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - EARTH OBS CTR NASDA
PI - INVESTIGATION GROUP JAPANESE GOVT AGENCIES

BRIEF DESCRIPTION
The Microwave Scanning Radiometer (MSR) provided parameter measurement on sea ice, snowfall, and the water vapor content at the ocean surface and in the atmosphere. The system consisted of an offset Cassegrain-type of antenna, a sky horn, two Dicke-type receivers, and detectors operating at 24 GHz and 31 GHz. The antenna scanned mechanically, following a conical path with a period of 3.2 s. It oscillated 10 deg to either side of nadir with beam widths of less than 1.99 deg for the 24-GHz band and less than 1.45 deg for the 31-GHz band. The corresponding ground resolutions were approximately 32 km and 23 km, respectively; and the swath width was 317 km along track. Data from MSR, plus range and range rate signals, were transmitted at 2000 MHz directly to the Earth Observation Center in Japan and to other overseas earth observation stations for processing.

------- MOS 1, EARTH OBS CTR-----------------------------------

INVESTIGATION NAME- DATA COLLECTION SYSTEM TRANSPONDER (DCS TRANSPONDER)

NSSDC ID- 87-018A-04 INVESTIGATIVE PROGRAM
APPLICATIONS SATELLITE

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - EARTH OBS CTR NASDA
PI - INVESTIGATION GROUP JAPANESE GOVT AGENCIES

BRIEF DESCRIPTION
The experimental Data Collection System (DCS) Transponder was used to locate Data Collection Platform (DCPs) such as drifting buoys. Observational data from DCPs were transmitted at 400 MHz to a down-converter in the transponder, and the output signal is then transmitted with phase modulation by a 1700-MHz link to the Earth Observation Station in Japan.

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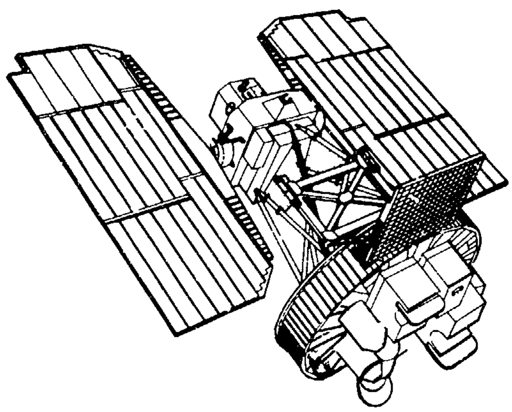
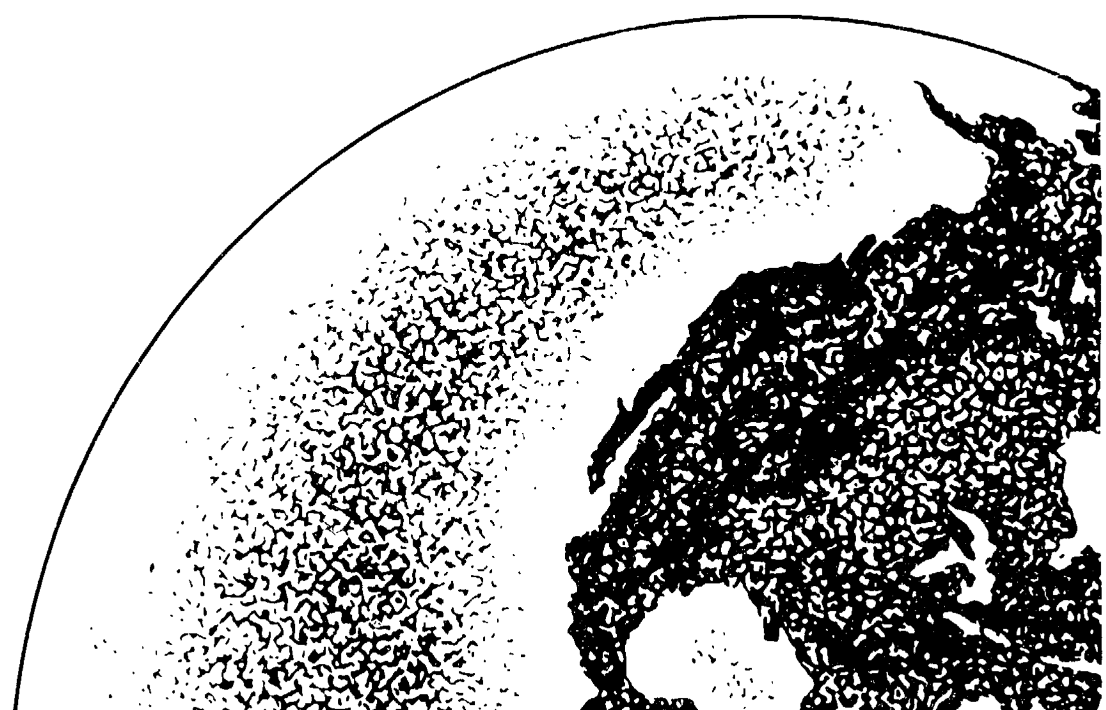
NIMBUS





NIMBUS PROGRAM

The Nimbus satellites were second-generation meteorological R&D spacecraft designed to serve as stabilized, earth-oriented platforms for the testing of advanced systems to sense and collect meteorological data. Seven Nimbus spacecraft have been launched into near-polar, sun-synchronous orbits beginning with Nimbus 1 on August 28, 1964.

Nimbus 1 and 2 each carried an Automatic Picture Transmission (APT) system. The APT system consisted of a camera and transmitter package designed to transmit local daylight, slow-scan television pictures of cloud cover to special ground-receiving stations on a real-time basis. The success of the APT system bolstered the decision to include it on future TIROS operational satellites.

The Advanced Vidicon Camera System (AVCS) was a three-camera system with a recorder and transmitter that could provide global daylight cloud-cover pictures. The AVCS was carried by Nimbus 1 and 2. The AVCS was replaced by an Image Dissector Camera System (IDCS) on Nimbus 3 and 4. The IDCS provided daylight cloud-cover pictures that could be stored on magnetic tape for subsequent playback or transmitted in real time to APT stations. The image dissector camera was a shutterless electronic scanning and stepping radiometer. No other daylight cloud-cover imaging instruments were carried by Nimbus.

Several infrared imaging radiometers were flown on the Nimbus series. The High Resolution Infrared Radiometer (HRIR) was carried by Nimbus 1, 2, and 3. Nimbus 2 and 3 also carried a Medium Resolution Infrared Radiometer (MRIR). Nimbus 4 through 7 replaced these IR imaging radiometers with a Temperature-Humidity Infrared Radiometer (THIR), which was a two-channel IR imaging radiometer.

The Nimbus series also carried various experiments to obtain temperature, pressure, and water vapor profiles in the atmosphere. Two of these were the Infrared Interferometer Spectrometer (IRIS) and the Satellite Infrared Spectrometer (SIRS) flown on Nimbus 3 and 4. Nimbus 4 and 5 carried a Selective Chopper Radiometer (SCR) to observe radiances in the carbon dioxide band. Nimbus 6 carried a High Resolution Infrared Sounder (HIRS), a limb radiance inversion radiometer (LRIR), and a Pressure Modulated Radiometer (PMR). Nimbus 7 carried several advanced profiling IR instruments, including the Limb Infrared Monitor of the Stratosphere (LIMS) and the Stratospheric and Mesospheric Sounder (SAMS).

Microwave frequencies for imaging and profiling the atmospheric parameters were also explored with instruments beginning with Nimbus 5, which had an Electronic Scanning Microwave

Radiometer (ESMR) operating at 19 GHz. Nimbus 6 carried a similar instrument but it operated at 37 GHz. Nimbus 7 carried an advanced microwave imager, the Scanning Multispectral Microwave Radiometer (SMMR), with five dual-polarized frequencies between 6 and 37 GHz. Nimbus 5 carried the first microwave spectrometer (NEMS), which was replaced by a Scanning Microwave Spectrometer (SCAMS) on Nimbus 6.

The Nimbus series carried additional instrumentation, such as the Tropical Wind Energy Conversion and Reference Level Experiment (TWERLE) on Nimbus 6, Earth Radiation Budget (ERB) on Nimbus 6 and 7, Backscatter Ultraviolet (BUV) spectrometer on NIMBUS 4, and Solar Backscatter Ultraviolet /Total Ozone Mapping System (SBUV/TOMS) on Nimbus 7, the Surface Composition Mapping Radiometer (SCMR) on Nimbus 5, and a Coastal Zone Color Scanner (CZCS) on Nimbus 7. A special issue of the Journal of Geophysical Research (v. 89, no. D4, 1984) contains papers on Nimbus 7 scientific results.

Nimbus was the first satellite series capable of providing both daytime and nighttime global coverage of the earth's cloud cover on a daily basis. This series also included the first U.S. satellites to routinely monitor the earth-atmosphere system using the microwave portion of the spectrum and the first satellites to provide radiance measurements from which daily, worldwide temperature and moisture profiles (SIRS) could be derived.

Nimbus 4 through 7 have far exceeded their design lifetime, each having operated for over 8 years.

SPACECRAFT COMMON NAME- NIMBUS 1
ALTERNATE NAMES- 00872, NIMBUS-A

NSSDC ID- 64-052A

LAUNCH DATE- 08/28/64 WEIGHT- 374.4 KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 08/28/64
ORBIT PERIOD- 98.42 MIN	INCLINATION- 98.66 DEG
PERIAPSIS- 429. KM ALT	APOAPSIS- 937. KM ALT

PERSONNEL
PM - H. PRESS(NLA) NASA-GSFC
PS - W.P. NORDBERG(DECEASED) NASA-GSFC

BRIEF DESCRIPTION

Nimbus 1, the first in a series of second-generation meteorological research-and-development satellites, was designed to serve as a stabilized, earth-oriented platform for the testing of advanced meteorological sensor systems and for collecting meteorological data. The polar-orbiting spacecraft consisted of three major elements: (1) a sensory ring, (2) solar paddles, and (3) the control system housing. The solar paddles and the control system housing were connected to the sensory ring by a truss structure, giving the satellite the appearance of an ocean buoy. Nimbus 1 was nearly 3.7 m tall, 1.5 m in diameter at the base, and about 3 m across with solar paddles extended. The sensory ring, which formed the satellite base, housed the electronics equipment and battery modules. The lower surface of the torus-shaped sensory ring provided mounting space for sensors and telemetry antennas. An H-frame structure mounted within the center of the torus provided support for the larger experiments and tape recorders. Mounted on the control system housing, which was located on top of the spacecraft, were sun sensors, horizon scanners, gas nozzles for attitude control, and a command antenna. Use of a stabilization and control system allowed the spacecraft's orientation to be controlled to within plus or minus 1 deg for all three axes (pitch, roll, and yaw). The spacecraft carried (1) an advanced vidicon camera system (AVCS) for recording and storing remote cloudcover pictures, (2) an automatic picture transmission (APT) camera for providing real-time cloudcover pictures, and (3) a high-resolution infrared radiometer (HRIR) to complement the daytime TV coverage and to measure nighttime radiative temperatures of cloud tops and surface terrain. A short second-stage burn resulted in an unplanned eccentric orbit. Otherwise, the spacecraft and its experiments operated successfully until September 22, 1964. The solar paddles became locked in position, resulting in inadequate electrical power to continue operations.

------- NIMBUS 1, BURDETT--------------------------------------

INVESTIGATION NAME- ADVANCED VIDICON CAMERA SYSTEM (AVCS)

NSSDC ID- 64-052A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - G.L. BURDETT NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 1 Advanced Vidicon Camera System (AVCS), which consisted of three cameras, a tape recorder, and an S-band transmitter, recorded and stored a series of remote daytime cloudcover pictures for subsequent playback to selected ground data acquisition stations. The AVCS cameras were mounted on the satellite sensory ring, facing earthward and deployed in a fan-like array to produce a three-segment composite picture. Each camera covered a 37-deg field of view with the center camera pointing straight down. The optical axes of the other two cameras were directed 35 deg to either side. Each of the cameras employed an f/4 lens with a focal length of 16.5 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 nadir 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 min. The AVCS experiment was highly successful. It provided the first near-global, high-resolution cloudcover pictures ever assembled and confirmed the decision to use this particular camera assembly as a basis for the first operational satellite system TOS/ESSA (TIROS Operational System/Environmental Science Services Administration). Data from this experiment can be obtained through SDSD. For an index of the data, see "Nimbus 1 Users' Catalog: AVCS and APT" (TRF B04499), available from NSSDC.

------- NIMBUS 1, FOSHEE--------------------------------------

INVESTIGATION NAME- HIGH-RESOLUTION INFRARED RADIOMETER (HRIR)

NSSDC ID- 64-052A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - L.L. FOSHEE USA ELECTRONICS CMD

BRIEF DESCRIPTION

The Nimbus 1 High-Resolution Infrared Radiometer (HRIR) was designed (1) to map the earth's nighttime cloudcover and thus to complement the daytime television (AVCS) coverage and (2) to measure the radiative temperatures of cloud tops and surface terrain. Mounted on the earth-oriented sensory ring, the radiometer measured thermal radiation in the 3.5- to 4.1-micrometer "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 deg, which at a nominal spacecraft altitude corresponded to a ground resolution of approximately 8 km at nadir. The radiometer was capable of measuring radiance temperatures from 210 to 330 K. Since the radiometer operated in the 3.5- to 4.1-micrometer 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. For a more detailed description and an index of the data, see "Nimbus I High Resolution Radiation Data Catalog and Users' Manual" (TRF B04500), available from NSSDC.

------- NIMBUS 1, HUNTER--------------------------------------

INVESTIGATION NAME- AUTOMATIC PICTURE TRANSMISSION (APT) SYSTEM

NSSDC ID- 64-052A-02 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - C.M. HUNTER NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 1 Automatic Picture Transmission (APT) system was a camera and transmitter combination designed to transmit local daytime, slow-scan television pictures of cloudcover conditions to properly equipped ground receiving stations on a real-time basis. The camera used a 108-deg wide-angle f/1.8 objective lens with a focal length of 5.7 mm. The camera was mounted facing earthward on the H-frame inside the sensory ring, with its optical axis parallel to the spacecraft spin axis. The actual picture taking required 8 s and the transmission 200 s. Earth-cloud images retained on the photo-sensitive surface of the 2.54-cm-diameter vidicon were read out at four lines per second to produce an 800-line picture. A 5-W TV transmitter (136.95 MHz) relayed the pictures to local APT stations within communication range. The faceplate of the vidicon had reticle marks that appeared on the picture format to aid in relating the picture to its geographical position on the earth's surface. At the nominal satellite altitude, a picture covered approximately a 1660- by 1660-km square with a horizontal resolution of around 3 km at nadir. The experiment supplied over 1600 high-quality cloudcover pictures to participating APT stations during the spacecraft's 3.5-week lifetime. It proved the capability of weather satellites to provide high-quality daytime local cloudcover data to operational meteorologists on an essentially real-time basis. Its success bolstered the decision to include such instrumentation in the TIROS Operational System (TOS). For more detailed information of the experiment, see "APT Users' Guide" (TRF B04499), available from NSSDC. APT data are primarily intended for operational use within the local APT acquisition station and are generally not available for distribution.

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**************************** NIMBUS 2****************************

SPACECRAFT COMMON NAME- NIMBUS 2
ALTERNATE NAMES- 02173, NIMBUS-C

NSSDC ID- 66-040A

LAUNCH DATE- 05/15/66 WEIGHT- 414. KG
LAUNCH SITE- VANDENBERG AFB, UNITED S' .'S
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 05/16/66
ORBIT PERIOD- 108.15 MIN INCLINATION- 100.35 DEG
PERIAPSIS- 1103. KM ALT APOAPSIS- 1179. KM ALT

PERSONNEL
PM - H. PRESS(NLA) NASA-GSFC
PS - W.P. NORDBERG(DECEASED) NASA-GSFC

BRIEF DESCRIPTION
Nimbus 2, the second in a series of second-generation meteorological research-and-development satellites, was designed to serve as a stabilized, earth-oriented platform for the testing of advanced meteorological sensor systems and the collecting of meteorological data. The polar-orbiting spacecraft consisted of three major elements: (1) a sensory ring, (2) solar paddles, and (3) the control system housing. The solar paddles and the control system housing were connected to the sensory ring by a truss structure, giving the satellite the appearance of an ocean buoy. Nimbus 2 was nearly 3.7 m tall, 1.5 m in diameter at the base, and about 3 m across with solar paddles extended. The sensory ring, which formed the satellite base, housed the electronics equipment and battery modules. The lower surface of the torus-shaped sensory ring provided mounting space for sensors and telemetry antennas. An H-frame structure mounted within the center of the torus provided support for the larger experiments and tape recorders. Mounted on the control system housing, which was located on top of the spacecraft, were sun sensors, horizon scanners, gas nozzles for attitude control, and a command antenna. Use of a stabilization and control system permitted the spacecraft's orientation to be controlled to within plus or minus 1 deg for all three axes (pitch, roll, and yaw). The spacecraft carried (1) an advanced vidicon camera system (AVCS) for recording and storing remote cloudcover pictures, (2) an automatic picture transmission (APT) camera for providing real-time cloudcover pictures, and (3) both high- and medium-resolution infrared radiometers (HRIR and MRIR) for measuring the intensity and distribution of electromagnetic radiation emitted by and reflected from the earth and its atmosphere. The spacecraft and experiments performed normally after launch until July 26, 1966, when the spacecraft tape recorder failed. Its function was taken over by the HRIR tape recorder until November 15, 1966, when it also failed. Some real-time data were collected until January 17, 1969, when the spacecraft mission was terminated owing to deterioration of the horizon scanner used for earth reference. More detailed information can be found in the "Nimbus II Users' Guide" (TRF B03406), available from NSSDC.

------- NIMBUS 2, FOSHEE--

INVESTIGATION NAME- HIGH-RESOLUTION INFRARED RADIOMETER (HRIR)

NSSDC ID- 66-040A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - L.L. FOSHEE USA ELECTRONICS CMD

BRIEF DESCRIPTION
The Nimbus 2 High-Resolution Infrared Radiometer (HRIR) was designed (1) to map the earth's nighttime cloud cover and thus to complement the daytime television (AVCS) coverage and (2) to measure the radiative temperatures of cloud tops and surface terrain. Mounted on the earth-oriented sensory ring, the radiometer measured thermal radiation in the 3.5- to 4.1-micrometer "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. Some HRIR data were also transmitted in a real-time mode by the APT transmitter. The radiometer had an instantaneous field of view of about 0.5 deg, which at an altitude of 1100 km corresponded to a ground resolution of approximately 8 km at nadir. The radiometer was capable of measuring radiance temperatures from 210 to 330 K. Since it operated in the 3.5- to 4.1-micrometer region, the daytime pictures included 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. The experiment was a success, and good data were obtained until the HRIR tape recorder failed on November 15, 1966. The failure of the spacecraft recorder on July 26, 1966, necessitated the use of the HRIR recorder on a part-time basis to record selected telemetry data, which resulted in a 15% reduction of available HRIR data thereafter. For more detailed information of the experiment and the index of data, see Section 3 of "Nimbus II Users' Guide" (TRF B03406), "The Nimbus II High Resolution Infrared Data World Montage Catalog" (TRF B06578), and "The Nimbus II Data Catalog" (TRF B06573), available from NSSDC.

------- NIMBUS 2, MCCULLOCH--

INVESTIGATION NAME- MEDIUM-RESOLUTION INFRARED RADIOMETER (MRIR)

NSSDC ID- 66-040A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - A.W. MCCULLOCH NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 2 Medium-Resolution Infrared Radiometer (MRIR) experiment measured the intensity and distribution of electromagnetic radiation emitted by and reflected from the earth and its atmosphere in five selected wavelength intervals from 0.2 to 30 micrometers. 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-micrometer channel, which covered the 6.7-micrometer water vapor absorption band, (2) the 10- to 11-micrometer band, which operated in the "atmospheric window," (3) the 14- to 16-micrometer band, which covered the 15-micrometer carbon dioxide absorption band, (4) the 5- to 30-micrometer band, which measured the emitted long-wavelength infrared energy for heat budget purposes, and (5) the 0.2- to 4.0-micrometer channel, which yielded information on the intensity of reflected solar energy (albedo). Radiant energy from the earth was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated at 8 rpm and 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-deg 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. The MRIR experiment was successful, and good data were obtained from launch until the recorder failed on July 29, 1966. For more detailed information of the experiment and the index of data, see Section 4 of "Nimbus II Users' Guide" (TRF B03406), "The Nimbus II Medium Resolution Infrared Pictorial Data Catalog" (TRF B06580), and "The Nimbus II Data Catalog" (TRF B06573), available from NSSDC.

------- NIMBUS 2, SCHULMAN--

INVESTIGATION NAME- ADVANCED VIDICON CAMERA SYSTEM (AVCS)

NSSDC ID- 66-040A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - J.R. SCHULMAN NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 2 Advanced Vidicon Camera System (AVCS) was a combination of cameras, tape recorder, and transmitter that could record and store a series of remote daytime cloudcover pictures for subsequent playback to a ground-data acquisition station. The AVCS sensors consisted of three vidicon cameras mounted on the satellite sensory ring, facing earthward and deployed in a fan-like array to produce a three-segment composite picture. Each camera covered a 35-deg field of view with the center camera pointing straight down. The optical axes of the other two cameras were directed 35 deg to either side. Each of the cameras employed an f/4 lens with a focal length of 18.2 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 vidicon pickup tubes yielded a linear resolution of better than 1 km at nadir from an approximate altitude of 1100 km. At this altitude, the camera array could produce a composite picture covering an area of 720 by 3400 km. Successive frames were taken at 91-s intervals providing about 20% overlap in coverage. A 40-ms exposure time was used, and the image was scanned by the electron beam in 6.5 s. The resulting signal was frequency modulated and recorded on three tracks of a magnetic tape, one track for each camera. Sufficient tape was provided for recording 53 pictures (about 1-2/3 orbits of data). The AVCS data were multiplexed with the High-Resolution Infrared Radiometer (HRIR) data and, using a transmission frequency of 1707.5 MHz, were telemetered to a ground station in 4 min. The experiment operated normally

until August 31, 1966, when the tape recorder malfunctioned. Sporadic operation was continued until September 2, 1966, when the recorder failed completely, terminating data acquisition except for direct readouts received over North Carolina and Alaska readout stations. The experiment was successful in providing high-quality cloudcover pictures over an entire season on a near-global basis and in confirming the reliability of the camera system for use in future operational weather satellites. Data from this experiment can be obtained through SDSD. For more detailed information of the experiment and the index of the data, see Section 2 of the "Nimbus II Users' Guide" (TRF B03406), "Nimbus 2 AVCS World Montage Catalog" (TRF B06579), and "The Nimbus 2 Data Catalog" (TRF B06573), available from NSSDC.

------- NIMBUS 2, SCHULMAN-------------------------------------

INVESTIGATION NAME- AUTOMATIC PICTURE TRANSMISSION (APT) SYSTEM

NSSDC ID- 66-040A-02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - J.R. SCHULMAN   NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 2 Automatic Picture Transmission (APT) system was a camera and transmitter combination designed to transmit local daytime slow-scan television pictures of cloudcover conditions to properly equipped ground receiving stations on a real-time basis. The camera used a 108-deg wide-angle f/1.8 objective lens with a focal length of 6.0 mm. The camera was mounted facing earthward on the H-frame inside the sensory ring, with its optical axis parallel to the spacecraft spin axis. The actual photography required 8 s and the transmission 200 s. Earth-cloud images retained on the photosensitive surface of the 2.54-cm-diameter vidicon were read out at four lines per second to produce an 800-line picture. A 5-W TV transmitter (137.5 MHz) relayed the pictures to local APT stations within communication range. The faceplate of the vidicon had reticle marks that appeared on the picture format to aid in relating the picture to its geographical position on the earth's surface. From the satellite attitude and altitude (approximately 1100 km), a picture covered a 1200- by 1200-km square with a horizontal resolution of better than 3 km at nadir. The APT system was capable of transmitting the nighttime high-resolution infrared radiometer (HRIR) sensor output through the APT transmitter. Hence, with some minor modifications, an APT station within telemetry range could receive HRIR data in the direct readout infrared radiometer (DRIR) mode. The experiment was a success, and good data were obtained during its operational lifetime. More detailed information can be found in Section 5 of the "Nimbus II Users' Guide" (TRF B03406), available from NSSDC APT/DRIR data are primarily intended for operational use within the local APT acquisition station and are generally not available for distribution.

**************************** NIMBUS 3****************************

SPACECRAFT COMMON NAME- NIMBUS 3
ALTERNATE NAMES- PL-684G, NIMBUS-B2
03890

NSSDC ID- 69-037A

LAUNCH DATE- 04/14/69   WEIGHT- 576. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY
UNITED STATES   NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 04/25/69
ORBIT PERIOD- 107.40 MIN	INCLINATION- 99.91 DEG
PERIAPSIS- 1075. KM ALT	APOAPSIS- 1135. KM ALT

PERSONNEL
PM - H. PRESS(NLA)   NASA-GSFC
PS - W.P. NORDBERG(DECEASED)   NASA-GSFC

BRIEF DESCRIPTION

Nimbus 3, the third in a series of second-generation meteorological research-and-development satellites, was designed to serve as a stabilized, earth-oriented platform for the testing of advanced meteorological sensor systems and the collecting of meteorological data. The polar-orbiting spacecraft consisted of three major elements: (1) a sensory ring, (2) solar paddles, and (3) the control system housing. The solar paddles and the control system housing were connected to the sensory ring by a truss structure, giving the satellite the appearance of an ocean buoy. Nimbus 3 was nearly 3.7 m tall, 1.5 m in diameter at the base, and about 3 m across with solar paddles extended. The torus-shaped sensory ring, which formed the satellite base, housed the electronics equipment and battery modules. The lower surface of the torus ring provided mounting space for sensors and telemetry antennas. An H-frame structure mounted within the center of the torus provided support for the larger experiments and tape recorders. Mounted on the control system housing, which was located on top of the spacecraft, were sun sensors, horizon scanners, gas nozzles for attitude control, and a command antenna. Use of the attitude control subsystem (ACS) permitted the spacecraft's orientation to be controlled to within plus or minus 1 deg for all three axes (pitch, roll, and yaw). Primary experiments consisted of (1) a satellite infrared spectrometer (SIRS) for determining the vertical temperature profiles of the atmosphere, (2) an infrared interferometer spectrometer (IRIS) for measuring the emission spectra of the earth-atmosphere system, (3) both high- and medium-resolution infrared radiometers (HRIR and MRIR) for yielding information on the distribution and intensity of infrared radiation emitted and reflected by the earth and its atmosphere, (4) a monitor of ultraviolet solar energy (MUSE) for detecting solar UV radiation, (5) an image dissector camera system (IDCS) for providing daytime cloudcover pictures in both real-time mode, using the real time transmission system (RTTS), and tape recorder mode, using the high data rate storage system, (6) a radioisotope thermoelectric generator (RTG), SNAP-19, to assess the operational capability of radioisotope power for space applications, and (7) an interrogation, recording and location system (IRLS) experiment designed to locate, interrogate, record, and retransmit meteorological and geophysical data from remote collection stations. Nimbus 3 was successful and performed normally until July 22, 1969, when the IRIS experiment failed. The HRIR and SIRS experiments were terminated on January 25, 1970, and June 21, 1970, respectively. The remaining experiments continued operation until September 25, 1970, when the rear horizon scanner failed. Without this horizon scanner, it was impossible to maintain proper spacecraft attitude, thus making most experimental observations useless. All spacecraft operations were terminated on January 22, 1972. More detailed information can be found in "The Nimbus III User's Guide" (TRF B03409), available from NSSDC.

------- NIMBUS 3, BRANCHFLOWER-------------------------------

INVESTIGATION NAME- IMAGE DISSECTOR CAMERA SYSTEM (IDCS)

NSSDC ID- 69-037A-06

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - G.A. BRANCHFLOWER(NLA)   SPAR AEROSPACE

BRIEF DESCRIPTION

The Nimbus 3 Image Dissector Camera System (IDCS) was designed to take daytime cloudcover photographs. The picture, could be transmitted to APT stations using the real-time transmission system (RTTS) 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 deg), 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 deg in the direction of flight and 98.2 deg 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 s. 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. For a more detailed description, see Section 2 of "The Nimbus III User's Guide" (TRF B03409). The experiment was a success and produced good data until September 25, 1970, when operations were terminated owing to spacecraft yaw problems. Data from this experiment are available through SDSD. The IDCS world montages were presented in "The Nimbus III Data Catalog" (TRF B06573), available from NSSDC.

------- NIMBUS 3, CHERRIX---------------------------------------

INVESTIGATION NAME- HIGH-RESOLUTION INFRARED RADIOMETER (HRIR)

NSSDC ID- 69-037A-02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - G.T. CHERRIX   NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 3 High-Resolution Infrared Radiometer (HRIR) was designed (1) to map the earth's nighttime cloud cover and thus to complement the daytime television (AVCS) coverage and (2) to measure the radiative temperatures of cloud tops and surface terrain. The Nimbus 3 HRIR was a modified version of previous experiments on Nimbus 1 and 2. It used a dual band-pass filter which transmitted reflected solar radiation in the 0.7- to 1.3-micrometer band as well as emitted thermal radiation in the 3.4- to 4.2-micrometer band. By detecting reflected solar radiation in the 0.7- to 1.3-micrometer 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 deg 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 deg K to a general accuracy of 1 deg K. For a more detailed description, see Section 3 of "The Nimbus III User's Guide" (TRF B03409). The experiment was successful until August 1969, when noise in the tape recorder system gradually reduced the quality of the data. Routine processing of HRIR data was terminated after January 31, 1970. All experiment operations ceased on January 22, 1972, when the spacecraft was deactivated. The HRIR world montages were presented in "The Nimbus III Data Catalog" (TRF B06523), available from NSSDC.

------ NIMBUS 3, HANEL------------------------------------

INVESTIGATION NAME- INFRARED INTERFEROMETER SPECTROMETER (IRIS)

NSSDC ID- 69-037A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - R.A. HANEL NASA-GSFC
OI - L. CHANEY U OF MICHIGAN

BRIEF DESCRIPTION

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 s 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. For a more detailed description, see Section 5 of "The Nimbus III User's Guide" (TRF B03409). The experiment was successful, and good data were obtained until the instrument failed on July 22, 1969.

------ NIMBUS 3, MCCULLOCH------------------------------------

INVESTIGATION NAME- MEDIUM-RESOLUTION INFRARED RADIOMETER (MRIR)

NSSDC ID- 69-037A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - A.M. MCCULLOCH NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 3 Medium-Resolution Infrared Radiometer (MRIR) experiment measured the intensity and distribution of the electromagnetic radiation emitted by and reflected from the earth and its atmosphere in five selected wavelength intervals from 0.2 to 23 micrometers. Data on the heat balance of the earth-atmosphere system were obtained as well as water vapor distribution data, surface or near-surface temperatures, and data on seasonal changes of stratospheric temperature distribution. The five wavelength regions were (1) the 6.5- to 7.0-micrometer channel, which covered the 6.7-micrometer water vapor absorption band, (2) the 10- to 11-micrometer band, which operated in the atmospheric window, (3) the 14.5- to 15.5-micrometer band, which covered the 15-micrometer carbon dioxide absorption band, (4) the 20- to 23-micrometer channel, which covered the spectral region containing the broad rotational absorption bands of water vapor, and (5) the 0.2- to 4.0-micrometer channel, which yielded information on the intensity of reflected solar energy. Radiant energy from the earth was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated at 8 rpm and 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-deg 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 45 km was obtained. The MRIR experiment was successful, in spite of a telemetry conflict that caused the experiment to be periodically turned off. During August and September 1970 (hurricane season), the MRIR was on essentially full time to cover the area from the equator to 70 deg N and from 10 deg E to 100 deg W. On September 25, 1970, the satellite's rear horizon scanner failed, making it impossible to determine where the MRIR sensor was pointing. The experiment was operated periodically until January 22, 1972, when all spacecraft operations were terminated.

------ NIMBUS 3, MARK------------------------------------

INVESTIGATION NAME- SATELLITE INFRARED SPECTROMETER (SIRS)

NSSDC ID- 69-037A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - D.Q. WARK NOAA-NESDIS
OI - D.T. HILLEARY NOAA-NESDIS

BRIEF DESCRIPTION

The Nimbus 3 Satellite Infrared Spectrometer (SIRS) experiment was designed to indirectly determine the vertical temperature profiles of the atmosphere by measuring the infrared radiation emitted from the earth and its atmosphere in seven spectral intervals in the carbon dioxide band (11 to 15 micrometers) and one interval in the atmospheric window centered at 11.1 micrometers. The main components of the Fastie-Ebert fixed-grating spectrometer consisted of (1) a plane, light-collecting mirror to provide a single earth-viewing beam fixed in the vertical, (2) a rotating chopper mirror, (3) a spherical mirror, (4) a 12.7-cm diffraction grating with 1250 lines per inch, (5) a set of eight exit slits with a single interference filter, (6) eight wedge-immersed thermistor bolometers, (7) a blackbody radiation source for calibration, and (8) eight preamplifiers and eight operational amplifiers. The incoming radiation was chopped, spectrally dispersed by the diffraction grating, focused on the exit slits as a spectrum by the spherical mirror, and converted to electrical signals. The signals were then amplified and stored on magnetic tape for subsequent playback to a ground acquisition station. The instrument field of view was 11.5 by 11.5 deg centered on nadir. This provided data over an area roughly 220 km on a side at a satellite height of 1100 km. Data from the 11.1-micrometer channel yielded surface and/or cloudtop temperatures. Data from the carbon dioxide band could be used to generate temperature-pressure profiles by a mathematical inversion technique. The resulting temperatures had rms errors slightly less than 1 deg C. For a more detailed description, see Section 6 of "The Nimbus III User's Guide" (TRF B03409). The SIRS experiment was successful and good data were obtained. On June 21, 1970, the experiment was turned off and all data acquisition effort was transferred to the SIRS experiment on Nimbus 4.

============================== NIMBUS 4 ==============================

SPACECRAFT COMMON NAME- NIMBUS 4
ALTERNATE NAMES- NIMBUS-D, PL-701E
04362

NSSDC ID- 70-025A

LAUNCH DATE- 04/08/70 WEIGHT- 620. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- THOR

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSTA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 04/09/70
ORBIT PERIOD- 107.2 MIN INCLINATION- 80.116 DEG
PERIAPSIS- 1092. KM ALT APOAPSIS- 1108. KM ALT

PERSONNEL
PM - C.M. MACKENZIE NASA-GSFC
PS - A.J. FLEIG NASA-GSFC

BRIEF DESCRIPTION

Nimbus 4, the fourth in a series of second-generation meteorological research-and-development satellites, was designed to serve as a stabilized, earth-oriented platform for the testing of advanced meteorological sensor systems, and for collecting meteorological data. The polar-orbiting spacecraft consisted of three major structures: (1) a ring-shaped sensor mount, (2) solar paddles, and (3) the control system housing. The solar paddles and the control system were connected to the sensor mount by a truss structure, giving the satellite the appearance of an ocean buoy. Nimbus 4 was nearly 3.7 m tall, 1.45 m in diameter at the base, and about 3 m across with solar paddles extended. The torus-shaped sensor mount, which formed the satellite base, housed the electronics equipment and battery modules. The lower surface of the torus ring provided mounting space for sensors and telemetry antennas. An H-frame structure mounted within the center of the torus provided support for the larger experiments and tape recorders. Mounted on the control system housing, which was on top of the spacecraft, were sun sensors, horizon scanners, gas nozzles for attitude control, and a command antenna. Use of an advanced attitude-control subsystem permitted the spacecraft's orientation to be controlled to within plus or minus 1 deg for all three axes (pitch, roll, and yaw). Primary experiments consisted of (1) an image dissector camera system (IDCS) for providing daytime cloudcover pictures, both in real-time and recorded modes, (2) a temperature-humidity infrared radiometer (THIR) for measuring daytime and nighttime surface and cloudtop temperatures as well as the water vapor content of the upper atmosphere, (3) an infrared interferometer spectrometer (IRIS) for measuring the emission spectra of the earth/atmosphere system, (4) a satellite infrared spectrometer (SIRS) for determining the vertical profiles of temperature and water vapor in the atmosphere, (5) a monitor of ultraviolet solar energy (MUSE) for detecting solar UV radiation, (6) a backscatter ultraviolet (BUV) detector for monitoring the vertical distribution and total amount of atmospheric ozone on a global scale, (7) a filter wedge spectrometer (FWS) for accurate measurement of IR radiance as a function of wavelength from the earth/atmosphere system, (8) a selective chopper radiometer (SCR) for determining the temperatures of six successive 10-km layers in the atmosphere from absorption measurements in the 15-micrometer CO2 band, and (9) an interrogation, recording, and location system (IRLS) for locating, interrogating, recording, and retransmitting meteorological and geophysical data from remote collection stations. A complete description can be found in "The Nimbus IV User's Guide" (TRF B06061), available from NSSDC. The spacecraft performed well until April 14, 1971, when attitude problems started. The experiments operated on a limited time basis after that time until September 30, 1980.

-------- NIMBUS 4, BRANCHFLOWER --------

INVESTIGATION NAME- IMAGE DISSECTOR CAMERA SYSTEM (IDCS)

NSSDC ID- 70-025A-06 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - G.A. BRANCHFLOWER(NLA) SPAR AEROSPACE
OI - E.J. WERNER NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 4 Image Dissector Camera System (IDCS) experiment was designed to take daytime cloudcover pictures. The pictures could be transmitted to APT (automatic picture transmission) stations using the real-time transmission system (RTTS) or stored on magnetic tape for subsequent playback to ground acquisition stations. This experiment was similar to those flown on Nimbus 3 and ATS 3. The camera was mounted on the bottom of the sensory ring of the satellite 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 deg), 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 deg along track, and 98.2 deg across track. The image was focused by the camera 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 s. At the nominal spacecraft altitude (approximately 1100 km), each resulting picture was approximately 1600 km on a side with a ground resolution of 3 km at nadir. The experiment was a success. However, owing to spacecraft yaw problems, archival data were produced only through April 8, 1971. Six days later the spacecraft turned around and flew backwards in orbit, with the resultant loss of all usable data. On May 12, 1971, the spacecraft was successfully rotated 180 deg, and limited data were obtained until February 5, 1972. Data from this experiment are available through the NSSDC. For a complete description, see Section 2 in "The Nimbus IV User's Guide" (TRF B06061), available from NSSDC.

-------- NIMBUS 4, HANEL --------

INVESTIGATION NAME- INFRARED INTERFEROMETER SPECTROMETER (IRIS)

NSSDC ID- 70-025A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - R.A. HANEL NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 4 Infrared Interferometer Spectrometer (IRIS) experiment was designed to provide information on the vertical structure of the atmosphere and on the emissive properties of the earth's surface by measuring the surface and atmospheric radiation in the 6.25- to 25-micrometer range using a modified Michelson interferometer. Radiation from a cone of the atmosphere, whose base on the surface of the earth was a circle about 94 km in diameter for a nominal satellite altitude of approximately 1100 km, was received and reflected by a mirror. The reflected radiation was split into two approximately equal beams by a beamsplitter. After reflection on a fixed and moving mirror, respectively, the two beams interfered with each other with a phase difference proportional to the optical path difference between both beams. The moving mirror traveled about 3.6 mm in 15 s to give an output signal from the bolometer. This signal, an interferogram, was recorded on tape. The interferograms were transmitted to a ground receiving 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 were derived, as well as other parameters of meteorological interest. The instrument had a field of view of 5 deg and a spectral resolution of less than 0.4 micrometer (nominally 1.4 reciprocal centimeters). For a complete description of the IRIS experiment, see Section 4 in "The Nimbus IV User's Guide" (TRF B06061), available from NSSDC. The IRIS experiment was successful in spite of a transmission conflict with the Real-Time Transmission System (RTTS) that resulted in some periods of lost data after November 20, 1970. The IRIS experiment was turned off on January 25, 1972 to conserve spacecraft power.

-------- NIMBUS 4, HEATH --------

INVESTIGATION NAME- BACKSCATTER ULTRAVIOLET (BUV) SPECTROMETER

NSSDC ID- 70-025A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL
PI - D.F. HEATH NASA-GSFC
OI - J.V. DAVE IBM CORPORATION
OI - A.J. KRUEGER NASA-GSFC
OI - C.L. MATEER ENVIRONMENT CANADA

BRIEF DESCRIPTION
The Nimbus 4 Backscatter Ultraviolet (BUV) spectrometer experiment was designed to monitor the vertical distribution and total amount of atmospheric ozone on a global scale by measuring the intensity of UV radiation backscattered by the earth/atmosphere system during day and night in the 2500- to 3400-A spectral band. The primary instrumentation consisted of a double monochromator containing all reflective optics and a photomultiplier detector. The double monochromator was composed of two Ebert-Fastie-type monochromators in tandem. Each monochromator had a 52- by 52-mm grating with 2400 lines per mm. Light from a 0.05-sr solid angle (subtending approximately a 222-sq-km 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 UV radiation in an ozone-free absorption area near 3800 A. Signals from both units were read by separate range-switching electrometers with seven ranges. A BUV experiment cycle required 6144 s. Each cycle, in turn, was divided into 192 BUV frames of 32-s duration. Calibration by onboard light sources was performed in 26 of the 192 frames. The other frames were used for experimental data. During each of these data frames, the monochromator measured the intensity of the UV radiation in each of the 12 wavelength bands, while the photometer measured the UV intensity in a single wavelength band. The dwell time at each wavelength was 1.8 s, and, during this interval, four analog UV intensity measurements were taken at 400-ms intervals in addition to an integrated pulse count measurement of the UV 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 1000 microamps. The vertical distribution of ozone was obtained by mathematical inversion techniques. For a complete description of the BUV experiment, see Section 7 in "The Nimbus IV User's Guide" (TRF B06061). For an index of the data, see "User's Guide to the Nimbus-4 Backscatter Ultraviolet Experiment Data Sets" (TRF B30067). Both documents are available from NSSDC.

-------- NIMBUS 4, HOUGHTON --------

INVESTIGATION NAME- SELECTIVE CHOPPER RADIOMETER (SCR)

NSSDC ID- 70-025A-10 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL
PI - J.T. HOUGHTON OXFORD U
OI - S.D. SMITH READING U

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BRIEF DESCRIPTION
The Nimbus 4 Selective Chopper Radiometer (SCR) observed the emitted infrared radiation in the 15-micrometer absorption band of carbon dioxide. From these measurements the temperatures of six successive 10-km layers of the atmosphere were determined from earth or cloudtop level to 60-km height. Height resolution was obtained by a combination of optical multi-layer filters and selective absorption of radiation using carbon-dioxide-filled cells within the experiment. The SCR had six channels, which were arranged in three units of two. The four lower channels were called single-cell channels. The optics of each channel consisted of a cantilever-mounted blade shutter that oscillated at 10 Hz and successively chopped the field of view (FOV) between earth and space. The chopped radiation was then passed through a 10-cm path length of carbon dioxide, the pressure being set for each channel to define the viewing depth of the atmosphere. Behind the carbon dioxide path was a narrow-band filter, the centers of which were different for each channel, and a light pipe which focused the radiation on a thermistor-bolometer detector. To obtain adequate height resolution in the upper layers of the atmosphere, the upper two channels operated on a slightly different principle and were known as double-cell channels. The technique consisted of switching the radiation between two half-cells, which were semicircular in shape and of 1-cm path length, and which contained different pressures of carbon dioxide. A movable 45-deg mirror replaced the oscillating shutter used in the lower four channels. During one half-period, earth radiation passed through one half-cell and space radiation through the other. The situation was reversed during the other half-period. The radiation then passed through a light pipe onto a thermistor-bolometer detector. Inflight calibration was carried out by viewing of an internal reference blackbody of known temperature prior to the view of space. The output of each channel was sampled once every second. The upper two channels had a circular FOV approximately 160 km in diameter, and the lower four had a rectangular FOV about 112 km square. For a complete description, see Section 9 in "The Nimbus IV User's Guide" (TRF B06861), available from NSSDC. The channel 1 temperature monitoring system failed on June 15, 1970, thereby reducing the accuracy of the SCR data. Channels 3 and 4 became noisy and unusable on April 18, 1972. The remaining channels were usable until June 15, 1973.

-------- NIMBUS 4, HOVIS--

INVESTIGATION NAME- FILTER WEDGE SPECTROMETER (FWS)

NSSDC ID- 70-025A-09 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - W.A. HOVIS NOAA-NESDIS

BRIEF DESCRIPTION
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- to 2.4- and 3.2- to 6.4-micrometer bands. The instrumentation consisted of (1) a telescope, (2) a rotating disk chopper, (3) a rotating (3.75 rpm) circular interference filter wheel, and (4) a lead selenide detector. The filter wheel was a two-180-deg-segment (one per passband) 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-deg 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 533 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 deg K. The incident radiation was sampled 20 times per second, resulting in a spectral intensity plot of 158 points for each passband per revolution. Onboard calibration was accomplished by alternate viewing of the earth and calibration standards by the detector. Spectral plots were analyzed by applying an inversion technique to the radiative transfer equations to obtain the water vapor content. At activation of this experiment on orbit 5, the data output was degraded, exhibiting ice absorption patterns in both channels. On June 8, 1970, the FWS suffered mechanical failure when the drive motor on the chopper wheel failed. No useful data were collected from this experiment.

-------- NIMBUS 4, MCCULLOCH--

INVESTIGATION NAME- TEMPERATURE-HUMIDITY INFRARED RADIOMETER (THIR)

NSSDC ID- 70-025A-02 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - A.W. MCCULLOCH NASA-GSFC
OI - I.L. GOLDBERG NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 4 Temperature-Humidity Infrared Radiometer (THIR) was designed to detect emitted thermal radiation in both the 10.5- to 12.5-micrometer region (IR window) and the 6.5- to 7.0-micrometer region (water vapor). The window channel measured cloudtop temperatures day and night. The other channel operated primarily at night to map the water vapor distribution in the upper troposphere and stratosphere. The instrument consisted of a 12.7-cm Cassegrain system, a scanning mirror common to both channels, a beam splitter, filters, and two germanium-immersed thermistor bolometers. In contrast to TV, no image was formed within the radiometer. Incoming radiant energy was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated through 360 deg at 48 rpm and scanned in a plane normal to the spacecraft velocity vector. The energy was then focused into a dichromatic beam splitter, which divided the energy spectrally and spatially into two channels. Both channels of the THIR sensor transformed the received radiation into an electrical (voltage) output with an information bandwidth of 0.5 to 360 Hz for the 10.5 to 12.5 micrometer channel and 0.5 to 120 Hz for the water vapor channel. The THIR sensor data were normally recorded on tape for subsequent playback to a ground acquisition station. However, direct readout infrared radiometer (DRIR) data could be transmitted to APT ground stations for both day and night portions of the orbit using the Nimbus 4 real-time transmission system (RTTS). At a nominal spacecraft altitude, the window channel had a ground resolution of about 7 km and the water vapor channel about 22 km at nadir. The THIR was initially successful but failed on January 11, 1971 (orbit 3731). It was restarted several times thereafter for very short periods of time before it finally ceased all operations in August 1971. A similar experiment was flown on Nimbus 5, 6 and 7.

-------- NIMBUS 4, HARK--

INVESTIGATION NAME- SATELLITE INFRARED SPECTROMETER (SIRS)

NSSDC ID- 70-025A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - D.Q. WARK NOAA-NESDIS
OI - D.T. HILLEARY NOAA-NESDIS

BRIEF DESCRIPTION
The Nimbus 4 Satellite Infrared Spectrometer (SIRS) experiment was designed to determine the vertical temperature and water vapor profiles of the atmosphere by using a Fastie-Ebert fixed-grating spectrometer. The instrument measured the infrared radiation (11 to 36 micrometers) emitted from the earth and its atmosphere in 13 selected spectral intervals in the carbon dioxide and water vapor bands plus one channel in the 11-micrometer atmospheric window. The main components of the spectrometer consisted of (1) a plane, light-collecting mirror to provide one fixed and two variable earth-viewing angles, (2) a rotating chopping mirror that served alternately to collect space radiation and earth radiation, (3) a 2.5-in. diffraction grating with 1250 lines per inch, (4) 14 slits with associated interference filters, (5) 14 thermistor bolometers, and (6) a blackbody source for calibration purposes. The SIRS used a scan mirror to observe 12.5 deg to either side of the subsatellite track. The field of view directly below the SIRS was approximately 215 sq km. The carbon dioxide band radiation data were transformed to a temperature profile by a mathematical inversion technique. By a similar technique, this information could then be combined with the water vapor band data to obtain a water vapor profile. The 11-micrometer atmospheric window data yielded surface and/or cloudtop temperatures. For a complete description of the SIRS experiment, see Section 5 of "The Nimbus IV User's Guide" (TRF B06861), available from NSSDC. The SIRS experiment performed normally for several months after launch but began to deteriorate in early 1971. Problems in the SIRS instrument calibration after April 1971, in addition to spacecraft yaw problems, significantly reduced the number of useful soundings obtained. The archival data were produced through April 8, 1971. The experiment operated on a limited time basis until March 6, 1973, when it was placed operationally off. Both NSSDC and SDSD have data.

************************** NIMBUS 5**************************

SPACECRAFT COMMON NAME- NIMBUS 5
ALTERNATE NAMES- NIMBUS-E, PL-721B
06305

NSSDC ID- 72-097A

LAUNCH DATE- 12/11/72 WEIGHT- 770. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 12/11/72
ORBIT PERIOD- 107.2 MIN INCLINATION- 99.9 DEG
PERIAPSIS- 1089. KM ALT APOAPSIS- 1101. KM ALT

PERSONNEL
PM - C.M. MACKENZIE NASA-GSFC
PS - A.J. FLEIG NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 5 research-and-development satellite was designed to serve as a stabilized, earth-oriented platform for the testing of advanced meteorological sensor systems and collecting meteorological and [illegible]gical data on a global scale. The polar-orbiting spacecraft consisted of three major structures: (1) a hollow, ring-shaped sensor mount, (2) solar paddles, and (3) a control system housing. The solar paddles and control system housing were connected to the sensor mount by a truss structure, giving the satellite the appearance of an ocean buoy. Nimbus 5 was nearly 3.7 m tall, 1.5 m in diameter at the base, and about 3 m wide with solar paddles extended. The torus-shaped sensor mount, which formed the satellite base, housed the electronics equipment and battery modules. The lower surface of the torus provided mounting space for sensors and antennas. A box-beam structure mounted within the center of the torus provided support for the larger sensor experiments. Mounted on the control system housing, which was located on top of the spacecraft, were sun sensors, horizon scanners, and a command antenna. An advanced attitude-control system permitted the spacecraft orientation to be controlled to within plus or minus 1 deg in all three axes (pitch, roll, and yaw). Primary experiments included (1) a temperature-humidity infrared radiometer (THIR) for measuring day and night surface and cloudtop temperatures, as well as the water vapor content of the upper atmosphere, (2) an electrically scanning microwave radiometer (ESMR) for mapping the microwave radiation from the earth's surface and atmosphere, (3) an infrared temperature profile radiometer (ITPR) for obtaining vertical profiles of temperature and moisture, (4) a Nimbus E microwave spectrometer (NEMS) for determining tropospheric temperature profiles, atmospheric water vapor abundances, and cloud liquid water contents, (5) a selective chopper radiometer (SCR) for observing the global temperature structure of the atmosphere, and (6) a surface composition mapping radiometer (SCMR) for measuring the differences in the thermal emission characteristics of the earth's surface. A more detailed description can be found in "The Nimbus 5 User's Guide" (TRF 14758), available from NSSDC.

------- NIMBUS 5, HOUGHTON-------

INVESTIGATION NAME- SELECTIVE CHOPPER RADIOMETER (SCR)

NSSDC ID- 72-097A-02 INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL
PI - J.T. HOUGHTON OXFORD U
OI - S.D. SMITH READING U

BRIEF DESCRIPTION
The Nimbus 5 Selective Chopper Radiometer (SCR) was designed to (1) observe the global temperature structure of the atmosphere up to 50 km in altitude, (2) make supporting observations of water vapor distribution, and (3) determine the density of ice particles in cirrus clouds. To accomplish these objectives, the SCR measured emitted radiation in 16 spectral intervals separated into the following four groups: (1) four CO2 channels between 13.8 and 14.8 micrometers, (2) four channels at 15.0 micrometers, (3) an IR window channel at 11.1 micrometers, a water vapor channel at 18.6 micrometers, two channels at 49.5 and 133.3 micrometers, and (4) four channels at 2.08, 2.59, 2.65, and 3.5 micrometers. From an average satellite altitude of 1100 km, the radiometer viewed a 48-km circle on the earth's surface with a ground resolution of about 25 km. A similar experiment was flown on Nimbus 4. For a more detailed description, see Section 6 in "The Nimbus 5 User's Guide" (TRF B14758), available from NSSDC. Both NSSDC and SDSD have data.

------- NIMBUS 5, HOVIS-------

INVESTIGATION NAME- SURFACE COMPOSITION MAPPING RADIOMETER (SCMR)

NSSDC ID- 72-097A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY
METEOROLOGY

PERSONNEL
PI - W.A. HOVIS NOAA-NESDIS
OI - W. CALLAHAN FAIRFIELD U

BRIEF DESCRIPTION
The Surface Composition Mapping Radiometer (SCMR) measured (1) terrestrial radiation in the 8.3- to 9.3-micrometer and 10.2- to 11.2-micrometer intervals and (2) reflected solar radiation in the 0.8- to 1.1-micrometer range. Surface composition and sea surface temperatures could be obtained from these measurements. The SCMR had an instantaneous field of view (FOV) of 0.6 mrad, equivalent to a ground resolution of 660 m at nadir. The scan mirror rotated at 10 rps to provide scan lines 800-km wide across the spacecraft track. For a complete description, see Section 3 in "The Nimbus 5 User's Guide" (TRF B14758), available from NSSDC. The instrument began malfunctioning soon after launch. The last usable data were transmitted on January 4, 1973. A modified instrument, heat capacity mapping radiometer, was flown on the Heat Capacity Mapping Mission (HCMM) later.

------- NIMBUS 5, MCCULLOCH-------

INVESTIGATION NAME- TEMPERATURE/HUMIDITY INFRARED RADIOMETER (THIR)

NSSDC ID- 72-097A-08 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - A.W. MCCULLOCH NASA-GSFC

BRIEF DESCRIPTION
The Nimbus 5 Temperature-Humidity Infrared Radiometer (THIR) was designed to detect emitted thermal radiation in both the 10.5- to 12.5-micrometer region (IR window) and the 6.5- to 7.0-micrometer region (water vapor). The window channel measured cloudtop temperatures during both day and night. The other channel operated primarily at night to map the water vapor distribution in the upper troposphere and stratosphere. Sensor data from these two channels were primarily used to support the other more sophisticated meteorological experiments on board Nimbus 5. The instrument consisted of a 12.7-cm Cassegrain system, a scanning mirror common to both channels, a beam splitter, filters, and two germanium-immersed thermistor bolometers. In contrast to TV, no image was formed within the radiometer. Incoming radiant energy was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated at 48 rpm and scanned in a plane perpendicular to the spacecraft velocity. The energy was focused on a dichromatic beam splitter, which divided the energy spectrally and spatially into the two channels. Both channels of the THIR sensor transformed the received radiation into electric outputs (voltages), which were recorded on magnetic tape for subsequent playback to a ground acquisition station. For more detailed information, see Section 2 in "The Nimbus 5 User's Guide" (TRF B14758). The THIR world montages were presented in "The Nimbus 5 Data Catalog" (TRF B17697). Both documents are available from NSSDC. A similar experiment was flown on Nimbus 4, 6, and 7.

------- NIMBUS 5, SMITH-------

INVESTIGATION NAME- INFRARED TEMPERATURE PROFILE RADIOMETER (ITPR)

NSSDC ID- 72-097A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL
PI - W.L. SMITH NOAA-NESDIS
OI - D.Q. WARK NOAA-NESDIS

BRIEF DESCRIPTION
The Nimbus 5 Infrared Temperature Profile Radiometer (ITPR) experiment was designed to measure the three-dimensional temperature field in the earth's atmosphere with a spatial resolution of 32 km. The radiometer sensed four intervals in the 15-micrometer CO2 band, one interval in the water vapor rotational band near 20 micrometers and two spectral intervals in the atmospheric window regions near 3.7 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 scan spots 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 s with the whole scanning sequence repeated every 240 s. 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

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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. For more detailed information, see Section 5 in "The Nimbus 5 User's Guide" (TRF B14750), available from NSSDC. Because of the erratic behavior of the scan mechanism which developed shortly after launch, the instrument operated only in the nadir mode except for brief periods.

------- NIMBUS 5, STAELIN-------

INVESTIGATION NAME- MICROWAVE SPECTROMETER (NEMS)

NSSDC ID- 72-097A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - D.H.	STAELIN	MASS INST OF TECH
OI - F.T.	BARATH	NASA-JPL
OI - N.E.	GAUT	ENVIRON RES + TECH INC
OI - P.	THADDEUS	NASA-GISS
OI - W.B.	LENOIR	NASA-JSC

BRIEF DESCRIPTION

The Nimbus E Microwave Spectrometer (NEMS) was designed primarily to demonstrate the capabilities and limitations of microwave sensors for measuring tropospheric temperature profiles, water vapor abundances, cloud liquid water content, and earth surface temperatures. The NEMS could continuously monitor emitted microwave radiation at frequencies of 22.235, 31.4, 53.65, 54.9 and 58.8 GHz. The three channels near the 5-mm oxygen absorption band were used primarily to determine the atmospheric temperature profiles. NEMS provided measurements even in cloudcover 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 to yield 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. More detailed descriptions can be found in Section 7 in "The Nimbus 5 User's Guide" (TRF B14750), available from NSSDC, and J. J. Barnett, et al., "Stratospheric Observations from Nimbus 5," Nature, v. 245, pp. 141-143, 1973. An advancement of this instrument, the Scanning Microwave Spectrometer (SCAMS), was flown on Nimbus 6 later.

------- NIMBUS 5, WILHEIT, JR.-------

INVESTIGATION NAME- ELECTRICALLY SCANNING MICROWAVE RADIOMETER (ESMR)

NSSDC ID- 72-097A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL

PI - T.T.	WILHEIT, JR.	NASA-GSFC
OI - P.	GLOERSEN	NASA-GSFC

BRIEF DESCRIPTION

The primary objectives of the Nimbus 5 Electrically Scanning Microwave Radiometer (ESMR) were (1) to derive the liquid water content of clouds from brightness temperatures over oceans, (2) to observe differences between sea ice and the open sea over the polar caps, and (3) to test the feasibility of inferring surface composition and soil moisture. To accomplish these objectives, the ESMR was capable of continuous global mapping of the 1.55-cm (19.36 GHz) microwave radiation emitted by the earth/atmosphere system, and could function even in the presence of cloud conditions that block conventional satellite infrared sensors. An 83.5- by 85.5-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 it consisted of 78 symmetrically distributed independent scan spots extending 50 deg 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 plus or minus 1 deg C with a spatial resolution of about 25 km at nadir. The ESMR data were stored on magnetic tape for transmission to ground acquisition stations. For more detailed information, see Section 4 in "The Nimbus 5 User's Guide" (TRF B14750). Selected ESMR images were presented in "The Nimbus 5 Data Catalog." Both documents are available from NSSDC.

########################## NIMBUS 6 ##########################

SPACECRAFT COMMON NAME- NIMBUS 6
ALTERNATE NAMES- PL-731B, NIMBUS-F
07924

NSSDC ID- 75-052A

LAUNCH DATE- 06/12/75 WEIGHT- 585. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCE /RIC	EPOCH DATE- 06/12/75
ORBIT PERIOD- 107.3 MIN	INCLINATION- 100. DEG
PERIAPSIS- 1093. KM ALT	APOAPSIS- 1101. KM ALT

PERSONNEL

PM - C.M.	MACKENZIE	NASA-GSFC
PS - A.J.	FLEIG	NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 6 research-and-development satellite served as a stabilized, earth-oriented platform for testing advanced systems for sensing and collecting meteorological data on a global scale. The polar-orbiting spacecraft consisted of three major structures: (1) a hollow torus-shaped sensor mount, (2) solar paddles, and (3) a control housing unit connected to the sensor mount by a tripod truss structure. Configured somewhat like an ocean buoy, Nimbus 6 was nearly 3.7 m tall, 1.5 m in diameter at the base, and about 3 m wide with solar paddles extended. The sensor mount that formed the satellite base housed the electronics equipment and battery modules. The lower surface of the torus provided mounting space for sensors and antennas. A box-beam structure mounted within the center of the torus supported the larger sensor experiments. Mounted on the control housing unit, which was located on top of the spacecraft, were sun sensors, horizon scanners, and a command antenna. The spacecraft spin axis was pointed at the earth. An advanced attitude-control system permitted the spacecraft's orientation to be controlled to within plus or minus 1 deg in all three axes (pitch, roll, and yaw). The nine experiments selected for Nimbus 6 were (1) earth radiation budget (ERB), (2) electrically scanning microwave radiometer (ESMR), (3) high-resolution infrared radiation sounder (HIRS), (4) limb radiance inversion radiometer (LRIR), (5) pressure modulated radiometer (PMR), (6) scanning microwave spectrometer (SCAMS), (7) temperature-humidity infrared radiometer (THIR), (8) tracking and data relay experiment (T+DRE), and (9) tropical wind energy conversion and reference level experiment (TWERLE). This complement of advanced sensors was capable of (1) mapping tropospheric temperature, water vapor abundance, and cloud water content; (2) providing vertical profiles of temperature, ozone, and water vapor; (3) transmitting real-time data to a geostationary spacecraft (ATS 6); and (4) yielding data on the earth's radiation budget. A more detailed description can be found in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC.

------- NIMBUS 6, GILLE-------

INVESTIGATION NAME- LIMB RADIANCE INVERSION RADIOMETER (LRIR)

NSSDC ID- 75-052A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL

PI - J.C.	GILLE	NATL CTR FOR ATMOS RES
OI - F.B.	HOUSE	DREXEL INST OF TECH
OI - R.A.	CRAIG	FLORIDA STATE U
OI - J.R.	THOMAS	HONEYWELL, INC

BRIEF DESCRIPTION

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 band, (2) the 14.2- 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 deg 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%. For a more detailed description, see Section 7 in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. The instrument functioned sucessfully until January 7, 1976, when the detector temperature began to

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rise rapidly, and the instrument was turned off.

——— NIMBUS 6, HOUGHTON———

INVESTIGATION NAME- PRESSURE MODULATED RADIOMETER (PMR)

NSSDC ID- 75-052A-09 INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL

PI - J.T.	HOUGHTON	OXFORD U
OI - C.D.	RODGERS	OXFORD U
OI - E.J.	WILLIAMSON	OXFORD U
OI - G.D.	PESKETT	OXFORD U
OI - P.	CURTIS	OXFORD U

BRIEF DESCRIPTION

The Nimbus 6 Pressure Modulator 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 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 deg on a 90-deg 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 could be rotated through plus or minus 7-1/2 deg 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 deg whole-angle across the spacecraft's line of flight and 40 deg whole-angle parallel to the line of flight. The derived temperature values were within 2 deg K at 65 km and about 0.2 deg K near 50 km with a vertical resolution of 10 km. For a more detailed description, see Section 8 in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. The instrument performed satisfactorily.

——— NIMBUS 6, JULIAN———

INVESTIGATION NAME- TROPICAL WIND ENERGY CONVERSION AND REFERENCE LEVEL (TWERLE)

NSSDC ID- 75-052A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - P.	JULIAN	NATL CTR FOR ATMOS RES
OI - W.H.	KELLOGG	NATL CTR FOR ATMOS RES
OI - V.E.	SUOMI	U OF WISCONSIN
OI - C.R.	LAUGHLIN	NASA-GSFC
OI - R.L.	TALLEY	SIGMA DATA SERV CORP
OI - W.R.	BANDEEN	NASA-GSFC
OI - C.E.	COTE	NASA-GSFC

BRIEF DESCRIPTION

The goals of the Nimbus 6 Tropical Wind Energy Conversion And Reference Level Experiment (TWERLE) were closely associated with the objectives of the Global Atmospheric Research Program (GARP) and included (1) measuring upper atmospheric winds in the tropics, (2) studying the relative air motion along isobaric surfaces to determine the rate of conversion of atmospheric potential energy into kinetic energy, and (3) providing direct measurements of various meteorological parameters that served as reference points in adjusting indirect temperature soundings made from satellites. The experiment consisted of two basic components: (1) approximately 300 constant-level meteorological balloons to yield measurements of winds, temperature, and pressure in the tropics and at southern hemisphere midlatitudes at 150 mb (about 13.6-km altitude), and (2) the Nimbus 6 random access measurements system (RAMS) to provide data collection and location determinations from the balloons. The 3.5-m-diameter polyester-mylar balloons were equipped with a transmitter-oscillator, solar power supply, digitizer/modulator, and sensors. The sensors consisted of a radio altimeter having an accuracy of better than plus or minus 20 m, a bead thermistor monitoring the ambient air temperature to an accuracy of 0.5 deg C, and a pressure sensor measuring the 150-mb flight altitude to an accuracy of 0.5 mb. A magnetic cutdown device was used to eliminate any accidental overflights into regions of the Northern Hemisphere north of 20 deg N latitude. The RAMS merely detected each balloon signal (401.2 MHz) and extracted the carrier frequency, balloon identification, and sensor data. This information, along with time references, was stored in digital form for subsequent relay to a ground acquisition station. The balloon's position and velocity were derived from the relative motion between the platform and the satellite by measuring Doppler shifts in the carrier signal received from the balloon. TWERLE was capable of a location accuracy of 5 km and a platform velocity accuracy of 1 m/s. For more detailed information, see Section 9 in "The Nimbus 6 User's Guide" (TRF B23261). For information concerning TWERLE data, contact Dr. Paul R. Julian, NCAR, P.O. Box 3000, Boulder, Colorado 80303. In addition to the TWERLE balloon experiment, many other experiments used RAMS. These experiments used ocean buoys to measure oceanographic and atmospheric parameters. Information about experiments can be obtained from principal investigators listed as Nimbus RAMS Experiments in the User's Guide and "The Nimbus 6 Data Catalog" (TRF B26731), both available from NSSDC.

——— NIMBUS 6, KYLE———

INVESTIGATION NAME- EARTH RADIATION BUDGET (ERB)

NSSDC ID- 75-052A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
ATMOSPHERIC PHYSICS

PERSONNEL

PI - H.L.	KYLE	NASA-GSFC
PI - H.	JACOBOWITZ	NOAA-NESDIS
OI - A.J.	DRUMMOND(DECEASED)	EPPLEY LAB, INC
OI - I.	RUFF	NOAA-NESDIS
OI - J.R.	HICKEY	EPPLEY LAB, INC
OI - W.J.	SCHOLES	EPPLEY LAB, INC
OI - L.L.	STOWE	NOAA-NESDIS

BRIEF DESCRIPTION

The Nimbus 6 Earth Radiation Budget (ERB) experiment measured reflected and emitted terrestrial radiation fluxes in conjunction with solar radiation. The results were used (1) to determine the earth radiation budget, (2) to determine the angular distribution of terrestrial radiation for various meteorological and geographic regimes, and (3) to correlate measurements made using identical but independent channels calibrated to the same standard. Incoming solar radiation from 0.2 to 50 micrometers was normally monitored in 10 spectral intervals as the satellite orbited over the Antarctic, just before it started its northward trip on the daylight side of the earth. Terrestrial radiation measurements were taken continuously in the 0.2- to 4-micrometer, 0.7- to 3-micrometer, and 4- to 50-micrometer intervals. The measurements were taken in two ways. Four channels, using fixed wide-angle optics (133.3-deg field of view), measured the total outgoing radiation integrated over the entire disk of the earth. The second set of measurements was obtained from eight high-resolution narrow-angle scanning channels that measured the terrestrial radiation emanating from a relatively small area over a range of zenith and azimuth angles. The multichannel radiometer employed a bi-axial scanning mechanism which enabled measurements to be obtained from the forward horizon to the aft horizon in a 64- interval. Each axis of the scanning mechanism contained four shortwave channels (0.2 to 4.0 micrometers) and four longwave channels (4.0 to 50 micrometers) with a 0.25- by 5.14-deg field of view. The channels were oriented in a directional fan to cover 20 deg to each side of the orbital plane. The 64-s scan period allowed an area to be measured from up to 17 different angles as the spacecraft passed overhead. For a more detailed description, see Section 6 in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. A similar instrument was flown on Nimbus 7 later. The solar and wide-angle channels operated successfully and provided good quality data. The scanning channels developed mechanical scan problems in August 1975 and operated only in the nadir position after March 1976. Data processing had been delayed due to lack of funding.

——— NIMBUS 6, MCCULLOCH———

INVESTIGATION NAME- TEMPERATURE/HUMIDITY INFRARED RADIOMETER (THIR)

NSSDC ID- 75-052A-12 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - A.W.	MCCULLOCH	NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 6 Temperature-Humidity Infrared Radiometer (THIR) detected emitted thermal radiation in both the 10.5- to 12.5-micrometer region (IR window) and the 6.5- to 7.0-micrometer region (water vapor). The window channel provided an image of cloud cover and temperatures of the cloud tops, land, and ocean surfaces. The other channel mapped the water vapor distribution in the upper troposphere and the stratosphere. The ground resolution at nadir was 8.2 km for the window channel and 22.5 km for the water vapor channel. Both channels provided day and night global coverage. Sensory data from these two channels were used primarily to support other more sophisticated meteorological experiments onboard Nimbus 6. The instrument consisted of a 12.7-cm Cassegrain

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system and scanning mirror common to both channels, a beam splitter, filters, and two germanium-immersed thermistor bolometers. In contrast to TV, no image was formed within the radiometer. Incoming radiant energy was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated through 360 deg at 48 rpm and scanned in a plane normal to the spacecraft velocity. The energy was then focused on a dichromatic beam splitter which divided the energy spectrally and spatially into the two channels. Both channels of the THIR sensor transformed the received radiation into electric outputs (voltages), which were recorded on magnetic tape for subsequent playback to a ground acquisition station. For more detailed information, see Section 2 in "The Nimbus 6 User's Guide" (TRF B23261). Daily world montages of the THIR were presented in "The Nimbus 6 Data Catalog" (TRF 26731). Both documents are available from NSSDC. A similar instrument was flown on Nimbus 4, 5 and 7.

------- NIMBUS 6, SMITH---

INVESTIGATION NAME- HIGH RESOLUTION INFRARED RADIATION SOUNDER (HIRS)

NSSDC ID- 75-052A-02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - W.L.	SMITH	NOAA-NESDIS
OI - A.H.	MCCULLOCH	NASA-GSFC
OI - H.	JACOBOWITZ	NOAA-NESDIS
OI - I.	RUFF	NOAA-NESDIS

BRIEF DESCRIPTION

The Nimbus 6 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 (11.1 and 3.7 micrometers) in the IR window, (3) two channels (8.2 and 6.7 micrometers) in the water vapor absorption band, (4) five channels in the 4.3-micrometer band, and (5) one channel in the visible 0.69-micrometer region. 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 deg to either side of nadir to provide data with a spatial resolution of 25 km. For a more detailed description, see Section 3 in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. The instrument was turned off as a precautionary move on May 27, 1976, when the filter chopper motor failed. Selected HIRS images were presented in "The Nimbus 6 Data Catalog" (TRF B26731), available from NSSDC.

------- NIMBUS 6, STAELIN---

INVESTIGATION NAME- SCANNING MICROWAVE SPECTROMETER (SCAMS)

NSSDC ID- 75-052A-10

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - D.H.	STAELIN	MASS INST OF TECH
OI - F.T.	BARATH	NASA-JPL
OI - A.H.	BARRETT	MASS INST OF TECH
OI - W.B.	LENOIR	NASA-JSC
OI - W.	PHILLIPS	MASS INST OF TECH

BRIEF DESCRIPTION

The Nimbus 6 Scanning Microwave Spectrometer (SCAMS) was designed to map tropospheric temperature profiles, water vapor abundance, and cloud water content to be used for weather prediction even in the presence of clouds, which block conventional satellite infrared sensors. The instrument was an advancement of the Nimbus E microwave spectrometer (NEMS) on Nimbus 5. The SCAMS continuously monitored emitted microwave radiation at frequencies of 22.235, 31.65, 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. The two channels near 10 mm permitted water vapor and cloud water content over calm oceans to be estimated separately. The instrument, a Dicke-superheterodyne type, scanned plus or minus 45 deg normal to the orbital plane with a 10-deg 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 deg K and that of the water vapor channels better than 1 deg K. The dynamic range for all channels was 0-400 deg K. The ground resolution was approximately 145 km near nadir and 330 km at the scan limit. For a more detailed description, see Section 4 in "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. The instrument ceased functioning on May 31, 1976, due to jamming of the scan mechanism. Selected SCAMS images were presented in "The Nimbus 6 Data Catalog" (TRF B26731), also available from NSSDC.

------- NIMBUS 6, WILHEIT, JR.---

INVESTIGATION NAME- ELECTRICALLY SCANNING MICROWAVE RADIOMETER (ESMR)

NSSDC ID- 75-052A-03

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL

PI - T.T.	WILHEIT, JR.	NASA-GSFC
OI - A.T.	EDGERTON	AEROJET ELECTROSYSTEMS

BRIEF DESCRIPTION

The Nimbus 6 Electrically Scanning Microwave Radiometer (ESMR) measured the earth's microwave emission to provide 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). The two-channel scanning radiometer operated in a 250-MHz band centered at 37 GHz. One channel was used to measure the vertical polarization and the other measured the horizontal polarization. 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 45 deg from the satellite antenna axis. The antenna beam scanned the earth in 71 discrete steps for various angles extending up to 35 deg on either side of the orbital plane. The deduced brightness temperatures were expected to be accurate to within 3-5 deg K. Spatial resolution was 20 km in the cross-track direction and 45 km in the direction parallel to the subpoint track. For a more detailed description, see Section 5 of "The Nimbus 6 User's Guide" (TRF B23261), available from NSSDC. The ESMR performance was satisfactory until September 15, 1976, when the horizontal channel output was zero due to a failure of the Ferrite-Dicke switch. Selected ESMR images were presented in "The Nimbus 6 Data Catalog" (TRF B26731), also available from NSSDC.

************************** NIMBUS 7**************************

SPACECRAFT COMMON NAME- NIMBUS 7
ALTERNATE NAMES- 11080, NIMBUS-G

NSSDC ID- 78-098A

LAUNCH DATE- 10/24/78 WEIGHT- 832. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- DELTA

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 10/25/78
ORBIT PERIOD- 104.0 MIN	INCLINATION- 99.3 DEG
PERIAPSIS- 938. KM ALT	APOAPSIS- 953. KM ALT

PERSONNEL

PM - C.M.	MACKENZIE	NASA-GSFC
PS - A.J.	FLEIG	NASA-GSFC

BRIEF DESCRIPTION

The Nimbus 7 research-and-development satellite served as a stabilized, earth-oriented platform for the testing of advanced systems for sensing and collecting data in the pollution, oceanographic and meteorological disciplines. The polar-orbiting spacecraft consisted of three major structures: (1) a hollow torus-shaped sensor mount, (2) solar paddles, and (3) a control housing unit that was connected to the sensor mount by a tripod truss structure. Configured somewhat like an ocean buoy, Nimbus 7 was nearly 3.04 m tall, 1.52 m in diameter at the base, and about 3.96 m wide with solar paddles extended. The sensor mount that formed the satellite base housed the electronics equipment and battery modules. The lower surface of the torus provided mounting space for sensors and antennas. A box-beam structure mounted within the center of the torus provided support for the larger sensor experiments. Mounted on the control housing unit, which was located on top of the spacecraft, were sun sensors, horizon scanners, and a command antenna. The spacecraft spin axis was pointed at the earth. An advanced attitude-control system permitted the spacecraft's orientation to be controlled to within plus or minus 1 deg in all three axes (pitch, roll, and yaw). Eight experiments were selected: (1) limb infrared monitoring of the stratosphere (LIMS), (2) stratospheric and mesopheric sounder (SAMS), (3) coastal-zone color scanner (CZCS), (4) stratospheric aerosol measurement II (SAM II), (5) earth radiation budget (ERB), (6) scanning multichannel microwave radiometer (SMMR), (7) solar backscatter UV and total ozone mapping spectrometer (SBUV/TOMS), and (8) temperature-humidity infrared radiometer (THIR). These sensors were capable of observing several parameters at and below the mesospheric levels. More details can be found in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC.

------- NIMBUS 7, GLOERSEN-------------------------------------

INVESTIGATION NAME- SCANNING MULTISPECTRAL MICROWAVE RADIOMETER (SMMR)

NSSDC ID- 78-098A-08

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL

TL - P.	GLOERSEN	NASA-GSFC
TM - R.O.	RAMSEIR	SURVEILLANCE SAT PROJ
TM - D.H.	STAELIN	MASS INST OF TECH
TM - W.J.	CAMPBELL	US GEOLOGICAL SURVEY
TM - D.B.	ROSS	NOAA-ERL
TM - P.	GUDMANSEN	TECH U OF DENMARK
TM - F.T.	BARATH	NASA-JPL
TM - T.T.	WILHEIT, JR.	NASA-GSFC
TM - J.C.	ALISHOUSE	NOAA-NESDIS
TM - D.J.	CAVALIERI	NASA-GSFC
TM - A.	CHANG	NASA-GSFC
TM - O.M.	JOHANNESSEN	US NAVAL POST GRAD SCH
TM - K.	KATSAROS	U OF WASHINGTON
TM - K.	KUNZI	U OF BERNE
TM - E.	LANGHAM	RADARSAT PROJ OFFICE
TM - E.P.L.	WINDSOR	BRITISH AIR CORP. LTD

BRIEF DESCRIPTION

The primary purpose of the Scanning Multichannel Microwave Radiometer (SMMR) was to obtain sea surface temperature and near-surface winds under all-weather conditions for developing and testing global ocean circulation models and other aspects of ocean dynamics. Winds, water vapor, liquid-water content, mean cloud droplet size, rainfall rate and sea ice parameters were also determined. Microwave brightness temperatures were observed with a 10-channel (five-frequency dual polarized) scanning radiometer operating at frequencies of 37, 21, 18, 10.69, and 6.6 GHz. Six Dicke-type radiometers were utilized. Those operating at the four longest wavelengths measured alternate polarizations during successive scans of the antenna; the others operated continuously for each polarization. The antenna was a parabolic reflector offset from the nadir by 42 deg. Motion of the antenna reflector provided observations from within a conical volume along the ground track of the spacecraft. The same instrument was flown on SEASAT 1. For a complete description, see Section 8 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC.

------- NIMBUS 7, HEATH-------------------------------------

INVESTIGATION NAME- SOLAR BACKSCATTER ULTRAVIOLET/TOTAL OZONE MAPPING SPECTROMETER (SBUV/TOMS)

NSSDC ID- 78-098A-09

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL

TL - D.F.	HEATH	NASA-GSFC
TM - C.L.	MATEER	ENVIRONMENT CANADA
TM - A.D.	BELMONT	CONTROL DATA CORP
TM - A.J.	MILLER	NOAA-NMC
TM - A.E.S.	GREEN	U OF FLORIDA
TM - D.M.	CUNNOLD	GEORGIA INST OF TECH
TM - W.L.	IMHOF	LOCKHEED PALO ALTO
TM - A.J.	KRUEGER	NASA-GSFC
TM - P.K.	BHARTIA	SYST & APPL SCI CORP
TM - A.J.	FLEIG	NASA-GSFC
TM - V.G.	KAVEESHWAR	SYST & APPL SCI CORP
TM - K.F.	KLENK	SYST & APPL SCI CORP
TM - R.	MCPETERS	NASA-GSFC
TM - H.W.	PARK	SYST & APPL SCI CORP

BRIEF DESCRIPTION

The objectives of the Solar Backscatter Ultraviolet and Total Ozone Mapping Spectrometer (SBUV/TOMS) were to determine the vertical distribution of ozone, map the total ozone content, and monitor the incident solar ultraviolet (UV) irradiance and ultraviolet radiation backscattered from the earth. The SBUV consisted of a double Ebert-Fastie spectrometer and a filter photometer similar to the BUV on Nimbus 4. The SBUV spectrometer measured solar UV backscattered by the earth's atmosphere at 12 wavelengths between 0.25 and 0.34 micrometer, with a spectral bandpass of 0.001 micrometer. The instrument's field of view (FOV) of 0.20 rad was directed at nadir. Both channels also viewed the sun for calibration through the use of a diffuser plate deployed near the terminator. The contribution functions for the eight shortest wavelengths were centered at levels ranging from 55 to 28 km and were used to infer the vertical ozone profile. The four longest wavelengths had contribution functions in the troposphere which were used to compute the total ozone amount. The SBUV spectrometer had a second mode of operation that allowed a continuous spectral scan from 0.16 to 0.4 micrometer for detailed examination of the extraterrestrial solar spectrum and its temporal variations. A parallel photometer channel at 0.343 micrometer measured the reflectivity of the atmosphere's lower boundary in the same 0.21-rad FOV. The TOMS was a single Ebert-Fastie spectrometer with a fixed grating and an array of exit slits. The TOMS step-scanned across the orbital track 51 deg from the nadir in 3-deg steps with an FOV of approximately 0.052 rad. At each scan position, the earth radiance was monitored at six wavelengths between 0.31 and 0.38 micrometer (3125 and 3800 A) to infer the total ozone amount. The signal-to-noise ratio of the SBUV was greater than 5.E3. The TOMS signal-to-noise ratio was greater than 1.E5. For a more detailed description, see Section 7 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC.

------- NIMBUS 7, HOVIS-------------------------------------

INVESTIGATION NAME- COASTAL ZONE COLOR SCANNER (CZCS)

NSSDC ID- 78-098A-03

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
EARTH RESOURCES SURVEY

PERSONNEL

TL - W.A.	HOVIS	NOAA-NESDIS
TM - C.S.	YENTSCH	BIGELOW LAB OCEAN SCI
TM - D.	CLARK	NOAA-NESDIS
TM - J.P.	APEL	APPLIED PHYSICS LAB
TM - S.Z.	EL-SAYED	TEXAS A+M
TM - H.R.	GORDON	NOAA-PMEL
TM - R.C.	WRIGLEY	NASA-ARC
TM - F.P.	ANDERSON	NATL RES INST OCEANOL
TM - R.	AUSTIN	SCRIPPS INST OCEANOGR
TM - E.	BAKER	NOAA-PMEL
TM - J.	MUELLER	US NAVAL POST GRAD SCH
TM - B.	STURM	EUROPE JCR

BRIEF DESCRIPTION

The Coastal Zone Color Scanner Experiment (CZCS) was designed to map chlorophyll concentration in water, sediment distribution, gelbstoffe concentrations as a salinity indicator, and temperature of coastal waters and ocean currents. Reflected solar energy was measured in six channels to sense color caused by absorption due to chlorophyll, sediments, and gelbstoffe in coastal waters. Spectral bands at 0.443 and 0.670 micrometers centered on the most intense absorption bands of chlorophyll, while the band at 0.550 micrometers centered on the "hinge point," the wavelength of minimum absorption. Ratios of measured energies in these channels were shown to closely parallel surface chlorophyll concentrations. Data from the scanning radiometer were processed, with algorithms developed from the field experiment data, to produce maps of chlorophyll absorption. The temperatures of coastal waters and ocean currents were measured in a spectral band centered at 11.5 micrometers. Observations were made also in two other spectral bands, 0.520 micrometers for chlorophyll correlation and 0.750 micrometers for surface vegetation. To avoid sun glint, the scanner mirror was tilted about the sensor pitch axis on command so that the line of sight of the sensor was moved in 2-deg increments up to 20 deg with respect to the nadir. The scan width was 1556 km centered on nadir and the ground resolution was 0.825 km at nadir. For a more detailed description, see Section 2 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC. Data are archived at SDSD. Since mid-1984, the instrument experienced occasional start-up problems. It was finally turned off in December 1986.

------- NIMBUS 7, KYLE-------------------------------------

INVESTIGATION NAME- EARTH RADIATION BUDGET (ERB)

NSSDC ID- 78-098A-07

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
ATMOSPHERIC PHYSICS

PERSONNEL

TL - H.L.	KYLE	NASA-GSFC
TL - H.	JACOBOWITZ	NOAA-NESDIS
TM - T.H.	VONDERHAAR	COLORADO STATE U
TM - F.B.	HOUSE	DREXEL U
TM - K.L.	COULSON	U OF CALIF, DAVIS
TM - J.R.	HICKEY	EPPLEY LAB, INC
TM - L.L.	STOWE	NOAA-NESDIS
TM - A.P.	INGERSOLL	CALIF INST OF TECH
TM - G.L.	SMITH	NASA-LARC
TM - A.	ARKING	NASA-GSFC
TM - G.	CAMPBELL	COLORADO STATE U
TM - R.	MASCHHOFF	GULTON INDUSTRIES, INC.

BRIEF DESCRIPTION

The objective of the Earth Radiation Budget (ERB) experiment, a continuation of Nimbus 6 ERB, was to determine, over a period of a year, the earth radiation budget on both synoptic and planetary scales by simultaneous measurements of incoming solar radiation and outgoing earth-reflected (shortwave) and emitted (longwave) radiation. Both (1) fixed wide-angle sampling of terrestrial fluxes at the satellite altitude and (2) scanned narrow-angle sampling of the angular radiance components, were used to determine outgoing radiation (reflected and emitted). The ERB subsystem consisted of a 22-channel radiometer containing separate subassemblies to perform the required solar, earth-flux (wide angle), and

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scanned earth radiance (narrow angle) measurements. The systems used optical filters for spectral discriminations, as well as uncooled thermal detectors, thermopile detectors in the solar and fixed-earth-flux channels, and pyroelectric detectors in the scanning channels. The 10 solar channels viewed in front of the observatory in the X-Y plane. The solar channels obtained usable solar data only during a period of about 3 min in each orbit when the spacecraft was over the Antarctic region. Their full response field of view (FOV) was 0.10 rad. The solar channel subassembly was pivoted plus or minus 0.35 rad in the X-Y plane to compensate for sun-angle deviation when required. The four earth-flux channels were mounted so that they could continuously view the total earth disk, and record data continuously at 0.25-s intervals. Demodulator output signals were integrated for periods of at least 3.8 s. There were eight narrow FOV channels (four shortwave and four longwave) mounted in the scanning head. The head was gimbal-mounted in the radiometer unit main frame. The FOVs of the telescopes were asymmetric (4.4 by 89.4 mrad) and those of the shortwave and longwave channels were coincident. The 89.4 mrad FOVs of the four pairs of channels were not contiguous, but covered only alternate 89.4 mrad angular intervals along the horizon. For a more detailed description, see Section 3 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC, and "The earth radiation budget (ERB) experiment: an overview" by H. Jacobowitz, et al., J. Geophys. Res., v. 89, n. D4, pp. 5021-5038, 1984. The narrow-view scanner failed in June 1980.

------- NIMBUS 7, MCCORMICK -------

INVESTIGATION NAME- STRATOSPHERIC AEROSOL MEASUREMENT-II (SAM-II)

NSSDC ID- 78-098A-06

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
UPPER ATMOSPHERE RESEARCH
METEOROLOGY
ATMOSPHERIC PHYSICS

PERSONNEL

TL - M.P.	MCCORMICK	NASA-LARC
TM - T.J.	PEPIN	U OF WYOMING
TM - G.M.	GRAMS	GEORGIA INST OF TECH
TM - B.M.	HERMAN	U OF ARIZONA
TM - P.B.	RUSSELL	NASA-ARC

BRIEF DESCRIPTION

The objective of the Stratospheric Aerosol Measurement (SAM II) experiment was to provide vertical distribution of stratospheric aerosols in the polar regions of both hemispheres. When no clouds were present in the instantaneous field of view (IFOV), the tropospheric aerosols could also be mapped. 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. 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 and in situ balloon-borne aerosol measurements were also made. For more detailed information, see Section 5 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC.

------- NIMBUS 7, RUSSELL, 3RD -------

INVESTIGATION NAME- LIMB INFRARED MONITOR OF THE STRATOSPHERE (LIMS)

NSSDC ID- 78-098A-01

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL

TL - J.M.	RUSSELL, 3RD	NASA-LARC
TL - J.C.	GILLE	NATL CTR FOR ATMOS RES
TM - F.B.	HOUSE	DREXEL INST OF TECH
TM - E.E.	REMSBERG	NASA-LARC
TM - C.B.	LOEVY	U OF WASHINGTON
TM - S.R.	DRAYSON	U OF MICHIGAN
TM - H.	FISCHER	U OF MUNICH
TM - W.G.	PLANET	NOAA-NESDIS
TM - A.	GIRARD	ONERA
TM - J.E.	HARRIES	NATL PHYSICAL LAB

BRIEF DESCRIPTION

The objective of the Limb Infrared Monitor of the Stratosphere (LIMS) experiment was 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. This experiment was a follow-on to limb radiance inversion radiometer (LRIR) flown on Nimbus 6. The instrument had 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, 6.3, 9.6, 11.3, and two 15 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 infrared 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 deg K. Constituent concentrations were determined with an accuracy of about 20%, with the exception of NO2 which was determined to within about 50%. 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. For more detailed information, see Section 4 in "The Nimbus 7 Users' Guide" (TRF B30045), available from NSSDC. The instrument was turned off due to depletion of cryogen as planned in June 1979.

------- NIMBUS 7, STOWE -------

INVESTIGATION NAME- TEMPERATURE/HUMIDITY INFRARED RADIOMETER (THIR)

NSSDC ID- 78-098A-10

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - L.L.	STOWE	NOAA-NESDIS
OI - L.J.	ALLISON(RETIRED)	NASA-GSFC
OI - P.H.	HWANG	NASA-GSFC
OI - K.F.	FLENK	SYST & APPL SCI CORP
OI - P.K.	BHARTIA	SYST & APPL SCI CORP

BRIEF DESCRIPTION

The Nimbus 7 Temperature-Humidity Infrared Radiometer (THIR) detected emitted thermal radiation in both the 10.5- to 12.5-micrometer region (IR window) and the 6.5- to 7.0-micrometer region (water vapor). The window channel provided an image of the cloud cover and temperatures of the cloud tops, land, and ocean surfaces. The other channel provided information on the moisture and cirrus cloud content of the upper troposphere and stratosphere, and the location of jet streams and frontal systems. The ground resolution at nadir was 6.7 km for the window channel and 20 km for the water vapor channel. Data from these two channels were used primarily to support other sophisticated meteorological experiments onboard Nimbus 7. The instrument was a non-imaging radiometer consisting of a 12.7-cm Cassegrain system and scanning mirror common to both channels, a beam splitter, filters, and two germanium-immersed thermistor bolometers. Incoming radiant energy was collected by a flat scanning mirror inclined at 45 deg to the optical axis. The mirror rotated through 360 deg at 48 rpm and scanned in a plane normal to the spacecraft velocity. The energy then was focused on a dichroic beam splitter which divided the energy spectrally and spatially. The two channels of this sensor transformed the received radiation into electric outputs (voltages), which were digitized and recorded on magnetic tape for subsequent playback to a ground acquisition station. For more complete information on instrument and data products, see Section 9 in "The Nimbus 7 Users' Guide" (TRF B30045) and the "Nimbus 7 Temperature-Humidity Infrared Radiometer (THIR) Data User's Guide" (TRF B30601), both available from NSSDC. Except for data being digitized on board, the Nimbus 7 THIR was of the same design and operation as the THIR flown on Nimbus 4, 5, and 6. The instrument was turned off in 1985 to conserve power.

------- NIMBUS 7, TAYLOR -------

INVESTIGATION NAME- STRATOSPHERIC AND MESOSPHERIC SOUNDER (SAMS)

NSSDC ID- 78-098A-02

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
UPPER ATMOSPHERE RESEARCH

PERSONNEL

PI - F.W.	TAYLOR	OXFORD U
OI - G.D.	PESKETT	OXFORD U
OI - C.D.	RODGERS	OXFORD U
OI - E.J.	WILLIAMSON	OXFORD U
OI - J.J.	BARNETT	OXFORD U
OI - M.	CORNEY	OXFORD U
OI - R.L.	JONES	OXFORD U
OI - J.G.	WHITNEY	OXFORD U

BRIEF DESCRIPTION

The objective of the Stratospheric and Mesospheric Sounder (SAMS) was to observe emission from the limb of the atmosphere through 12-channel pressure-modulator radiometers in order to determine temperature and vertical concentrations of H_2O, N_2O, CH_4, CO, and NO in the stratosphere and mesosphere. Measurements of zonal wind in this region were attempted by observing the Doppler shift of atmospheric emission lines. Radiation from the limb of the atmosphere was incident on a telescope of 15-cm aperture. In front of the telescope, a plane mirror scanned the limb, viewed space for calibration, and viewed the atmosphere obliquely to obtain vertical profiles. Three adjacent fields of view, each 20 by 2.0 mrad (corresponding to 100 km by 10 km at the limb), focused onto a field-splitting mirror which directed radiation to six detectors. The remaining division into channels was accomplished through dichroic beam splitters. There were seven pressure modulator cells (PMC), two containing CO_2, the remainder N_2O, NO, CH_4, CO, H_2O. Pressure in the cells could be varied on command by changing the temperature of a small container of molecular sieve material attached to each PMC. The spectral parameters for the H_2O channel were 2.7 micrometers and 25 to 100 micrometers. All other channels lay within the range 4.1 to 15 micrometers. Within the telescope, a chopper operating at 250 Hz allowed measurement of two separate signals from all detectors, one at 250 Hz and one at the PMC frequency. Comparison of these signals permitted the elimination of emission from interfering gases within a particular spectral interval. In front of the chopper, a small black body at known temperature could be introduced for calibration. Ac ate measurement of the atmospheric pressure at the level being viewed was obtained from the two signals from one CO_2 channel. For a more detailed description, see Section 6 in "The Nimbus 7 Users' Guide" (TRF B32045), available from NSSDC.

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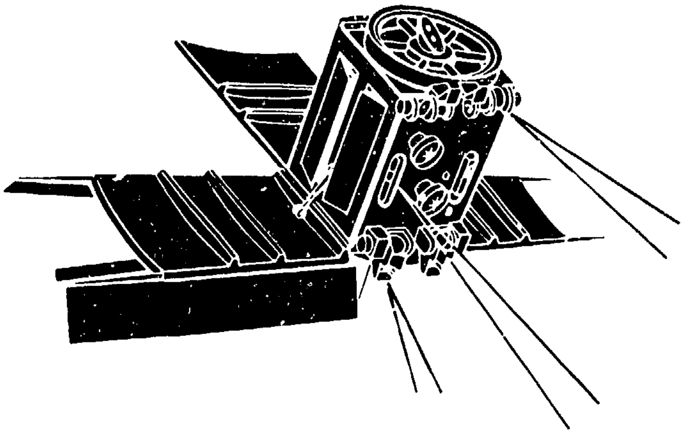
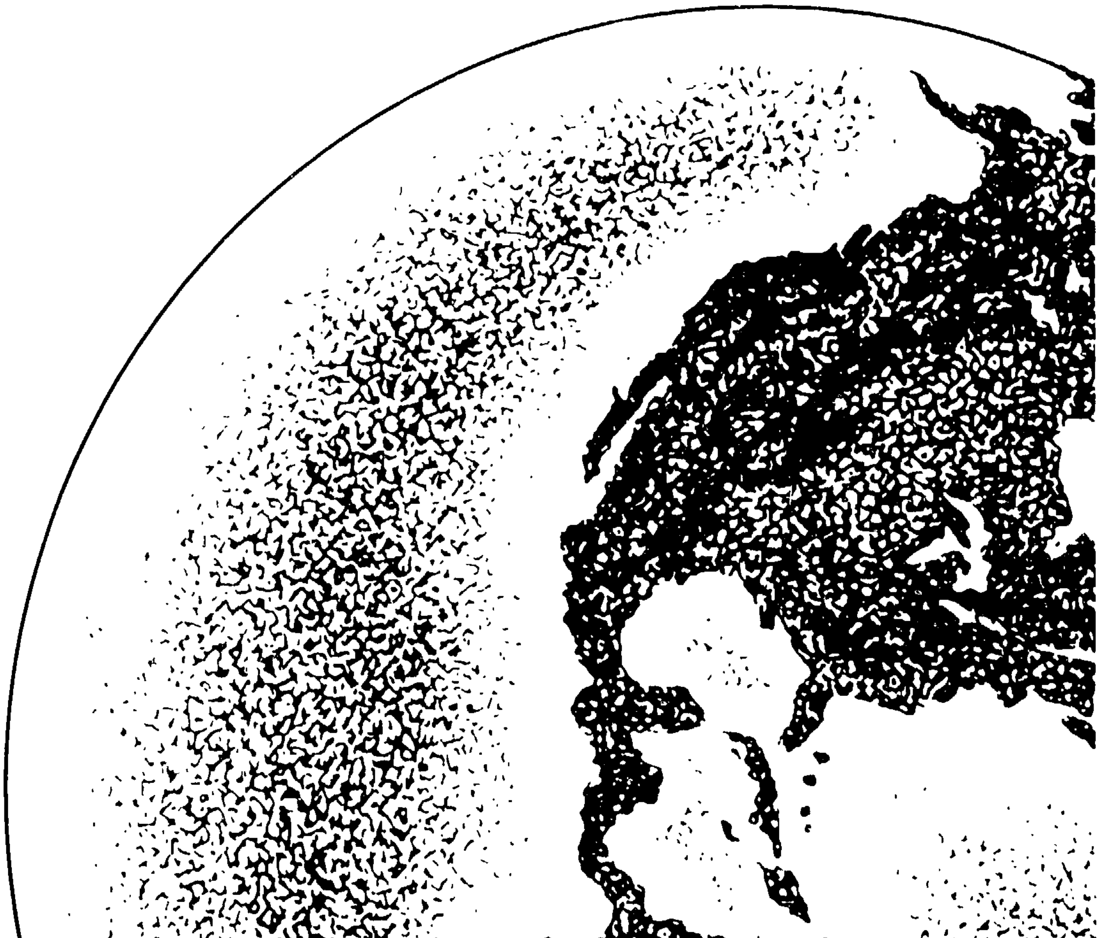
NOAA (1-5)/ITOS





NOAA (1-5)/ITOS PROGRAM

The Improved TIROS Operational Satellite (ITOS) represented a second generation of operational meteorological satellites. As with the TOS system it replaced, the NOAA/ITOS series comprised satellites built and launched in the 1970's by NASA, but operated and financed by NOAA.

Each NOAA/ITOS spacecraft was launched into a circular, near-polar, sun-synchronous orbit. Nominal spacecraft altitude was 1450 km with an inclination of 102 deg.

All NOAA/ITOS spacecraft were three-axis stabilized. The initial version, TIROS-M (ITOS 1 after launch), and the ITOS-A (NOAA 1 after launch) were each fitted with dual Automatic Picture Transmission (APT) and Advanced Vidicon Camera system (AVCS) cameras, thereby eliminating the need for two spacecraft to operate simultaneously in orbit as in the case of the TOS system. Each spacecraft also carried a Scanning Radiometer (SR) and a Flat Plate Radiometer (FPR) system, giving them both high- and low-resolution infrared imaging capability. The two-channel SR had both daytime and nighttime capability and could either read out data directly to a ground receiving station or store the information on magnetic tape for subsequent transmission, depending on whether the satellite was within or beyond communication range of the station.

Four more spacecraft were included in the series: ITOS-D (later NOAA 2), launched in October 1972, and ITOS-E through -G (later NOAA 3 through 5). All the satellites carried a modified dual instrument payload that included an SR, a Very High Resolution Radiometer (VHRR), and a Vertical Temperature Profile Radiometer (VTPR). These improved spacecraft replaced TV cameras with radiometers for earth-cloud imagery. The SR was identical to that flown previously on the TIROS series. The two-channel VHRR operated in a similar manner to the SR but with a much better resolution. The VTPR was designed to take radiation measurements around the globe that permitted the determination of vertical temperature profiles over selected points every 12 h. These radiometers provided, for the first time, nighttime monitoring of the earth-atmosphere system.

The resolution of the SR was 4 km in the visible and IR at nadir, while the VHRR incorporated in the later models had a resolution of about 1 km in the visible and IR channels, and 4 km in the water vapor channels. The footprint of the VTPR was approximately 50 by 50 km.

The NOAA/ITOS series was subsequently replaced by a third and fourth generation of meteorological satellites. Their descriptions can be found under "NOAA (6, 7, D)/TIROS-N Program" and "NOAA (8-10, H-J)/ATN Program," respectively.

********************************ITOS 1, NOAA 1-5********************************

Spacecraft Name - ITOS 1, NOAA 1-5

S/C	Alternate Name	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
ITOS 1	TIROS-M	70-008A	01/23/70	102.0	1432	1478	115.0
NOAA 1	ITOS-A	70-106A	12/11/70	101.9	1422	1472	114.8
NOAA 2	ITOS-D	72-082A	10/15/72	101.8	1448	1453	114.9
NOAA 3	ITOS-F	73-086A	11/06/73	102.1	1500	1509	116.1
NOAA 4	ITOS-G	74-089A	11/15/74	101.7	1443	1457	114.9
NOAA 5	ITOS-H	76-077A	07/29/76	102.1	1502	1520	116.2

S/C	PM	PS
ITOS 1, NOAA 1	W. W. Jones (NLA) NASA/GSFC	I. L. Goldberg NASA/GSFC
NOAA 2, 3	S. Weiland (Retired) NASA/GSFC	I. L. Goldberg NASA/GSFC
NOAA 4, 5	G. A. Branchflower (NLA) NASA/GSFC A. Butera NOAA/NESDIS S. Weiland (Retired) NASA/GSFC	I. L. Goldberg NASA/GSFC

Brief Description

The primary objective of the ITOS 1/NOAA 1-5 three-axis stabilized, sun-synchronous meteorological satellites was to provide improved operational infrared and visual observations of earth cloud cover, surface/cloud top temperatures, and global atmospheric temperature soundings for weather analysis and forecasting. The secondary objective was to provide solar proton flux data on a regular daily basis. ITOS 1 and NOAA 1 each had five experiments: (1) Advanced Vidicon Camera System (AVCS), (2) Automatic Picture Transmission (APT), (3) Scanning Radiometer (SR), (4) Flat Plate Radiometer (FPR), and (5) Solar Proton Monitor (SPM). NOAA 2-5 were redesigned to incorporate two instruments and to eliminate the APT and AVCS cameras as well as the FPR. With the addition of the Very High Resolution Radiometer (VHRR) and the Vertical Temperature Profile Radiometer (VTPR), NOAA 2-5 entirely relied on scanning radiometers for images and carried an operational instrument capable of obtaining vertical temperature profiles of the atmosphere. The nearly cubical spacecraft measured 1 by 1 by 1.2 m. The spacecraft was equipped with three curved solar panels that were folded during launch and deployed after orbit was achieved. Each panel measured over 4.2 m in length when unfolded and was covered with 3420 solar cells, each measuring 2 by 2 cm. The attitude control system maintained desired spacecraft orientation through gyroscopic principles incorporated into the satellite design. Earth orientation of the satellite body was maintained by taking advantage of the precession induced from a momentum flywheel so that the satellite body precession rate of one revolution per orbit provided the desired "earth looking" attitude.

------------------------------------ITOS 1, NOAA 1-5, NESDIS Staff------------------------------------

Investigation Name - Advanced Vidicon Camera System (AVCS)

Flown on - ITOS 1, NOAA 1

NSSDC ID - 70-008A-04, 70-106A-04

PI - NESDIS Staff NOAA/NESDIS

Brief Description

The Advanced Vidicon Camera System (AVCS) was a redundant camera and tape recorder combination designed to record a series of wide-angle, high-resolution television pictures of the earth and its cloud cover during daylight. The AVCS operated in three modes: record, playback, and direct readout. The AVCS system was essentially the same as that used on all TOS/ESSA spacecraft (ESSA 3, 5, 7, and 9). The two major elements of the system were (1) the camera sensor assembly, which contained lens, shutter, gray scale 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-deg wide-angle lens (5.7-mm length) with an f/1.8 aperture and a 2.54-cm-diameter vidicon with 833 scan lines. A video frame consisted of 0.25 s of blanked video, followed by 6.25 s of vidicon scan video (833 lines), and a final 0.25-s period of blanked video. Eleven pictures were taken at 260-s intervals to cover the sunlit portion of the earth (sun elevation greater than 15 deg). The tape recorder could be read out between photographic cycles without losing a picture or interrupting a sequence. At nominal satellite altitude (1,450 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% picture overlap along the track to ensure complete coverage. The recorder could store up to 38 pictures (three orbits of data) in a single start-stop operation. Data are available through SDSD.

------------------------------------ITOS 1, NOAA 1-5, NESDIS Staff------------------------------------

Investigation Name - Automatic Picture Transmission (APT)

Flown on - ITOS 1, NOAA 1

NSSDC ID - 70-008A-05, 70-106A-05

PI - NESDIS Staff NOAA/NESDIS

Brief Description

The Automatic Picture Transmission (APT) experiment was designed to automatically take wide-angle, slow-scan television pictures of the earth and its cloud cover during daylight. This experiment consisted of two APT subsystems. The photographic operations of APT were controlled by program commands transmitted to the satellite by the command and data acquisition (CDA) stations. A complete APT picture sequence lasted approximately 46 min, during which 11 pictures were taken at 260-s intervals. These pictures were transmitted by 137.62-MHz real-time transmitters to APT-equipped ground stations within communication range of the satellites. The APT subsystem was essentially the same as that used on the TOS/ESSA spacecraft (ESSA 1, 4, 6, and 8). The major elements of the subsystem were the camera sensor assembly, video amplifier, camera electronics module, and power circuits. The earth-oriented camera used a 108-deg (5.7-mm focal length) wide-angle lens with a maximum aperture of f/1.8 and a 2.54-cm-diameter vidicon with 600 scan lines. At the nominal satellite altitude of 1450 km, each picture covered approximately 3140 km across the track and 2400 km along the track with a ground resolution of about 3 km at nadir. There was an approximate 20% overlap between pictures along the track to ensure complete coverage. APT data were intended primarily for local operational use within an APT acquisition station and generally are not available for distribution.

----------------------------------ITOS 1, NOAA 1-5, NESDIS Staff----------------------------------

Investigation Name - Scanning Radiometer (SR)

Flown on - ITOS 1, NOAA 1-5

NSSDC ID - 70-008A-03, 70-106A-03, 72-082A-02, 73-086A-02,
74-089A-02, 76-077A-03

PI - NESDIS Staff NOAA/NESDIS

Brief Description

The Scanning Radiometer (SR) experiment consisted of two scanning radiometers, a dual processor, and two recorders. This subsystem permitted the determination of surface temperatures of the ground, the sea, or cloud tops viewed by the radiometers. The radiometer measured reflected radiation from the earth-atmosphere system in the 0.52- to 0.73-micrometer band during the day and emitted radiation from the earth and its atmosphere in the 10.5- to 12.5-micrometer band day and night. The SR on NOAA 2 and 5 had an additional channel in the 0.50- to 0.94-micrometer region. 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 one of the two acquisition stations. The data could also be transmitted in real time to local Automatic Picture Transmission (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 temperature between 185 and 330 K to an accuracy of 4 and 1 K, respectively. Data from this experiment are available through SDSD.

----------------------------------ITOS 1, NOAA 1-5, NESDIS Staff----------------------------------

Investigation Name - Very High-Resolution Radiometer (VHRR)

Flown on - NOAA 2-5

NSSDC ID - 72-082A-03, 74-089A-03, 76-077A-01, 73-086A-03

PI - NESDIS Staff NOAA/NESDIS

Brief Description

The Very High-Resolution Radiometer (VHRR) experiment was designed to continuously measure surface temperatures of the earth, sea, and cloud tops day and night. The data were transmitted in real time to High Resolution Picture Transmission (HRPT) receiving stations throughout the world for local weather forecasting. In addition, 8 min of data per orbit were programmed for storage in the satellites for later playback to command and data acquisition (CDA) stations. The experiment included two scanning radiometers, a magnetic tape recorder, and associated electronics. The two-channel VHRR operation was similar to that of 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 spectral range of 0.6 to 0.7 micrometer. 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-micrometer 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 deg 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 radiometer failed, the system was still capable of measuring both visible and infrared radiation using only the remaining radiometer. Data from this experiment are presently maintained at SDSD.

----------------------------------ITOS 1, NOAA 1-5, NESDIS Staff----------------------------------

Investigation Name - Vertical Temperature Profile Radiometer (VTPR)

Flown on - NOAA 2-5

NSSDC ID - 72-082A-04, 73-086A-04, 74-089A-04, 76-077A-02

PI - NESDIS Staff NOAA/NESDIS

Brief Description

This experiment consisted of two Vertical Temperature Profile Radiometer (VTPR) subsystems. The VTPR sensed the radiance energy from atmospheric carbon dioxide in six narrow spectral regions centered at 15.0, 14.8, 14.4, 14.1, 13.8, and 13.4 micrometers. The atmospheric total water vapor content was determined from measurements centered at 18.7 micrometers. Measurements were also taken in the 12.0-micrometer spectral region to determine surface/cloud top temperatures. The VTPR consisted of an optical system, a detector and associated electronics, and a scanning mirror. The scanning mirror looked at the earth's surface perpendicular to the satellite orbital path. 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 sq km 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. Data from this experiment are presently maintained at SDSD.

Investigation Name - Flat Plate Radiometer (FPR)

Flown on - ITOS 1, NOAA 1

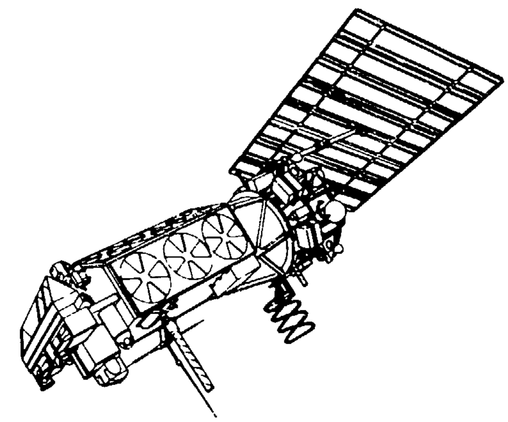
NSSDC ID - 70-008A-02, 70-106A-02

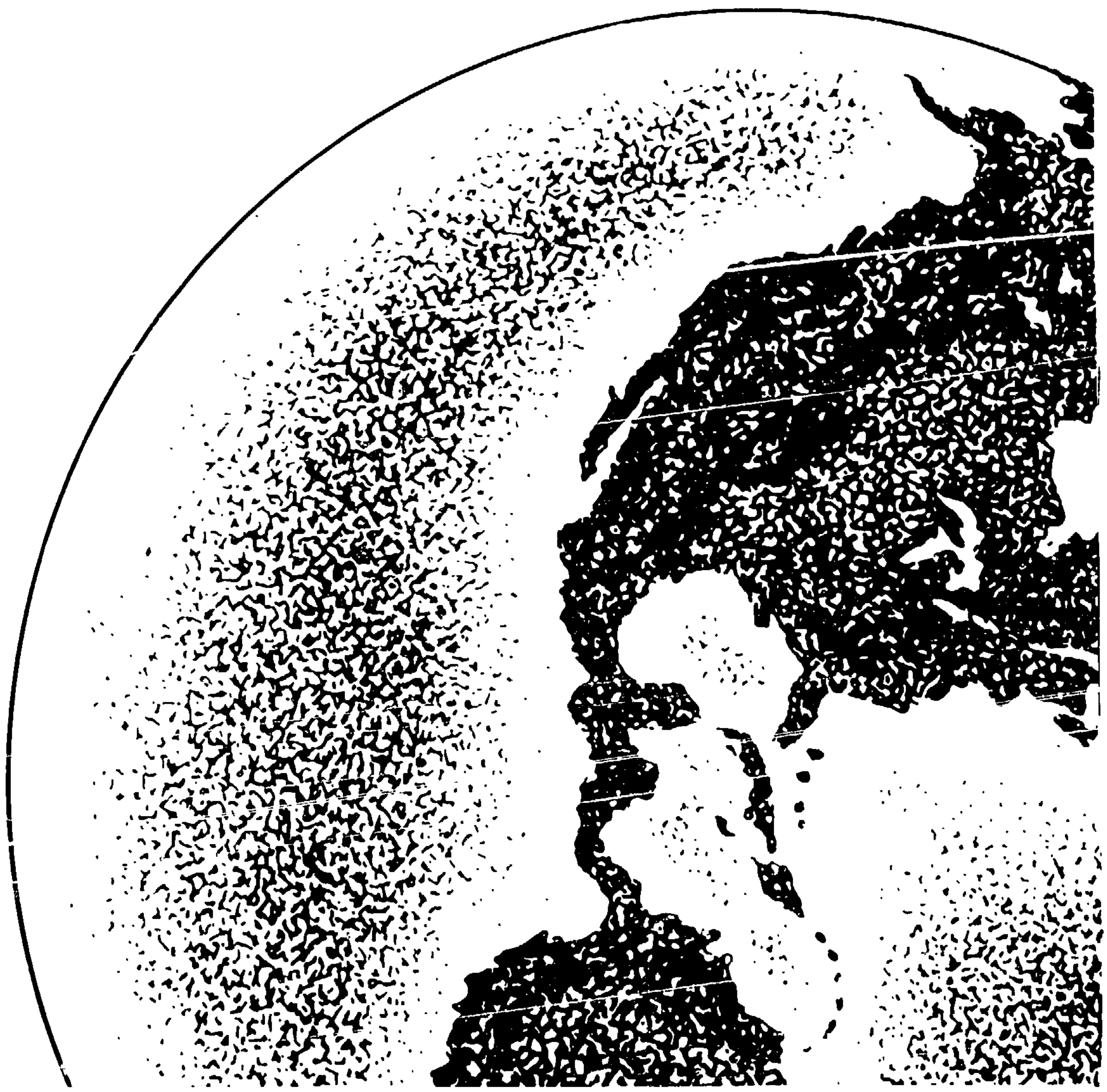
PI - V. E. Suomi U. of Wisconsin

Brief Description

The Flat Plate Radiometer (FPR) system was designed to provide a measurement of the global distribution of reflected solar and longwave radiation leaving the earth. The FPR system consisted of four detectors, an analog-to-digital converter, and a tape recorder. The detectors had a hemispheric field of four detectors, an analog-to-digital converter, view of 2 pi sr, and were mounted on the satellite baseplate facing the earth. The detectors used coated aluminum disks as a sensing element. Two of the disks were white and responded only to infrared energy (7 to 30 micrometers) radiated from the earth and its atmosphere. The other two disks were painted black and had a broader band sensitivity (0.3 to 30 micrometers). Two disks (one of each type) had a thermistor bolometer mounted on the back surface to measure the disk temperature. The other two disks used thermopiles. A similar experiment was flown on ESSA 3, 5, 7, and 9. For a full description of the FPR system, see "Studies in Atmospheric Energetics Based on Aerospace Probings, Annual Report - 1967," pp. 179-189, Dept. of Meteorology, University of Wisconsin, March 1968.

NOAA (6, 7, D)/TIROS-N





NOAA (6, 7, D)/TIROS-N PROGRAM

The TIROS-N type spacecraft were third-generation operational, polar-orbiting, meteorological satellites for use in the National Operational Environmental Satellite System to support the Global Atmospheric Research Program (GARP). Originally, this program was planned for NOAA-A through NOAA-G. Later, NOAA-E, -F, and -G (NOAA 8, 9, and 10 after launch, respectively), and NOAA-H through -J were modified to compose an Advanced TIROS-N (ATN) series. TIROS-N and the three follow-on satellites (NOAA 6, 7, and -D) provided an economical and stable, sun-synchronous platform for advanced operational instruments to measure the earth atmosphere, surface, cloud cover, and near space environment. The name TIROS-N refers to both the general spacecraft type as well as the specific sixth satellite in the NOAA series. Considering ITOS 1 and TIROS-N, NOAA 6 was thus the eighth satellite in the NOAA series.*

Unlike the NOAA 1 through 5 that were flown one satellite at a time, all follow-on NOAA satellites were maintained in orbits two at a time (at 90 deg apart) for increased coverage and redundancy. Normally, one spacecraft would cross the equator at 7:30 a.m. local time in the descending node, while the other would cross at 2:30 p.m. local time in the ascending node.

Each satellite was a modified USAF DMSP Block 5D spacecraft bus which carried the Advanced Very High Resolution Radiometer (AVHRR) to observe emitted and reflected radiation in visible (0.55 to 0.9 micrometer), near IR (0.725 to 1.3 micrometers), and IR (10.5 to 11.5 micrometers, 3.55 to 3.93 micrometers) wavelengths. NOAA 7 had a fifth channel in the 11.5 to 12.5 micrometers range. From these observations made in a scanning mode, global day and nighttime sea-surface temperatures, ice, snow, and cloud-cover information can be derived. Spatial resolution of 1.1 km (high) or 4 km (low) was attained. Thermal resolution for the two IR channels was 0.12 K at 300 K.

Also, each satellite carried a hybrid vertical temperature and humidity sounder known as the TIROS Operational Vertical Sounder (TOVS). This sounder was a composite of three instruments observing reflected and emitted radiances in a total of 27 channels ranging from 3.7 to 57.9 micrometers. The instruments were a 20-channel, high-resolution, IR spectrometer (HIRS/2), a 3-channel Stratospheric Sounding Unit (SSU), and a 4-channel Microwave Sounding Unit (MSU). From the observed radiances, temperature and humidity profiles from the earth's surface up to the stratosphere (approximately 1 mb) were obtained.

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* For a complete listing of prelaunch and postlaunch equivalent spacecraft names, see Table 14 appended to the TIROS program summary.

Two additional packages were also on all TIROS-N type satellites: the Space Environment Monitor (SEM) and the Data Collection System (DCS). The SEM was an extension of the solar proton monitoring experiment on the ITOS spacecraft series. The DCS was designed to receive low-duty cycle transmissions of meteorological observations from free-floating balloons, ocean buoys, other satellites, and fixed, ground-based sensor platforms distributed around the globe.

TIROS-N was turned off in the spring of 1981 due to budget restraint. For the same reason, NOAA-D was put into storage to be used as a backup for other spacecraft in this series. NOAA 7 was retired in June 1986 after 5 years of service, while NOAA 6 operated for 7 years until January 1987.

******************************TIROS-N, NOAA 6-7******************************

Spacecraft Name - TIROS-N, NOAA 6-7

S/C	Alternate Name	NSSDC ID	Launch Date	Incl. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
TIROS-N		78-096A	10/13/78	98.9	846	862	102
NOAA 6	NOAA-A	79-057A	06/27/79	98.7	833	844	101.5
NOAA 7	NOAA-C	81-059A	06/23/81	98.9	845	863	102

S/C	PM	PS
TIROS-N, NOAA 6	G. W. Longanecker NASA/GSFC J. Muller, Jr. NASA/GSFC G. A. Branchflower (NLA) NASA/GSFC	A. Arking NASA/GSFC
NOAA 7	G. W. Longanecker NASA/GSFC G. A. Branchflower (NLA) NASA/GSFC	J. Susskind NASA/GSFC

Brief Description

The TIROS-N/NOAA series was the third generation of operational polar-orbiting meteorological satellites for use in the National Operational Environmental Satellite System (NOESS), which supported the Global Atmospheric Research Program (GARP) during 1978-84. The spacecraft design provided an economical and stable sun-synchronous platform for advanced operational instruments to be used in making measurements of the earth's atmosphere, its surface and cloud cover, and the near-space environment. Primary sensors included an Advanced Very High Resolution Radiometer (AVHRR) and a TIROS Operational Vertical Sounder (TOVS). Secondary experiments consisted of a space environment monitor (SEM) and a data collection system (DCS). The NOAA 7 had an additional contamination monitor to obtain contamination sources, levels, and effects for consideration on future spacecraft. The spacecraft was based upon the DMSP Block 5D spacecraft bus developed for the U.S. Air Force, and was capable of maintaining an earth-pointing accuracy of better than plus or minus 0.1 deg with a motion rate of less than 0.035 deg/s. For a more detailed description, see A. Schwalb, "The TIROS-N/NOAA A-G Satellite Series," NOAA Tech. Mem. NESS 95, 1978.

------------------------------------TIROS-N, NOAA 6-7, NESDIS Staff----------------------------------

Investigation Name - Advanced Very High Resolution Radiometer (AVHRR)

Flown on - TIROS-N, NOAA 6-7

NSSDC ID - 78-096A-01, 79-057A-01, 81-059A-01

PI - NESDIS Staff — NOAA/NESDIS
OI - W. E. Shenk — NASA/GSFC

Brief Description

The Advanced Very High Resolution Radiometer (AVHRR) was a four- or five-channel scanning radiometer capable of providing global daytime and nighttime sea-surface temperature and information about ice, snow, and clouds. These data were obtained on a daily basis for use in weather analysis and forecasting. On TIROS-N and NOAA 6, the radiometer measured emitted and reflected radiation in the following spectral intervals: channel 1, 0.55 to 0.9 micrometer (visible); channel 2, 0.725 to 1.1 micrometers (near IR); channel 3, 3.55 to 3.93 micrometers (IR window); and channel 4, 10.5 to 11.5 micrometers (IR window). The AVHRR on NOAA 7 had a fifth channel in the 11.5- to 12.5-micrometer (IR window) region. All channels had a spatial resolution of 1.1 km at nadir, and the IR-window channels had a thermal resolution of 0.12 K at 300 K. The AVHRR was capable of operating in both real-time or recorded modes. Direct readout data were transmitted to ground stations of the Automatic Picture Transmission (APT) class at low resolution (4 km) and to ground stations of the High Resolution Picture Transmission (HRPT) class at high resolution (1 km). Data recorded on board were available for processing in the NOAA Central Computer Facility. They included global area coverage (GAC) data, with a resolution of 4 km, and local area coverage (LAC) data that were from selected portions of each orbit with a 1-km resolution. Archival data are available from SDSD.

------------------------------------TIROS-N, NOAA 6-7, NESDIS Staff----------------------------------

Investigation Name - TIROS Operational Vertical Sounder (TOVS)

Flown on - TIROS-N, NOAA 6-7

NSSDC ID - 78-096A-02, 79-057A-02, 81-059A-02

PI - NESDIS Staff — NOAA/NESDIS

Brief Description

The TIROS Operational Vertical Sounder (TOVS) consisted of three instruments designed to provide temperature and humidity profiles of the atmosphere from the surface to the stratosphere (approximately 1 mb). The first instrument was the second version of the High Resolution Infrared Spectrometer (HIRS/2). The HIRS was originally tested on board the Nimbus 6. The HIRS/2 had 20 channels in the following spectral intervals: channels 1 through 5, the 15-micrometer CO_2 bands (15.0, 14.7, 15.4, 14.2, and 14.0 micrometers); channels 6 and 7, the 13.7- and 13.4-micrometer CO_2/H_2O bands; channel 8, the 11.1-micrometer window region; channel 9, the 9.7-micrometer ozone band; channels 10, 11, and 12, the 6-micrometer water vapor bands (8.3, 7.3, and 6.7 micrometers); channels 13 and 14, the 4.57- and 4.52-micrometer N_2O bands; channels 15 and 16, the 4.46- and 4.40-micrometer CO_2/N_2O bands; channel 17, the 4.24-micrometer CO_2 band; channels 18 and 19, the 4.0- and 3.7-micrometer window bands;

and channel 20, the 0.7-micrometer window region. The HIRS/2 provided data for calculations of temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere, and total ozone content. The second instrument, the Stratospheric Sounding Unit (SSU), was provided by the British Meteorological Office and was similar to the Pressure Modulated Radiometer (PMR) flown on Nimbus 6. The SSU operated at three 15.0-micrometer channels using selective absorption, passing the incoming radiation through three pressure modulated cells containing CO_2. The SSU provided temperature information in the stratosphere. The third instrument, the Microwave Sounding Unit (MSU), was similar to the Scanning Microwave Spectrometer (SCAMS) flown on Nimbus 6. The MSU had one channel in the 50.31-GHz window region and three channels in the 55-GHz oxygen band (53.73, 54.96, 57.95 GHz) to obtain temperature profiles which were free of cloud interference. The instruments were cross-course scanning devices utilizing a step scan to provide a traverse scan, while the orbital motion of the satellite provided scanning in the orthogonal direction. The HIRS/2 had a field of view (FOV) 30 km in diameter at nadir, whereas the MSU had an FOV of 110 km in diameter. The HIRS/2 sampled 56 FOVs in each scan line about 2250 km wide, and the MSU sampled 11 FOVs along the swath with the same width. Each SSU scan line had 8 FOVs with a width of 1500 km. For a more detailed description, see W. L. Smith, "The TIROS-N Operational Vertical Sounder," Bull. Am. Meteorol. Soc., v. 60, pp. 1177-1187, 1979. Archival data are available from SDSD.

NOAA (8-10, H-J)/ATN

NOAA (8-10, H-J)/ATN PROGRAM

The Advanced TIROS-N (ATN) program is a modified version of the NOAA 6, 7, and NOAA-D/TIROS-N series to add payload capacity without changing the basic environmental mission of the original program. Additional satellites are being added to the initial program to extend the lifetime of the program to the end of the decade. This series, sometimes referred to at NSSDC as the NOAA-X series, includes NOAA-H, -I, and -J.

The spacecraft are similar to the NOAA 6, 7, and NOAA-D/TIROS-N series, with the exception that the Equipment Support Module (ESM) is stretched 48 cm to allow integration of the new payload. Each spacecraft includes the AVHRR, TOVS, DCS, and Search And Rescue (SAR) systems. The sensor characteristics of TOVS and DCS are the same as those in the preceding series; the AVHRR is a five-channel version. Both the SSU in the TOVS and the SEM are flown on every other spacecraft only. The SAR can receive, process, and relay distress signals transmitted by beacons carried by civilian aircraft and some classes of marine vessels. The SAR program is a cooperative effort of the U.S.A., Canada, France, and the U.S.S.R.

Both NOAA 9 and 10 carry an Earth Radiation Budget Experiment (ERBE) to make high-latitude observations. This is an eight-channel radiometer designed to measure the energy exchange between the earth-atmosphere system and space. The instrument consists of a five-channel non-scanner package and a three-channel scanner package. The scanner package has four channels pointing directly at the earth. Two channels observe the 0.2- to 5-micrometer earth/atmosphere radiance, one at wide-angle (135 deg) and the other at medium-angle resolution (32 deg). The other two channels, also one wide and one medium FOV, observe total radiance from 0.2 to >50 micrometers. All four channels are designed primarily for nadir operation. The fifth channel (0.2 to >50 micrometers), with an 18-deg FOV, provides a reference observation of the sun and periodically measures the solar constant. The scanner package observes radiances in short wave (0.2 to 5 micrometers), long wave (5 to >50 micrometers), and total radiance (0.2 to >50 micrometers). Each channel makes cross-track scanning from horizon to horizon with a 3- by 4.5-deg FOV. This experiment is also flown concurrently on the the Earth Radiation Budget Satellite (ERBS), which makes mid- and low-latitude observations. Starting with NOAA 9, a Solar Backscatter Ultraviolet radiometer (SBUV/2) is carried on every afternoon-ascending satellite. It is a nonscanning, nadir-viewing instrument designed to measure the radiance in the 160- to 400-nanometer wavelength for determining the total ozone and the vertical distribution of ozone in the earth's atmosphere and the solar irradiance. The SBUV was originally flown on the Nimbus 7.

NOAA 8 suffered a premature failure after orbiting for only one year. Following an 11-month maneuver by NASA/Goddard engineers, the spacecraft resumed operations for another 5 months before a permanent shutdown in January 1986.

*****************************NOAA 8-10***********************************

Spacecraft Name - NOAA 8-10

S/C	Alternate Name	NSSDC ID	Launch Date	Incl. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
NOAA 8	NOAA-E	83-022A	03/28/83	98.8	806	829	101.2
NOAA 9	NOAA-F	84-123A	12/12/84	98.9	841	862	102
NOAA 10	NOAA-G	86-073A	09/17/86	98.7	807	826	101.2

S/C	PM	PS
NOAA 8-10	G. W. Longanecker NASA/GSFC G. A. Branchflower (NLA) NASA/GSFC	J. Susskind NASA/GSFC

Brief Description

The advanced TIROS-N/NOAA series was the fourth generation of operational polar-orbiting meteorological satellites for use in the National Operational Environmental Satellite System (NOESS), which supported the Global Atmospheric Research Program (GARP) during 1978-84. The spacecraft design provided an economical and stable sun-synchronous platform for advanced operational instruments to be used in making measurements of the earth's atmosphere, its surface and cloud cover, and the near-space environment. Primary sensors included an Advanced Very High Resolution Radiometer (AVHRR) and a TIROS Operational Vertical Sounder (TOVS). Secondary experiments consisted of a Space Environment Monitor (SEM) and a Data Collection System (DCS). The NOAA 9 carried two other instruments: the Earth Radiation Budget Experiment (ERBE) and the Solar Backscatter Ultraviolet Radiometer (SBUV/2). The spacecraft were also equipped with a Search And Rescue (SAR) system to receive, process, and relay distress signals which were transmitted by beacons carried on civil aircraft and some classes of marine vessels. The spacecraft was based upon the DMSP Block 5D spacecraft bus developed for the U.S. Air Force, and was capable of maintaining an earth-pointing accuracy of better than plus or minus 0.1 deg with a motion rate of less than 0.035 deg/s. For a more detailed description, see A. Schwalb, "The TIROS-N/NOAA A-G Satellite Series," NOAA Tech. Mem. NESS 95, 1978.

---NOAA 8-10, Barkstrom---

Investigation Name - Earth Radiation Budget Experiment (ERBE)

Flown on - NOAA 9, 10

NSSDC ID - 84-123A-05, 86-073A-05

PI - B. R. Barkstrom NASA/LaRC

Brief Description

The Earth Radiation Budget Experiment (ERBE) was designed to measure the energy exchange between the earth-atmosphere system and space. The measurements of global, zonal, and regional radiation budgets on monthly time scales helped in climate prediction and in the development of statistical relationships between regional weather and radiation budget anomalies. The ERBE consisted of two instrument packages: the nonscanner (ERBE-NS) instrument and the scanner (ERBS-S) instrument. The ERBE-NS instrument had five sensors, each using cavity radiometer detectors. Four of them were primarily earth-viewing: two wide field-of-view (FOV) sensors viewed the entire disk of the earth from limb to limb, approximately 135 deg; two medium FOV sensors viewed a 10-deg region. The fifth sensor was a solar monitor that measured the total radiation from the sun. Of the four earth-viewing sensors, one wide and one medium FOV sensor made total radiation measurements; the other two measured reflected solar radiation in the shortwave spectral band between 0.2 and 5 micrometers by using Suprasil-W filters. The earth-emitted longwave radiation component was determined by subtracting the short wave measurement from the total measurement The ERBE-S instrument was a scanning radiometer containing three narrow FOV channels. One channel measured reflected solar radiation in the shortwave spectral interval between 0.2 and 5 micrometers. Another channel measured earth-emitted radiation in the longwave spectral region from 5 to 50 micrometers. The third channel measured total radiation with wavelength between 0.2 and 50 micrometers. All three channels were located within a continuously rotating scan drum that scanned the FOV across track sequentially from horizon to horizon. Each channel made 74 radiometric measurements during each scan, and the FOV of each channel was 3 by 4.5 deg that covered about 40 km at the earth's surface. The ERBE-S also viewed the sun for calibration. Additional information can be obtained from a special issue of the Review of Geophysics, v. 24, no. 2, 1986.

--NOAA 8-10, Cunningham--

Investigation Name - Solar Backscattered Ultraviolet Radiometer (SBUV/2)

Flown on - NOAA 9

NSSDC ID - 84-123A-07

PI - F. G. Cunningham NASA/GSFC

Brief Description

The Solar Backscatter Ultraviolet Radiometer (SBUV/2) was designed to map total ozone concentrations on a global scale and to provide the vertical distribution of ozone in the earth's atmosphere. The instrument design was based upon the technology developed for the SBUV/TOMS flown on Nimbus 7. The SBUV/2 instrument measured backscattered solar radiation in an 11.3-deg field of view of the nadir direction at 12 discrete, 1.1-nm wide, wavelength bands between 252.0 and 339.8 nm. The solar irradiance was determined at the same 12 wavelength bands by deploying a diffuser that reflected sunlight into the instrument's field of view. The SBUV/2 also measured the solar irradiance or the atmospheric radiance with a continuous spectral scan from 160 to 400 nm in increments of 0.148 nm. The SBUV/2 had another narrowband filter photometer channel, called the Cloud Cover Radiometer (CCR), that continuously measured the earth's surface brightness at 380 nm. The CCR field of view was 11.3 deg.

--NOAA 8-10, NESDIS Staff------------------------------------

Investigation Name - Advanced Very High Resolution Radiometer (AVHRR)

Flown on - NOAA 8-10

NSSDC ID - 83-022A-01, 84-123A-01, 86-073A-01

PI - NESDIS Staff	NOAA/NESDIS
OI - W. E. Shenk	NASA/GSFC

Brief Description

The Advanced Very High Resolution Radiometer (AVHRR) was a four- or five-channel scanning radiometer capable of providing global daytime and nighttime sea-surface temperature and information about ice, snow, and clouds. These data were obtained on a daily basis for use in weather analysis and forecasting. On NOAA 8, the radiometer measured emitted and reflected radiation in the following spectral intervals: channel 1, 0.55 to 0.9 micrometer (visible); channel 2, 0.725 to 1.1 micrometers (near IR); channel 3, 3.55 to 3.93 micrometers (IR window); and channel 4, 10.5 to 11.5 micrometers (IR window). The AVHRR on NOAA 9 had a fifth channel in the 11.5- to 12.5-micrometer (IR window) region. All channels had a spatial resolution of 1.1 km at nadir, and the IR-window channels had a thermal resolution of 0.12 K at 300 K. The AVHRR was capable of operating in both real-time or recorded modes. Direct readout data were transmitted to ground stations of the Automatic Picture Transmission (APT) class at low resolution (4 km) and to ground stations of the High Resolution Picture Transmission (HRPT) class at high resolution (1 km). Data recorded on board were available for processing in the NOAA Central Computer Facility. They included global area coverage (GAC) data, with a resolution of 4 km, and local area coverage (LAC) data which were from selected portions of each orbit with a 1-km resolution. Archival data are available from SDSD.

--NOAA 8-10, NESDIS Staff------------------------------------

Investigation Name - TIROS Operational Vertical Sounder (TOVS)

Flow on - NOAA 8-10

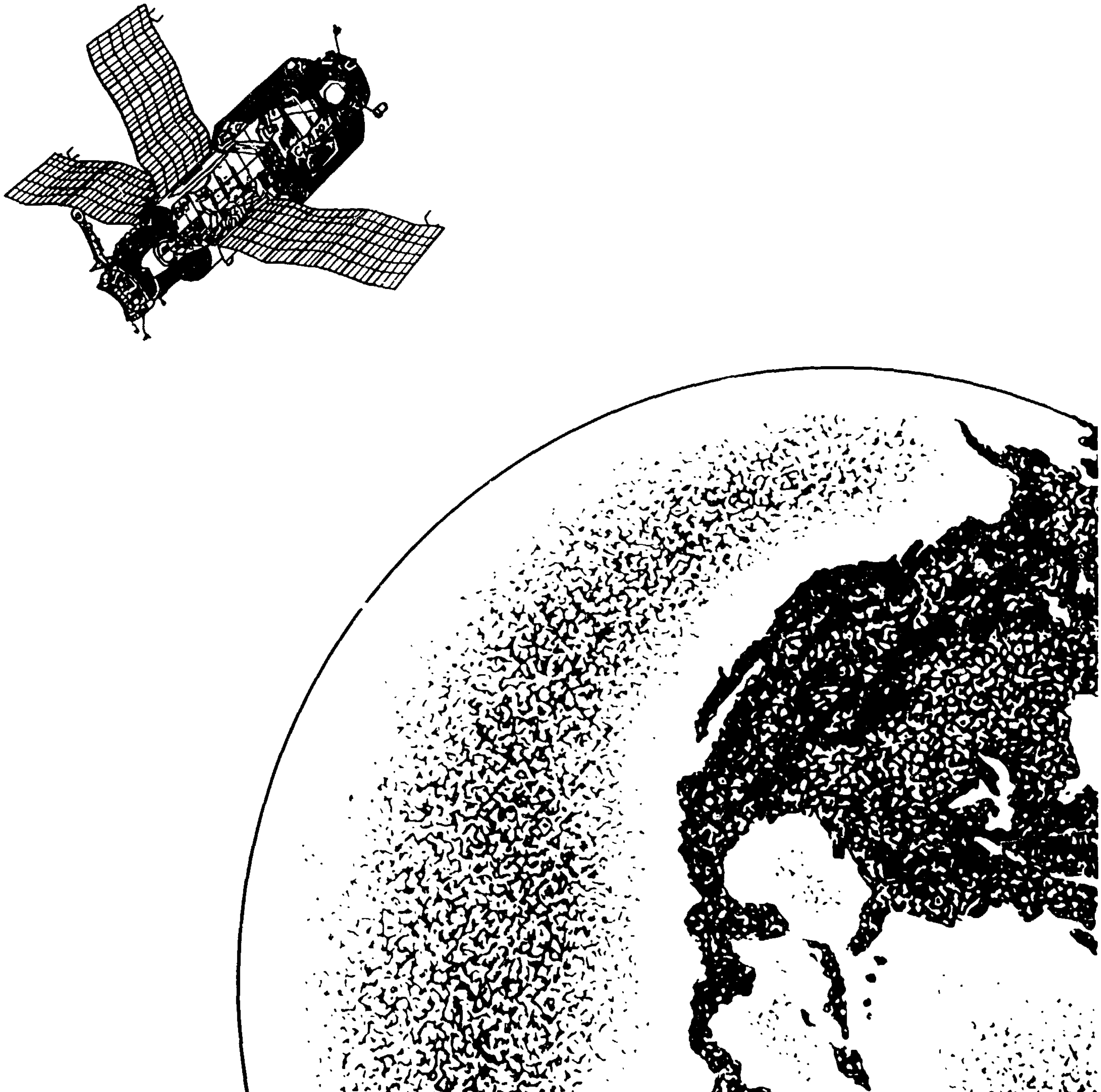
NSSDC ID - 83-022A-02, 84-123A-02, 86-073A

PI - NESDIS Staff	NOAA/NESDIS

Brief Description

The TIROS Operational Vertical Sounder (TOVS) consisted of three instruments designed to provide temperature and humidity profiles of the atmosphere from the surface to the stratosphere (approximately 1 mb). The first instrument was the second version of the High Resolution Infrared Spectrometer (HIRS/2). The HIRS was originally tested on board the Nimbus 6. The HIRS/2 had 20 channels in the following spectral intervals: channels 1 through 5, the 15-micrometers CO_2 bands (15.0, 14.7, 14.5, 14.2, and 14.0 micrometers); channels 6 and 7, the 13.7- and 13.4-micrometer CO_2/H_2O bands; channel 8, an 11.1-micrometer window region; channel 9, the 9.7-micrometer ozone bands; channels 10, 11, and 12, the 6-micrometer water vapor bands (8.3, 7.3, and 6.7 micrometers); channels 13 and 14, the 4.57- and 4.52-micrometer N_2O bands; channels 15 and 16, the 4.46- and 4.40-micrometer CO_2/N_2O bands; channel 17, the 4.24-micrometer CO_2 band; channels 18 and 19, the 4.0- and 3.7-micrometer window bands; and channel 20, the 0.7-micrometer window region. The HIRS/2 provided data for calculations of temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere, and total ozone content. The second instrument, the Stratospheric Sounding Unit (SSU), was provided by the British Meteorological Office and was similar to the Pressure-Modulated Radiometer (PMR) flown on Nimbus 6. The SSU operated at three 15.0-micrometer channels using selective absorption, passing the incoming radiation through three pressure-modulated cells containing CO_2. The SSU provided temperature information in the stratosphere. The third instrument, the Microwave Sounding Unit (MSU), was similar to the Scanning Microwave Spectrometer (SCAMS) flown on Nimbus 6. The MSU had one channel in the 50.31-GHz window region and three channels in the 55-GHz oxygen band (53.73, 54.96, 57.95 GHz) to obtain temperature profiles that were free of cloud interference. The instruments were cross-course scanning devices utilizing a step scan to provide a traverse scan, while the orbital motion of the satellite provided scanning in the orthogonal direction. The HIRS/2 had a field of view (FOV) 30 km in diameter at nadir, whereas the MSU had an FOV of 110 km in diameter. The HIRS/2 sampled 56 FOVs in each scan line about 2250 km wide, and the MSU sampled 11 FOVs along the swath with the same width. Each SSU scan line had 8 FOVs with a width of 1500 km. For a more detailed description, see W. L. Smith, "The TIROS-N Operational Vertical Sounder," Bull. Am. Meteor. Soc., v. 60, pp. 1177-1187, 1979. Archival data are available from SDSD.

SALYUT



SALYUT

The Salyut program ("Salute" to the 10th anniversary of spaceflight) is the U.S.S.R space station program. A generally accepted definition of "space station" infers: 1) high enough orbit (or sufficient orbit boosts) so that time before decay will permit visits and work by more than one spacecraft crew, 2) provision other than EVA for personnel transfer to the station, and 3) sufficient work volume for three or more astronauts. The Salyut program spacecraft generally fit this definition; thus, Salyut 1 launched in April 1971 was the world's first space station. Salyut 6 and subsequent flights remained active for years and accommodated many dockings and long-term visiting crews.

The Salyut were generally cylindrical in shape, 14 m long with diameters varying from 2.0 to 4.15 m. Salyut 1 and 2 had four wings appended while subsequent Salyut spacecraft had only three wings or vanes appended. In all cases, these appendages were for the purpose of providing power from surfaces covered with solar cells. Weight varied from 18,500 to 20,000 kg. The early versions through Salyut 5 had only one docking port, but subsequent versions had two ports. Docking vehicles have docked, redocked at the alternate port, occupied both ports simultaneously, and docked manually and automatically, with manned and unmanned spacecraft.

As would be expected, the primary emphasis on the first few Salyut missions (Salyut 1 through 5) was on developing technique, experience, and hardware to make space station rendezvous, docking, and operation a routine activity. Biology relating to man in space, photo reconnaissance, and earth resources imagery appear to be a secondary emphasis. Although meteorological observations were not primary activities, there were meteorological observations made on all successful Salyut flights. These observations should contribute significantly to meteorological research. Meteorology related work from the Salyut included observations coordinated with weather research field programs; occultation observations; imagery in UV, visible and IR; and multispectral photography for earth resources studies. Due to the limited information available on Soviet spacecraft, Table 11 is substituted for individual brief descriptions of the Salyut satellites and their meteorological experiments.

TABLE 1¹

SALYUT PROGRAM

NSSDC ID	COMMON NAME AND ORBIT INFORMATION		REMARKS
71-032A	Salyut 1		
	Launch	04-19-71	• Soyuz 10 (71-034R) docked for 5.5 h on 4-23-71, but none of the crew boarded.
	Performance	6 mo	• Soyuz 11 (71-053R) docked on 6 -71 for 22 days. Weather data taken on 9 days included:
	a/p	208/198 km	1) Visual observations coordinated with Meteor satellite data and aircraft observations
	inc	52 deg	2) Volga valley cloud cover imagery
	pd	89 min	3) Solar occultation studies
			4) Earth resources photography.
73-017A	Salyut 2		
	Launch	04-04-73	• Station did not achieve intended orbit and exploded on 4-24-73.
	Performance	10 days	
	a/p	248/207 km	
	inc	52 deg	
	pd	89 min	
74-046A	Salyut 3		
	Launch	06-25-74	• Soyuz 14 (74-051A) docked for 14 days on 7-14-74 and was a docking demonstration for the subsequent Apollo-Soyuz. Weather data taken included:
	Performance	214 days	1) Coordinated observations for TROPEX 74 (tropical weather experiment)
	a/p	269/266 km	2) Day horizon and occultation spectrography
	inc	52 deg	3) Atmospheric cloud imagery.
	pd	90 min	• Soyuz 15 (74-067A) rendezvous on 8-27-74, but docking was not accomplished.
			• Film pod was returned to earth and recovered in September 1974.

TABLE 11

SALYUT PROGRAM (continued)

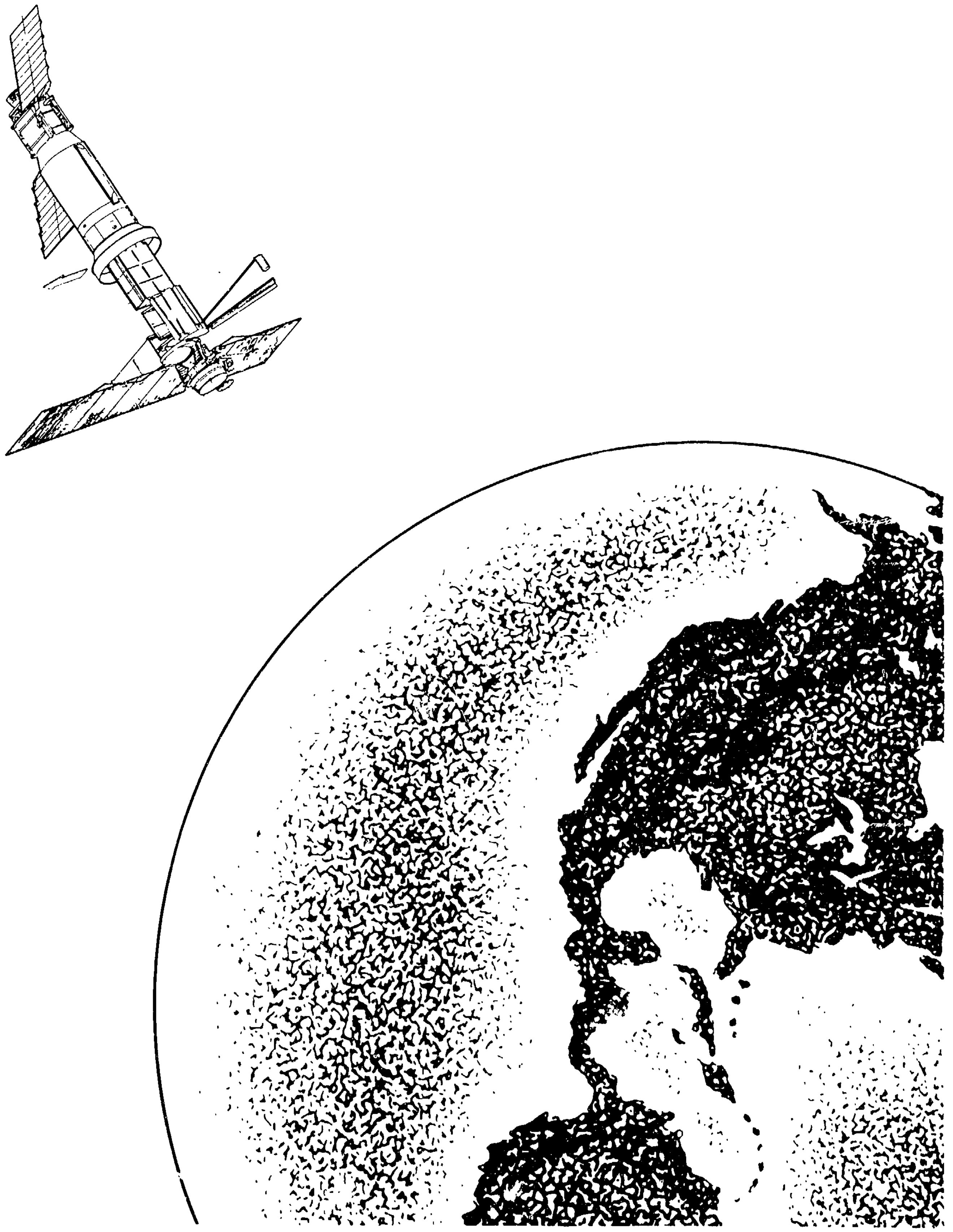
NSSDC ID	COMMON NAME AND ORBIT INFORMATION		REMARKS
74-104A	Salyut 4		• Soyuz 17 (75-001A) docked for 29 days on 1-11-75. Weather observations included UV and IR data to derive ozone and water concentrations. • Soyuz 18A (April 5 anomaly) orbit not achieved. • Soyuz 18B (75-044A) docked for 62 days on 5-25-75. Weather data included: 1) Earth multispectral photography on June 8-11 2) Use of new sounding method using UV and IR observations to map upper atmosphere ozone, water vapor, and nitrous oxides 3) Spectrographic photography of luminescent clouds and aurora. • Soyuz 20 (75-106A) accomplished an unmanned docking for 89 days on 11-17-75.
	Launch	12-26-74	
	Performance	25 mo	
	a/p	350/337 km	
	inc	52 deg	
	pd	91 min	
77-057A	Salyut 5		• Salyut 5 was thought to be primarily a military photo-reconnaissance mission. Data collection which may be weather related included: 1) IR spectrometry to study the nitric oxide-ozone interactions above 20 km 2) IR observations in the 2-15 micrometer band to obtain land and water temperatures 3) Occultation experiments to observe the vertical composition of the atmosphere 4) Observation of pollutants with 500-800 m vertical accuracy 5) Participation in "Polar Experiment-North-76" that involved a coordinated observation program with ships to study the climate of E. Greenland and adjacent ocean areas. • Soyuz 21 (76-064A) docked on 7-06-76 for 48 days.
	Launch	06-22-76	
	Performance	14 mo	
	a/p	245/230 km	
	inc	52 deg	
	pd	89 min	

TABLE 11

SALYUT PROGRAM (concluded)

NSSDC ID	COMMON NAME AND ORBIT INFORMATION		REMARKS
			• Soyuz 23 (76-100A), launched on 10-15-76, made 33 earth orbits but did not dock as planned. An unscheduled successful water recovery was made on Lake Tengis. • Soyuz 24 (77-008A) docked on 2-09-77, for 16 days. • Film pod ejected and recovered 10 days after Soyuz 24 recovery.
77-097A	Salyut 6		
	Launch	09-29-77	• Salyut 6 was an improved model space station with two docking ports. There were 33 dockings with visiting crews, of which five crews stayed for long terms. Of the 58 months of operation, there were 676 days or about 22 1/2 months of occupancy. About one-third of the occupancy time included earth observations using a new multi-spectral camera tested on Soyuz 22.
	Performance	58 mo	
	a/p	380/391 km	
	inc	52 deg	
	pd	92 min	
82-033A	Salyut 7		
	Launch	04-19-82	• Salyut 7 structure and operation were similar to Salyut 6. Numerous dockings have occurred, including Salyut 26 through 33 and Progress 1 through 12 (excluding 7 and 11).
	Performance	44 mo	
	a/p	212/260 km	
	inc	52 deg	
	pd	89 min	

SEASAT



SEASAT (OCEAN DYNAMIC SATELLITE) PROGRAM

The Ocean Dynamic Satellite, Seasat 1, was a proof-of-concept mission whose objectives included demonstration of techniques for global monitoring of oceanographic phenomena and features, provision of oceanographic data for both applications and scientific users, and the determination of key features of an operational ocean dynamics monitoring system.

Seasat 1 was launched on June 27, 1978, and injected into a 790 km, near-circular, polar orbit with an inclination of 108 degrees. Seasat 1 was designed to monitor oceanographic phenomena over a 3-year period, but spacecraft power malfunctions ended the mission prematurely after only 4 months.

The Seasat 1 sensor complement comprised a radar altimeter (ALT), a Synthetic Aperture Radar (SAR), a Seasat-A Satellite Scatterometer (SASS) that was a microwave imaging radiometer, a Scanning Multichannel Microwave Radiometer (SMMR) identical to the one on Nimbus 7, and a Visible/IR Radiometer (VIRR) identical to the Scanning Radiometer (SR) on NOAA 5.

The compressed pulse radar altimeter (ALT) measured the altitude between the spacecraft and the ocean surface with a precision of ± 10 cm. Other derived parameters include wave height, ocean-surface slope, ocean-surface currents and sea state.

The microwave wind scatterometer (SASS) operated at 14.6 GHz with a pulse repetition frequency of 34 pulses per second. Radar signal strength returns were observed across a 1500-km wide subsatellite swath with the 250-km outer edges of the swath providing only high wind speeds. There was a 400-km wide swath directly below the spacecraft where no measurements were made. Observations over the remaining portion of the swath were interpreted up to an accuracy of ± 2 m/s for wind speed and ± 20 deg in direction for wind velocities that ranged from 4 to 26 m/s.

The Synthetic Aperture Radar (SAR) produced images in both clear and cloudy areas. It operated at 1.275 GHz or the L-band (bandwidth 19.0 MHz) with pulse repetition frequencies of 1464, 1540, 1580, or 1647 pulses per second. Returns of wave form and signal strength of the radar signal were interpreted as images of the ocean surface. Wave properties (direction and height) for wavelengths between 50 and 1000 m were determined. Some meteorological features, such as severe storms, squall lines, rain cells, and windrows over sea surface, were imaged. Ice, oil spills, current patterns, and other similar features were also identified. Identical SAR observing equipment was later carried on the Shuttle STS-2.

The Scanning Multichannel Microwave Radiometer (SMMR) was a 10-channel (five frequencies: 37, 21, 18, 10.69, and 6.63 GHz dual-polarized) scanning radiometer to observe microwave brightness temperatures at wavelengths of 0.8, 1.4, 1.7, 2.8, and 4.6 cm. From these observations, sea-surface temperature, surface wind magnitude, low-level winds, water vapor, liquid water content, mean cloud-droplet size, and ocean ice were determined. These ocean-momentum and energy-transfer parameters were obtainable on a nearly all-weather basis.

The Visual and Infrared Scanning Radiometer (VIRR) was a two-channel radiometer used to observe reflected radiation in visible wavelengths (0.52 to 0.73 micrometer) during the day, and emitted IR radiation (10.5 to 12.5 micrometers) during day and night. Derived observables include surface temperatures (earth, sea, and cloud top) and imagery of visible and thermal features, such as clouds and ocean currents.

A second spacecraft, Seasat-B, was proposed to continue the proof-of-concept for ocean monitoring. However, this flight had been deferred to the National Oceanographic Satellite System (NOSS), which was to be launched in the late 1980's, but was then cancelled. Two special issues of the Journal of Geophysical Research (87, no. C5, 1982, and 88, no. C3, 1983) contain papers on all of the Seasat instruments and some data analyses.

************************** SEASAT 1 **************************

SPACECRAFT COMMON NAME- SEASAT 1
ALTERNATE NAMES- OCEAN DYNAMICS SAT-A, SEA SATELLITE-A
10967, SEASAT-A

NSSDC ID- 78-064A

LAUNCH DATE- 06/27/78 WEIGHT- 1800. KG
LAUNCH SITE- VANDENBERG AFB, UNITED STATES
LAUNCH VEHICLE- ATLAS-AGEN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OSTA

INITIAL ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC EPOCH DATE- 06/28/78
ORBIT PERIOD- 100.7 MIN INCLINATION- 108.0 DEG
PERIAPSIS- 769. KM ALT APOAPSIS- 799. KM ALT

PERSONNEL
PM - W.E. GIBERSON NASA-JPL
PS - J.A. DUNNE NASA-JPL

BRIEF DESCRIPTION
The Ocean Dynamics Satellite (Seasat 1) was designed to provide measurements of sea-surface winds, sea-surface temperatures, wave heights, internal waves, atmospheric liquid water content, sea ice features, ocean features, ocean topography, and the marine geoid. Seasat 1 provided 95% global coverage every 36 h. The instrument payload consisted of (1) an X-band compressed pulse radar altimeter (ALT), (2) a coherent synthetic aperture radar (SAR), (3) a Seasat-A scatterometer system (SASS), (4) a scanning multichannel microwave radiometer (SMMR), and (5) a visible and infrared radiometer (VIRR). The accuracies obtained were distance between spacecraft and ocean surface to 10 cm, wind speeds to 2 m/s, and surface temperatures to 1 deg C. For more information about Seasat 1, see "Seasat mission overview," Science, v. 204, pp. 1405-1424, 1979, and a special issue on the Seasat 1 sensors, IEEE J. of Oceanic Eng., v. OE-5, 1980. On October 10, 1978, Seasat 1 failed due to a massive short circuit in its electrical system. During most of its 105 days in orbit, Seasat 1 returned a unique and extensive set of observations of the earth's oceans.

------- SEASAT 1, MCLAIN--

INVESTIGATION NAME- VISIBLE AND INFRARED RADIOMETER (VIRR)

NSSDC ID- 78-064A-04 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL
TL - E.P. MCLAIN NOAA-NESDIS
TM - R. BERNSTEIN SCRIPPS INST OCEANOGR
TM - C.K. HUH LOUISIANA STATE U
TM - W.L. BARNES NASA-GSFC
TM - F.M. VUKOVICH RESEARCH TRIANGLE INST
TM - K.D. FELLERMAN NASA-GSFC

BRIEF DESCRIPTION
The Visible and Infrared Radiometer (VIRR) experiment provided (1) cloudcover and (2) clear air sea surface termperatures and cloud top brightness temperatures. This sensor, nearly identical to the Scanning Radiometer (SR) flown on the ITOS/NOAA series spacecraft, 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 0.49- to 0.94-micrometer region during the day and emitted thermal IR radiation from the earth and its atmosphere in the 10.5- to 12.5-micrometer region during both daytime and nighttime. The measurements were used to aid in interpreting the measurements from the microwave instruments. The spatial resolution was 9 km for both channels. More detailed information can be found in P. McClain, "Visible and infrared radiometer on Seasat-1," IEEE J. Oceanic Eng., v. OE-5, pp. 164-168, 1980. The instrument performance was better than specified until August 27, 1978, when the scan drive ceased functioning. Data are available from SDSD.

------- SEASAT 1, PIERSON--

INVESTIGATION NAME- SEASAT-A SATELLITE SCATTEROMETER (SASS)

NSSDC ID- 78-064A-03 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY

PERSONNEL
TL - W.J. PIERSON CUNY INST MAR+ATMOS SC
TM - W.L. GRANTHAM NASA-LARC
TM - C. FLITTNER NOAA-NWS
TM - L. BAER OCEAN + ATMOSP SERVICE
TM - I.M. HALBERSTAM NASA-JPL
TM - W.L. JONES, JR. NASA-LARC
TM - D. MOORE U OF KANSAS

BRIEF DESCRIPTION
The Seasat-A Satellite Scatterometer (SASS) experiment was designed to use an active radar system to measure sea surface winds. The instrument, developed from the Skylab experimental scatterometer, determined wind direction within 20 deg and wind speed from 4 to 26 m/s with an accuracy of 2 m/s. The transmitted frequency was 14.6 GHz. The SASS illuminated the sea surface with four fan-shaped beams (two orthogonal beams, each 500 km wide, on each side of the ground track). The high wind swaths added an additional 250 km to each side. The spatial resolution was 50 km over a region of 200 to 700 km on either side of the spacecraft. For more detailed information, see J. W. Johnson, et al., "Seasat-A satellite scatterometer instrument evaluation," IEEE J. of Oceanic Eng., v. OE-5, pp. 138-144, 1980. The SASS began operating on July 6, 1978, and gathered data for approximately 2290 h. Data are available from SDSD.

------- SEASAT 1, ROSS--

INVESTIGATION NAME- SCANNING MULTICHANNEL MICROWAVE
RADIOMETER (SMMR)

NSSDC ID- 78-064A-05 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY

PERSONNEL
TL - D.B. ROSS NOAA-ERL
TM - J.W. SHERMAN, III NOAA-NESDIS
TM - F.T. BARATH NASA-JPL
TM - J. WATERS NASA-JPL
TM - J.P. HOLLINGER US NAVAL RESEARCH LAB
TM - T.T. WILHEIT, JR. NASA-GSFC
TM - N. HUANG NASA-GSFC-WFF
TM - C.T. SWIFT NASA-LARC
TM - W.J. CAMPBELL US GEOLOGICAL SURVEY
TM - V.J. CARDONE OCEAN WEATHER INC

BRIEF DESCRIPTION
The primary purpose of the Scanning Multichannel Microwave Radiometer (SMMR) experiment was (1) to provide all-weather measurements of ocean surface temperature and wind speed, and (2) to obtain integrated liquid water column content and atmospheric water vapor column content for path length and attenuation corrections to the ALT and SASS observations. Microwave brightness temperatures were observed with a 10-channel (five-frequency dual polarized) scanning radiometer operating at 0.8-, 1.4-, 1.7-, 2.8-, and 4.6-cm wavelengths (37, 21, 18, 10.7, and 6.6 GHz). The antenna was a parabolic reflector offset from nadir by 0.73 rad. Motion of the antenna reflector provided observations from within a conical volume along the ground track of the spacecraft. The SMMR had a swath width of about 600 km and the spatial resolution ranged from about 22 km at 37 GHz to about 100 km at 6.6 GHz. The absolute accuracy of sea surface temperature obtained was 2 K deg with a relative accuracy of 0.5 K deg. The accuracy of the wind speed measurements was 2 m/s for winds ranging from 7 to about 50 m/s. The same experiment was flown on Nimbus 7. A more detailed description can be found in E. Njoku, et al., "The Seasat Scanning Multichannel Microwave Radiometer (SMMR): instrument description and performance," IEEE J. Oceanic Eng., v. OE-5, pp. 100-115, 1980. The instrument operated continuously in orbit from July 6, 1978 for a period of 95 days, until the spacecraft failed on October 10, 1978. Data are available from SDSD.

------- SEASAT 1, TAPLEY--

INVESTIGATION NAME- RADAR ALTIMETER (ALT)

NSSDC ID- 78-064A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY

PERSONNEL
TL - B.D. TAPLEY U OF TEXAS, AUSTIN
TM - S.L. SMITH, III USN SURFACE WEAPNS CTR
TM - B.H. CHOVITZ NOAA-NOS
TM - W.F. TOWNSEND NASA-GSFC-WFF
TM - J.T. MCGOOGAN NASA-GSFC-WFF
TM - H.M. BYRNE NOAA-PMEL
TM - E.M. GAPOSCHKIN SAO
TM - P. DELEONIBUS US NAVAL RESEARCH LAB
TM - B. YAPLEE US NAVAL RESEARCH LAB
TM - C.J. COHEN USN SURFACE WEAPNS CTR

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BRIEF DESCRIPTION

The Radar Altimeter (ALT) experiment measured (1) the spacecraft height above mean sea level and (2) the significant wave height and backscatter coefficient of the ocean surface beneath the spacecraft. The altimeter was a more accurate version of the Skylab Radar Altimeter, and was similar to the altimeter flown on GEOS 3. Two of its unique features were a linear FM transmitter with a 320-MHz bandwidth, which yielded a 3.125-ns time-delay resolution, and microprocessor-implemented closed-loop range tracking, automatic gain control, and real-time estimation of significant wave height. The instrument operated at 13.5 GHz using a 1-m parabolic antenna pointed at nadir and had a swath width which varied from 2.4 to 12 km, depending on sea state. The precision of the height measurement was 10 cm (rms). The estimate of significant wave height was accurate to 0.5 m or 10%, whichever was greater, and the ocean backscatter coefficient had an accuracy of 1 dB. For a more detailed description, see W. Townsend, "An initial assessment of the performance achieved by the Seasat-1 radar altimeter," IEEE J. of Oceanic. Eng., v. OE-5, pp. 80-92, 1980. The ALT was turned on for the first time on July 3, 1978, and declared operational on July 7, 1978. The ALT operated successfully until October 10, 1978, when the spacecraft prematurely terminated the mission. Data are available from SDSD.

------- SEASAT 1, TELEKI------------------------------------

INVESTIGATION NAME- SYNTHETIC APERTURE RADAR (SAR)

NSSDC ID- 78-064A-02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY

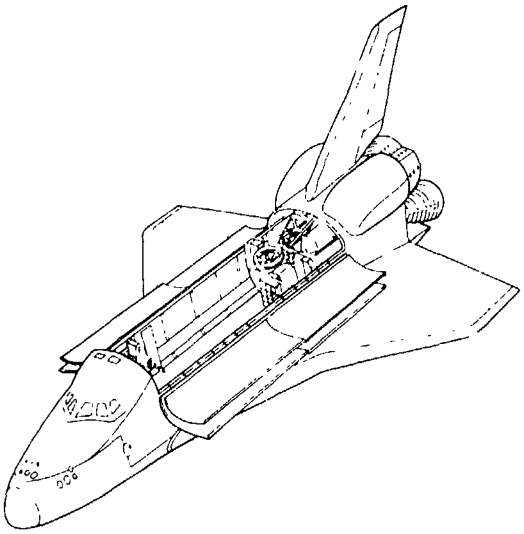
PERSONNEL

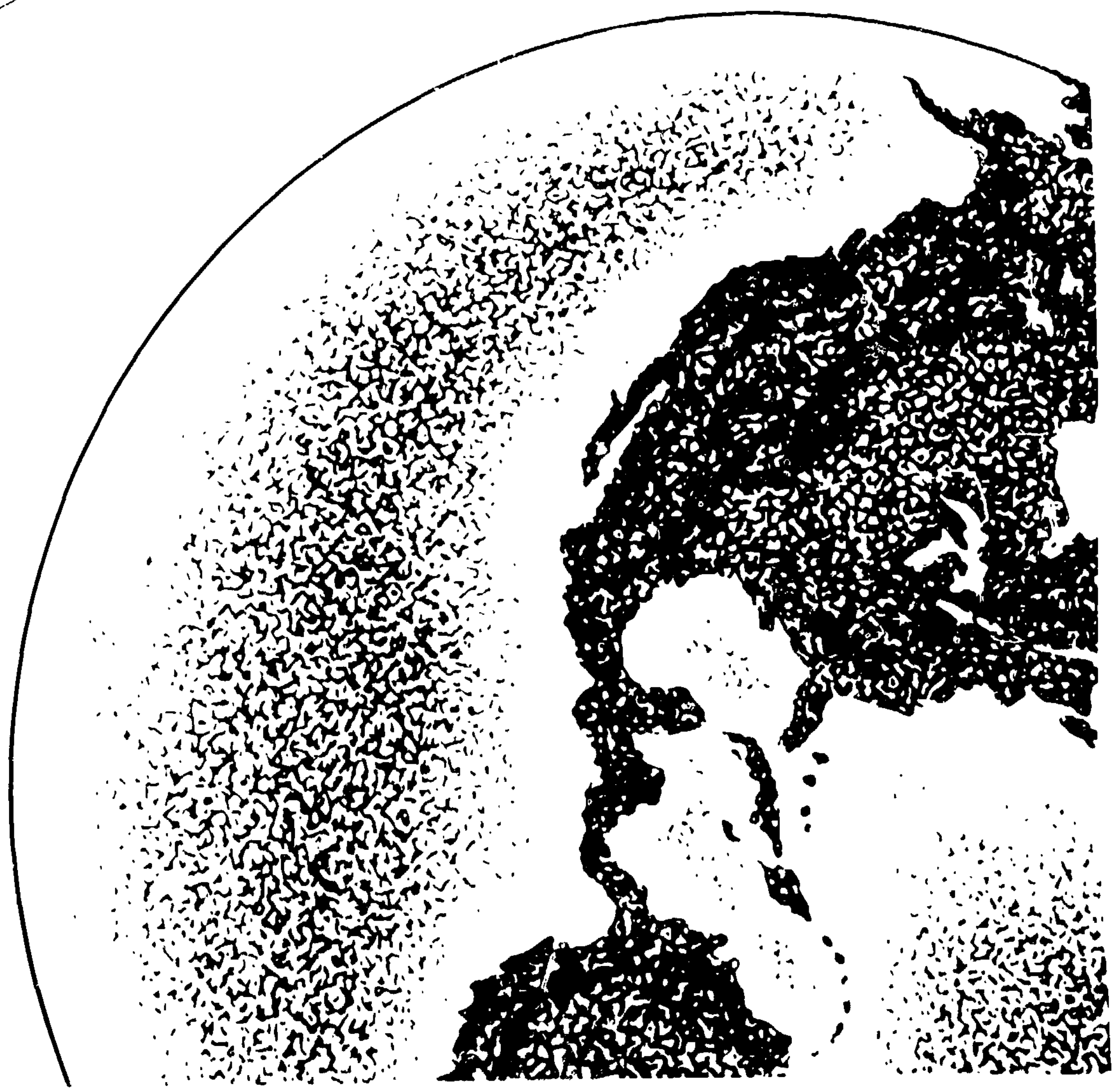
TL -	P.G.	TELEKI	US GEOLOGICAL SURVEY
TM -	D.B.	ROSS	NOAA-ERL
TM -	W.J.	CAMPBELL	US GEOLOGICAL SURVEY
TM -	A.	LOOMIS	NASA-JPL
TM -	W.E.	BROWN, JR.	NASA-JPL
TM -	F.T.	BARATH	NASA-JPL
TM -	D.H.	RODGERS	NASA-JPL
TM -	C.L.	RUFENACH	NOAA-ERL
TM -	J.W.	SHERMAN, III	NOAA-NESDIS
TM -	R.	STEWART	SCRIPPS INST OCEANOGR
TM -	J.	ZELENKA	ENVIRON RES INST OF MI
TM -	O.H.	SHEMDIN	NASA-JPL

BRIEF DESCRIPTION

The coherent Synthetic Aperture Radar (SAR) was designed to use wave pattern and dynamic behavior information to obtain images of the ocean. The SAR, imaging in the L-band (1.275 GHz) looked to the starboard side of the subsatellite track with a swath 100 km wide at a 20-deg incidence angle. The images had a spatial resolution of 25 m. The instrument, flown on Apollo 17 as the Apollo lunar sounder, yielded images of waves with wave length in the range of 50 to 1000 m and could determine wave direction within 25 deg with the possibility of a 180-deg ambiguity for one-side images. Wave height could also be determined from the data for fully developed seas. The imaging radar functioned through clouds and nominal rain to provide wave patterns near shoreline and pictures of ice, oil spills, current patterns, and similar features. For a more detailed description, see R. L. Jordan, "The Seasat-A synthetic-aperture radar systems," IEEE J. Oceanic Eng., v. OE-5, pp. 154-164, 1980. This experiment generated a very high rate of data (110 Mbps). The SAR data were not recorded on board the satellite, but were transmitted to the earth and recorded at ground stations. Data were collected from about 500 passes, with an average pass duration of 5 min. For an index of data, see "Seasat views oceans and sea ice with synthetic-aperture radar," JPL 81-120, NASA-JPL, 1981. Data are available from SDSD and ESRIN-Earthnet Programme Office, Via Galileo Galilei, 00044 Frascati, Italy.

SHUTTLE 1





SHUTTLE REMOTE SENSING PROGRAMS (I)

The NASA Space Transportation System (STS) orbiters, more commonly known as the Space Shuttle, have carried experiments and payloads since 1982 that are designed to obtain remote-sensing measurements of the earth. Despite the fact that the flights were short (usually several days) and the paths were limited to low- to mid-latitudes, some exciting data were collected. Of particular interest to meteorologists, besides those data obtained from the Spacelabs which are described in the Shuttle Remote Sensing Programs (2), are the Night/Day Optical Survey of Lightning (NOSL) experiment data and the numerous photographs taken with hand-held cameras.

The NOSL experiment was performed by astronauts on the STS 2, 4, and 6 flights. Its main objective was to relate storm development to lightning structure and occurrence. The experiment consisted of a camera with a zoom lens, a photocell sensor, and a connected tape recorder. The camera was a 16-mm motion picture, Data Acquisition Camera (DAC) that had been flown on Apollo and Skylab missions. The zoom action of the camera ranged from a 40-deg FOV (222-km ground coverage) for object locations, to a 6-deg FOV only (32-km ground coverage) for closed up observations. The diffraction grating attached to the lens provided lightning spectrographs during nighttime observations from which temperature, pressure, molecular species, electron density, and percent of ionization in the path of lightning were derived. The photocell system mounted beside the camera acquired lightning stroke data, through the recorder, to correlate with the photography of daylight lightning flashes or nighttime lightning strokes.

Because the STS 2 flight was curtailed by orbiter system problems and available crew time was very limited, very few data were collected the first time the experiment was conducted. The NOSL on STS 4 and 6 operated nominally and obtained a large quantity of data.

During other Shuttle flights, thousands of photographs were taken with hand-held cameras. Some were specifically designated for meteorological use, such as the series of cloud photographs taken during the STS 41-D mission. Besides the NOSL data and the hand-held camera photographs, there were data from other Shuttle experiments that may be applied to the study of atmospheric chemistry and meteorology.

An experiment called Measurement of Air Pollution from Satellites (MAPS) was conducted on the STS 2 and 41-G flights. It measured the distribution of carbon monoxide in the troposphere by means of a two-channel (4.67-micrometer) gas filter radiometer. The Shuttle imaging radars SIR-A and SIR-B were flown on the same flights with MAPS. They were the follow-on experiments of the Seasat Synthetic Aperture Radar (SAR). The instrument operated at L-band (1.278 GHz) with varying viewing angles of 15 to 60 deg (47 deg for SIR-A) to create two-dimensional images of the earth's surface. SIR-A obtained a total of 8 h of data with a swath width of 50 km and a spatial resolution of 40 m x 40 m; SIR-B obtained about 7 h of data with a swath width of 20 to 50 km and a spatial resolution of 25 m x (17 to 58) m. Although most images are used for geoscientific studies, several were interpreted for fronts and wind and wave patterns in the ocean incurred by severe storms.

Another imaging instrument, the Modular Optoelectric Multispectral Scanner (MOMS), was flown on the Shuttle Pallet Satellite (SPAS) onboard the STS 7 and 11, respectively. The two-channel scanner measured earth targets at 0.6 and 0.8 micrometer, with a swath width of 140 km and a ground resolution of 20 m. About 250 visible and IR images were collected from each of the two missions. Lastly, the large format camera (LFC) flown on the STS 41-G obtained thousands of stereographic photographs with a 10-m ground resolution. Although most test sites were imaged under optimum weather conditions, and both the MOMS and the LFC data are primarily for earth resources studies, some may be applicable to meteorological studies.

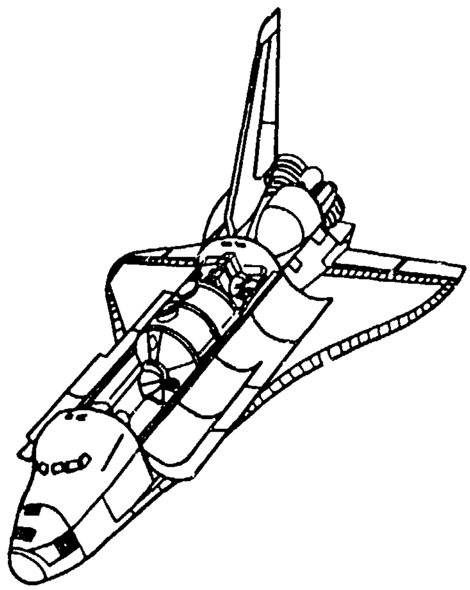
No individual spacecraft and experiment descriptions are included here. Instead, a listing of Shuttle remote sensing programs follows to identify the contacts for data (see Table 12).

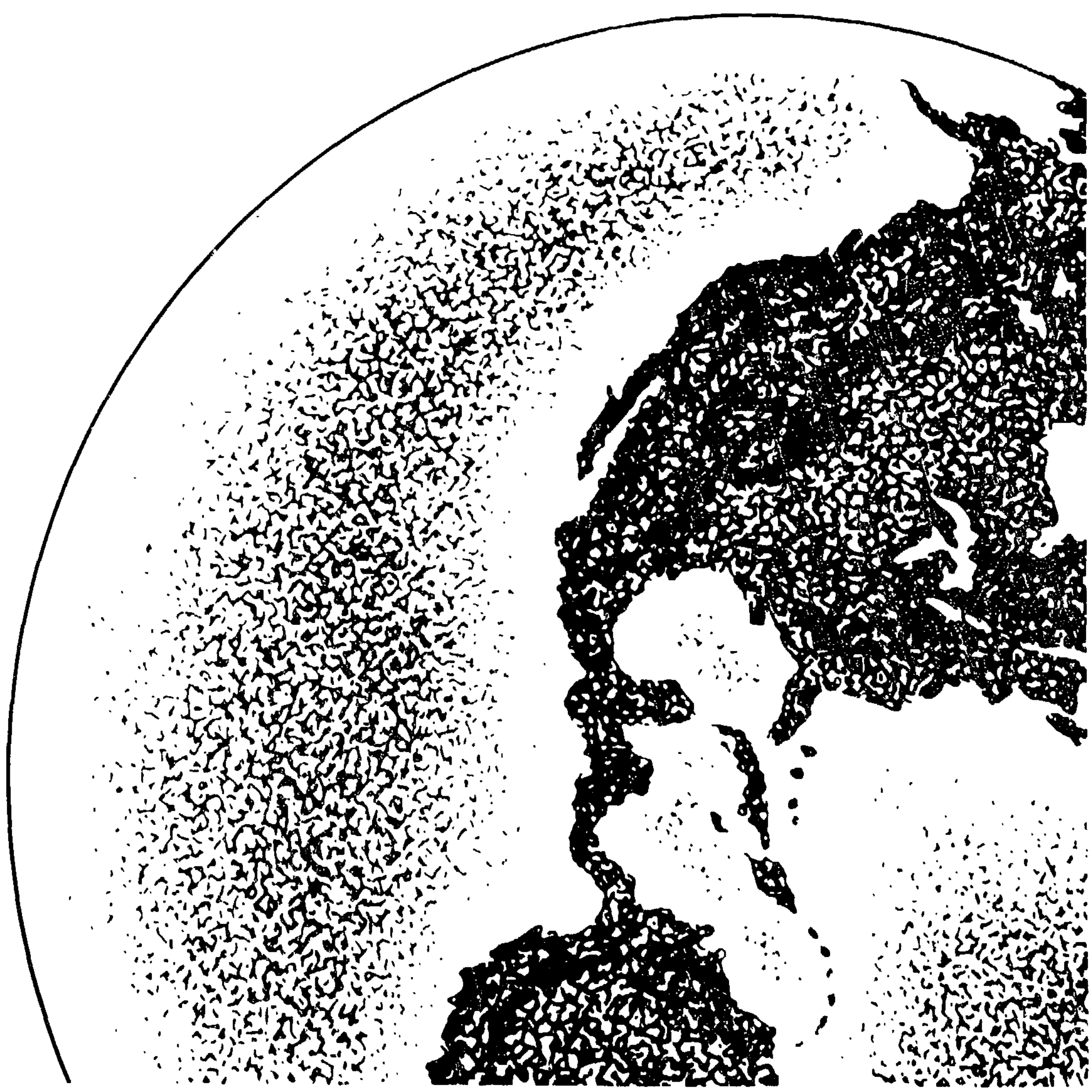
TABLE 12

SHUTTLE REMOTE SENSING PROGRAMS (1)

EXPERIMENT	SHUTTLE FLIGHTS	FLIGHT DURATION	CONTACT
Hand-held camera photo	Multiple	Vary	EROS Data Center
LFC	STS 41-G	10/05/84-10/13/84	EROS Data Center
MAPS	STS 2 STS 41-G	11/12/81-11/14/81 10/05/84-10/13/84	NSSDC/WDC-A-R&S
MOMS	STS 7 STS 11	06/18/83-06/24/83 02/03/84-02/11/84	German Remote Sensing Data Center, Oberpfaffenhofen
NOSL	STS 2 STS 4 STS 6	11/12/81-11/14/81 06/27/82-07/04/82 04/04/83-04/09/83	Dr. Bernard Vonnegut, State University of New York at Albany
SIR-A SIR-B	STS 2 STS 41-G	11/12/81-11/14/81 10/05/84-10/13/84	NSSDC/WDC-A-R&S

SHUTTLE 2: SPACELAB





SHUTTLE REMOTE SENSING PROGRAMS (2): SPACELAB

The Spacelab, always remaining attached to a Space Shuttle, serves as a near-earth platform for scientists participating directly in the experiments for periods of 1 to 4 weeks. The Shuttle/Spacelab system, a joint effort of NASA and ESA, offers a new capability for investigating the earth's environment, solar-terrestrial relationships, and the physics of the solar system and beyond. Experiments carried out by the payloads range from passive observation of remote astronomical energy sources, to in situ active probing of the earth's atmosphere and magnetosphere, to the examination of the processing of materials in space.

Initial Spacelab missions were planned as multidisciplinary flights, and later missions were dedicated to a particular scientific discipline. On a given flight, the Spacelab configuration can consist of a module only, a pallet only, or a combination of a module and pallet. Spacelabs are launched into circular 250- to 370-km orbits with 50- to 57-deg inclination. The first Spacelab was launched on September 30, 1983, for a 10-day duration.

Experiments of meteorological interest included a metric camera and a Microwave Remote Sensing Experiment (MRSE) on Spacelab 1. The metric camera provided over 1000 black and white, color, and color IR images of the earth's surface with a ground resolution of 20 m. The MRSE was a radar facility that operated at a frequency of 9.65 GHz in three modes: (1) a two-frequency scatterometer for measurement of ocean wave spectra at wavelengths within a range of 5 to 500 m, (2) a Synthetic Aperture Radar (SAR) for imaging earth surface at a 25-m resolution over an 8.5-km swath, and (3) a passive microwave radiometer for observing naturally emitted microwave radiation from the earth to provide sea surface temperatures to an accuracy of ± 1 K. Due to some operational problems, the MRSE was able to work only in the passive sensing mode and, consequently, had collected very few data. Images from the metric camera can be obtained from Dr. M. Reynolds, ESTEC, Postbus 299, 2200 AG Noordwijk, Netherlands.

******************************* STS 9/SPACELAB 1 ********************

SPACECRAFT COMMON NAME- STS 9/SPACELAB 1
ALTERNATE NAMES- SPACELAB 1/STS 9, SPACE TRANSPORT SYS-9
14523, SPACELAB 1

NSSDC ID- 83-116A

LAUNCH DATE- 11/28/83 WEIGHT- 14730. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SHUTTLE

SPONSORING COUNTRY/AGENCY

INTERNATIONAL	ESA
UNITED STATES	NASA-OSSA

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 11/29/83
ORBIT PERIOD- 89.5 MIN	INCLINATION- 57. DEG
PERIAPSIS- 242. KM ALT	APOAPSIS- 254. KM ALT

PERSONNEL

MM - J.A.	DOWNEY, 3RD	NASA-MSFC
MS - C.R.	CHAPPELL	NASA-MSFC
PM - H.G.	CRAFT, JR.	NASA-MSFC

BRIEF DESCRIPTION

The first Spacelab mission was a joint NASA and European Space Agency (ESA) mission. Spacelab 1 consisted of a pressurized compartment (module) for housing equipment and flight personnel and a space-exposed platform to accommodate instruments. The compartment and platform were flown into space and returned inside the payload compartment of the Space Shuttle. The mission lasted 10 days, and while in space, the Shuttle payload compartment doors were opened to allow viewing of the earth, sun, and deep space. Spacelab 1 was a multidiscipline mission comprising five broad areas of investigation: Atmospheric Physics and Earth Observations, Space Plasma Physics, Astronomy and Solar Physics, Material Sciences and Technology, and Life Sciences. The Atmospheric Physics investigations conducted studies of the earth's environment through surveys of temperature, composition, and motion of the atmosphere. The Earth Observations investigations used and evaluated the capability of advanced measuring systems for making topographic and thematic maps from high-resolution photographs and from remote-sensing data. Investigations in the Space Plasma Physics group studied the charged particle or plasma environment of the earth. The Astronomy investigations studied astronomical sources of radiation in the ultraviolet and X-ray wavelengths. The Solar Physics investigations measured the total energy output of the sun using three different methods with the instruments cross calibrated so that meaningful comparisons could be made. The Material Sciences and Technology investigations took advantage of the microgravity conditions to perform studies in such areas as crystal growth, metallurgy, tribology, fluid physics, and ceramics technology. The Life Sciences investigations were concerned with the effects of the space environment (zero gravity and high-energy radiation) on human physiology and on the growth, development, and organization of biological systems. The mission was considered very successful.

------- STS 9/SPACELAB 1, DIETERLE-----------------------------

INVESTIGATION NAME- MICROWAVE REMOTE SENSING EXPERIMENT

NSSDC ID- 83-116A-39

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY
EARTH RESOURCES SURVEY

PERSONNEL

PI - G.	DIETERLE	ESA-TOULOUSE
PI - G.P.	DE LOOR	TNO PHYSICS LAB

BRIEF DESCRIPTION

The objectives of the microwave remote sensing experiment were to develop all-weather remote sensing methods, study sensor-object interaction by measurement of ocean surface wave spectra with a two-frequency scatterometer, and verify synthetic aperture radar behavior. The microwave remote sensing experiment instrumentation was a radar facility. In the active modes, the instrument transmitted microwave energy in X-band (9.65 GHz) to earth targets. A sensitive low-noise receiver detected the backscattered radar signals. The instrument operated in three modes: (1) a main mode as a two-frequency scatterometer (2FS), (2) a high-resolution mode as a synthetic aperture radar (SAR), and (3) a passive mode as a passive microwave radiometer. In the 2FS mode, the instrument measured the ocean surface wave spectra at wavelengths within a range of 5 to 500 m by using the complex backscattering of the ocean surface at two adjacent microwave frequencies. In the SAR mode, areas of the earth's surface were imaged. The backscattered data were coherently recorded and off-line processing provided imagery with a ground resolution of 25 m by 25 m. The radiometer mode, which measured naturally emitted microwave radiation from the earth to provide ocean surface temperatures, was used in time multiplex with other modes. Due to equipment malfunction, only 20% of the planned objectives were accomplished.

------- STS 9/SPACELAB 1, REYNOLDS-----------------------------

INVESTIGATION NAME- METRIC CAMERA EXPERIMENT

NSSDC ID- 83-116A-38

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
EARTH RESOURCES SURVEY

PERSONNEL

PI - M.	REYNOLDS	ESA-TOULOUSE
PI - G.	KONECNY	TECH U OF HANNOVER

BRIEF DESCRIPTION

The purpose of the metric camera experiment was to test the mapping capability of high-resolution space photography. The experiment used a Zeiss RMK A30/23 aerial survey camera and a Skylab optical window having the following characteristics: f = 305 mm; f-stops available--f/5.6, f/8, f/11; shutter speeds--1/100, 1/250, 1/500, and 1/1000 s; negative size--23 x 23 cm (length for 550 photos per magazine); angle of field--56 deg; and ground resolution--20 m. Black-and-white, color, and color IR films were used. To obtain 80% longitudinal overlap of subsequent photographs at a Spacelab velocity of 7.7 km/s, there was a time interval of about 5 s between two successive exposures. Strips 1800 to 2300 km in length were covered on the ground in each sequence. Approximately 80% of the planned objectives were accomplished.

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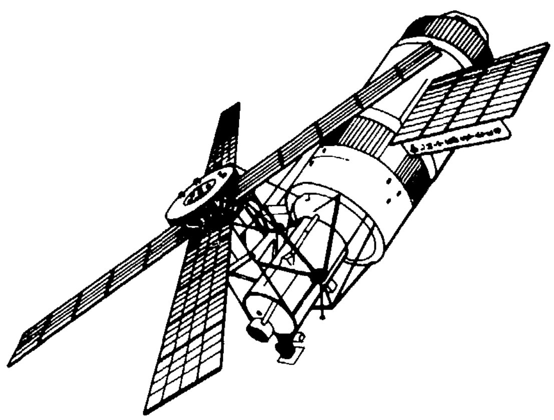
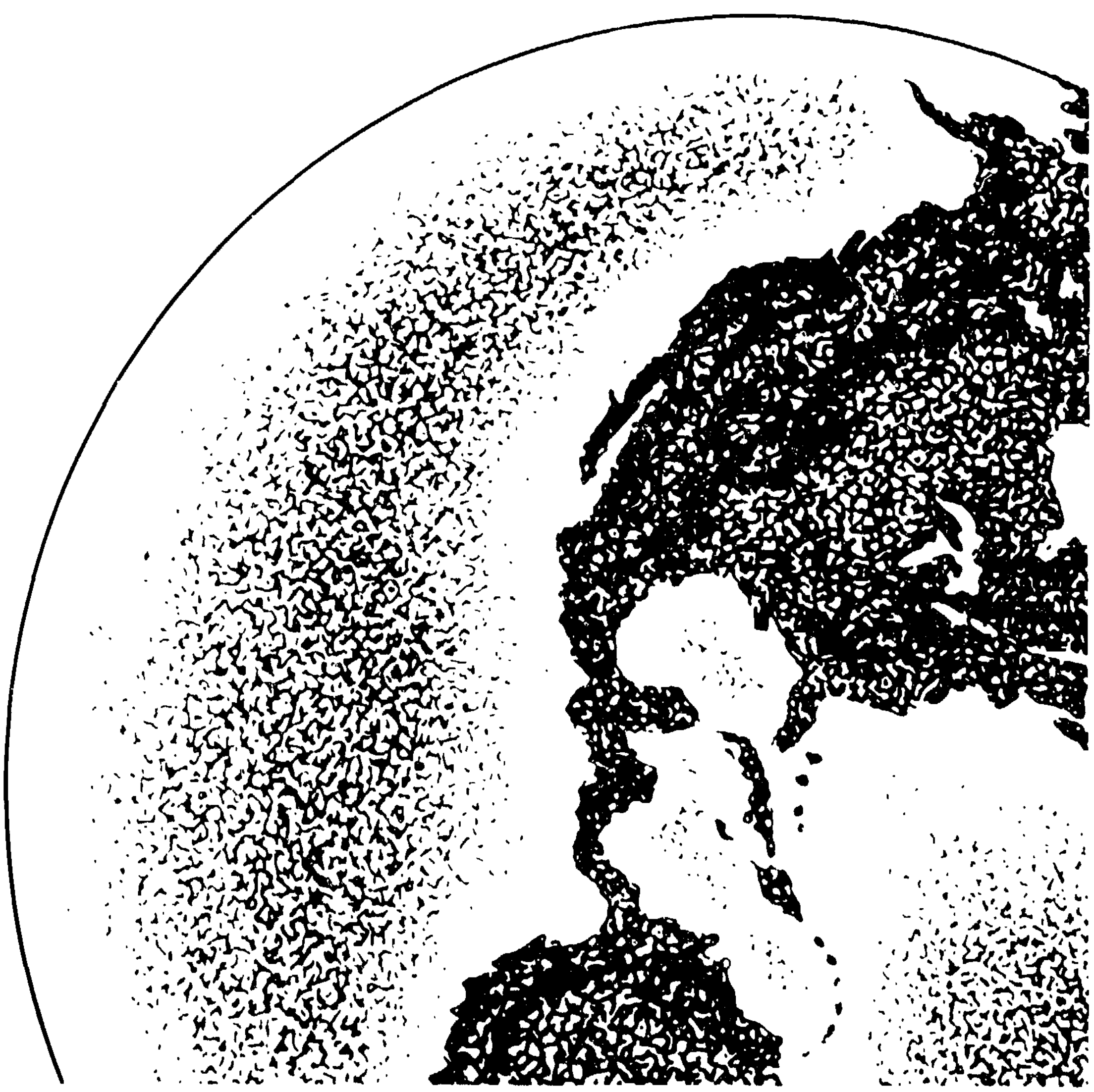
SKYLAB





SKYLAB PROGRAM

Skylab, with experiments developed through cooperative efforts with the world's scientific community, was the first space station. An extension of the manned Mercury-Gemini-Apollo space programs, Skylab was designed to expand our knowledge of long-duration space flights of men and systems and to accomplish selected scientific investigations and observations from earth orbit. Skylab, consisting of four major assemblies (the orbital workshop, the airlock module, the multiple docking adapter, and the Apollo telescope mount), was launched into a 430-km orbit on May 14, 1973. At three subsequent times, three-man crews in a modified Apollo command and service module were launched into rendezvous orbit to dock with Skylab. These crews operated Skylab experiments for periods ranging from 1 to 3 months over a total period of 9 months. Over 50 experiments were carried out in areas of life sciences, earth resources, solar physics, astrophysics, material sciences, engineering, and technology. Some solar observations were continued during two unmanned periods.

Five experiments in the Earth Resources Experiment Package (EREP) on Skylab permitted simultaneous remote sensing of ground-truth sites in the visible, infrared, and microwave spectral bands for a coverage of the entire contiguous United States and much of the world. The experiments were: (1) the Multispectral Photographic Facility (S190), (2) the Infrared Spectrometer (S191), (3) the Multispectral Scanner (S192), (4) the Microwave Radiometer/Scatterometer/Altimeter (S193), and (5) the L-band Microwave Radiometer (S194).

The Multispectral Photographic Facility had two parts. One, a multispectral photographic camera (S190A) was used for medium-resolution (about 75 m) black and white and color infrared photos and for higher resolution (about 38 m) black and white color photos in visible spectral bands. The second part, an earth terrain camera (S190B), was a single-lens camera that produced black and white, color, and color infrared photos with a much finer resolution (17 to 30 m). This experiment provided valuable photographs for large-scale observations of croplands, forests, watersheds, geological formations, etc. The cloud and snow cover in the pictures were used for meteorological study.

The other four experiments in the EREP provided valuable data for meteorological use. The Infrared Spectrometer (S191) was observed in the visible through near-infrared (0.4 to 2.5 micrometers) and in the far-infrared (6.0 to 16.0 micrometers) spectral bands. This experiment provided data to study the extent and health of surface vegetation, geological structure, atmospheric density distribution, and the sea surface temperature field. The Multispectral Scanner (S192) operated in 13 spectral bands from 0.4 to 12.5 micrometers. Data were used for spectral signature identification and mapping of ground truth targets in agriculture, forestry, geology, hydrology, and oceanography. The fourth experiment in EREP was a Microwave Radiometer/Scatterometer/ Altimeter (S193). This passive radiometer and active radar scatterometer operated at 13.9 GHz jointly or separately and shared one antenna with the altimeter. The radiometer/scatterometer experiment was suitable for establishing sea-surface brightness temperature and roughness (related to sea-surface winds). The altimeter was a compressed pulse radar system operating at 13.9 GHz. It measured average sea-surface elevations with a resolution of about 0.9 m. The fifth experiment was an L-band experiment (S194) that supplemented the measurement results of the microwave radiometer by taking into consideration the effect of clouds on radiometric measurements.

During launch, a solar panel sustained severe damage. This damage was corrected with the construction of a makeshift awning by the first visiting crew. It was planned to boost the Skylab orbit for further scientific use with a boost rocket that would rendezvous and be joined to the Skylab. Due to unpredicted rapid orbit decay, the timetable for completion and orbit of the booster was over one year late, and the plan had to be cancelled. Reentry occurred in the Indian Ocean area, and some debris was recovered in Australia. Queries about data can be directed to the EROS Data Center in Sioux Falls, SD.

**************** SKYLAB ****************

SPACECRAFT COMMON NAME- SKYLAB
ALTERNATE NAMES- 6633

NSSDC ID- 73-027A

LAUNCH DATE- 05/14/73 WEIGHT- 90607. KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- SATURN

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA-OMSF

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC	EPOCH DATE- 05/14/73
ORBIT PERIOD- 93.4 MIN	INCLINATION- 50.0 DEG
PERIAPSIS- 434.0 KM ALT	APOAPSIS- 442.0 KM ALT

PERSONNEL
PM - O.G. SMITH NASA-JSC

BRIEF DESCRIPTION

The Skylab (SL) was a manned, orbiting spacecraft composed of five parts, the Apollo telescope mount (ATM), the multiple docking adapter (MDA), the airlock module (AM), the instrument unit (IU), and the orbital workshop (OWS). The Skylab was in the form of a cylinder, with the ATM being positioned 90 deg from the longitudinal axis after insertion into orbit. The ATM was a solar observatory, and it provided attitude control and experiment pointing for the rest of the cluster. It was attached to the MDA and AM at one end of the OWS. The retrieval and installation of film used in the ATM was accomplished by astronauts during extravehicular activity (EVA). The MDA served as a dock for the command and service modules, which served as personnel taxis to the Skylab. The AM provided an airlock between the MDA and the OWS, and contained controls and instrumentation. The IU, which was used only during launch and the initial phases of operation, provided guidance and sequencing functions for the initial deployment of the ATM, solar arrays, etc. The OWS was a modified Saturn 4B stage suitable for long duration manned habitation in orbit. It contained provisions and crew quarters necessary to support three-person crews for periods of up to 84 days each. All parts were also capable of unmanned, in-orbit storage, reactivation, and reuse. The Skylab itself was launched on May 14, 1973. It was first manned during the period May 25 to June 22, 1973, by the crew of the SL-2 mission (73-032A). Next, it was manned during the period July 28 to September 25, 1973, by the crew of the SL-3 mission (73-050A). The final manned period was from November 16, 1973, to February 8, 1974, when it was manned by the crew from the SL-4 mission (73-090A).

------- SKYLAB, BARNETT --

INVESTIGATION NAME- INFRARED SPECTROMETER

NSSDC ID- 73-027A-18 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY
EARTH RESOURCES SURVEY

PERSONNEL
PI - T.L. BARNETT NASA-JSC

BRIEF DESCRIPTION

The primary goal of Skylab experiment S191 was 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. Another specific goal was to assess the value of real-time identification of ground sites by an astronaut. The S191 was a dual spectral band system, with its short-wavelength band at 0.4 to 2.5 micrometers, and its long wavelength spectral band at 6.0 to 16.0 micrometers. The field of view of the system was one millirad (0.435-km diameter circular foot print), 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 in size. A 16-mm camera was used to photograph these sites. The primary data were recorded on magnetic tape along with data from other sensors in the earth resources experiment package (EREP). The magnetic tape and the film from the viewfinder camera were returned with each crew rotation. For information of data availability, contact the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota.

------- SKYLAB, DEMEL --

INVESTIGATION NAME- MULTISPECTRAL PHOTOGRAPHIC FACILITY

NSSDC ID- 73-027A-17 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY
EARTH RESOURCES SURVEY

PERSONNEL
PI - K. DEMEL NASA-JSC

BRIEF DESCRIPTION

The S190 Skylab experiment was designed to photograph regions of the earth's surface, including oceans, in a range of wavelengths from near infrared through the visible. The facility had two parts: the multispectral photographic cameras (S190A) that simultaneously photographed the same area, each viewing a different wavelength, and the earth terrain camera (S190B) which was a single-lens camera. The S190A experiment consisted of six high-precision 70-mm cameras. The matched distortion and focal length camera array contained forward motion compensation to correct for spacecraft motion. The f/2.8 lenses, with a focal length of 6 in., had a field of view of 21.1 deg providing a square surface coverage of about 163 km on each side from the 435-km altitude. The system was designed for the following wavelength/film combinations: (1) 0.5-0.6 micrometer, Panatomic-X B+W, (2) 0.6-0.7 micrometer, Panatomic-X B+W, (3) 0.7-0.8 micrometer, IR B+W, (4) 0.8-0.9 micrometer, IR B+W, (5) 0.5-0.88 micrometer, IR color, and (6) 0.4-0.7 micrometer, high-resolution color. The spectral regions designated were selected to separate the visible and photographic infrared spectrum into bands that were expected to be most useful for multispectral analysis of earth surface features. Further spectral refinements were made by using different filter combinations. This camera system provided photos with a ground resolution of 30 to 46 m in the visible wavelengths and 73 to 79 m in the infrared wavelengths. The S190B camera utilized a single 18-in focal length lens with 5-in. film. Its field of view of 14.2 deg provided a surface coverage of about 109 km by 109 km. This camera was designed to use high-resolution color film and was operated from the OWS sal window, producing photos with a ground resolution of 17 to 30 m. The camera compensated for spacecraft forward motion through programmed camera rotation. Shutter speeds were selectable at 5, 7, and 10 msec with a curtain velocity of 110 in./s. For information of data availability, contact the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota.

------- SKYLAB, EVANS --

INVESTIGATION NAME- MICROWAVE RADIOMETER/SCATTEROMETER/ ALTIMETER

NSSDC ID- 73-027A-20 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY
EARTH RESOURCES SURVEY

PERSONNEL
PI - D.E. EVANS NASA-JSC

BRIEF DESCRIPTION

The objectives of this S193 Skylab experiment were (1) to provide the near-simultaneous measurement of the radar differential backscattering cross section and the passive microwave thermal emission of the land and ocean on a global scale, and (2) to provide engineering data for use in designing space radar altimeters. The S193 was useful in studying varying ocean surfaces, wave conditions, sea and lake ice, snow cover, seasonal vegetational changes, flooding, rainfall and soil types. The sensor generally operated over ocean and ground areas where ground truth data were available, but additional targets of opportunity, such as hurricanes and storms, were viewed when the opportunity arose. S193 incorporated a radiometer, a scatterometer, and a radar altimeter, all operating at the same frequency of 13.9 GHz. The equipment shared a common gimballed antenna mounted on the outside of the multiple docking adapter. The scatterometer measured the backscattering coefficient of ocean and terrain as a function of incidence angle ranging from 0 to 48 deg. The radiometer was a passive sensor which measured the brightness temperature, from a cell on the earth's surface, as a function of incidence angle from the surface. The altimeter was a compressed-pulse radar system to measure average ocean-surface elevation variations with a resolution of about 0.9 km. The S193 ground coverage was 48 deg forward and 48 deg to either side of the spacecraft ground track. 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. For information of data availability, contact the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota.

------- SKYLAB, EVANS --

INVESTIGATION NAME- L-BAND MICROWAVE RADIOMETER

NSSDC ID- 73-027A-21 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY
EARTH RESOURCES SURVEY

PERSONNEL
PI - D.E. EVANS NASA-JSC

BRIEF DESCRIPTION
This Skylab experiment (S194) was to supplement experiment S193 (73-027A-20) in measuring the brightness temperature of the earth's surface along the spacecraft track, which would provide ocean surface features, varying winds over ocean areas, and earth surface features information. The S194 experiment was a passive, non-scanning microwave sensor that utilized a fixed planar array antenna. The brightness temperature of the earth was recorded in the L-band range from 1.4 t 1.427 GHz with a digital output giving an absolute antenna temperature to an accuracy of 1 deg K. The system utilized a built-in calibration scheme that sampled known sources. The spatial characteristics were a half-power beam width of 15 deg, first null beam width of 37 deg (97% of power) and a circular footprint of approximately 124-km diam. (half-power). All data were recorded on magnetic tapes. The data output was at 200 bps. For information of data availability, contact the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota.

------- SKYLAB, KORB--

INVESTIGATION NAME- MULTISPECTRAL SCANNER

NSSDC ID- 73-027A-19

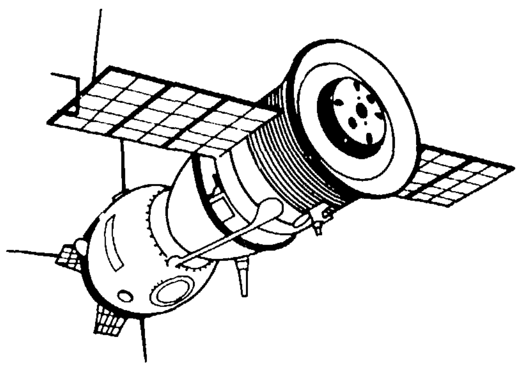
INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

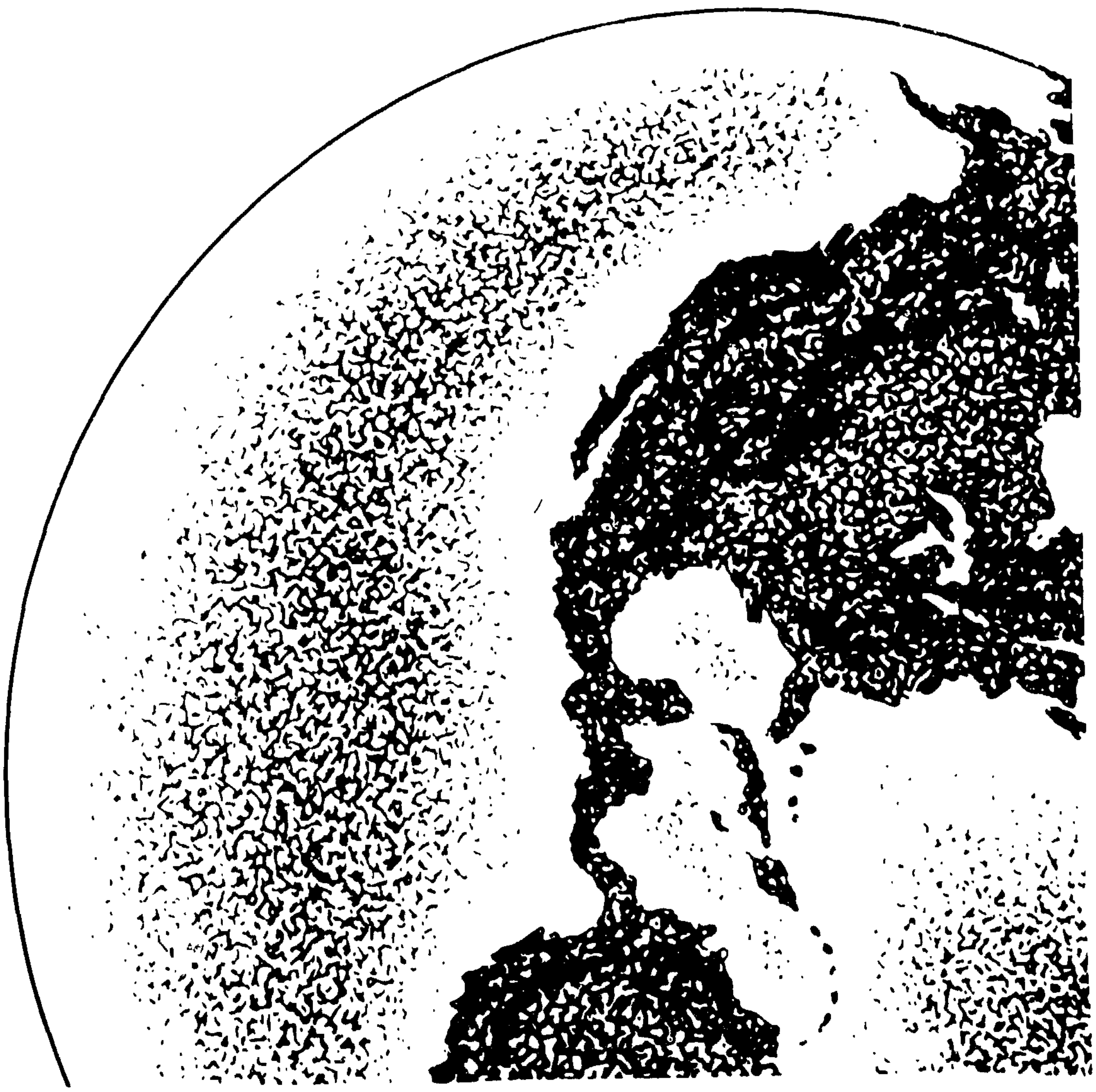
INVESTIGATION DISCIPLINE(S)
METEOROLOGY
OCEANOGRAPHY
EARTH RESOURCES SURVEY

PERSONNEL
PI - C.L. KORB NASA-JSC

BRIEF DESCRIPTION
The primary goal of Skylab experiment S192 was to assess the feasibility of multispectral techniques, developed in the aircraft program, for remote sensing of earth resources from space. Specifically, attempts were made at spectral signature identification and mapping of ground truth targets in agriculture, forestry, geology, hydrology, and oceanography. The S192 instrument had 12 spectral bands with wavelengths ranging from 0.41 to 2.43 micrometers in the visible and near IR regions, and 1 band in the 10.2-12.5 micrometer thermal IR region. The system gathered quantitative high-spatial-resolution line-scan imagery data on radiation reflected and emitted by selected ground sites in the U.S. and other parts of the world. The motion of the sensor was a circular scan with a radius of 41.8 km. Data of ground scenes were recorded as the scan swept a track 74 km wide in front of the spacecraft, yielding a 79-m ground resolution. The S192 optical mechanical scanner utilized a 30-cm reflecting telescope with a rotating mirror. The telescope and mirror were mounted outside the multiple docking adapter. Information on days of operation and area of coverage of experiment can be obtained from the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota.

SOYUZ





SOYUZ PROGRAM

The Soyuz program is the U.S.S.R. solution to transportation of crews and material to and from their space station (Salyut) satellites. The major emphasis of the project is to develop ferry craft technology and use/docking techniques in concert with analogous development in the Salyut and Progress programs. Other experimental emphasis included medical/biological experiments, manufacturing, and surveys related to geology and earth resources. In addition to the Soyuz spacecraft, an unmanned program (Progress spacecraft) was developed to transport fuel and supplies to space stations.

The Soyuz satellites were nominally made up of two or three sections. The cylindrically shaped (approximately 7 feet in diameter by 9 feet in length) service module has been launched in at least four major variations and has always been one component of the Soyuz spacecraft. The command module was headlight shaped (paraboloid of revolution) with dimensions similar to the service module and has been launched in at least three major versions. The small end of the command module was usually connected to the spherical (over 2 m diameter) orbital module. This has flown in at least four versions and has contained equipment, food, and supplies in addition to the docking port. On occasion, the orbital or the command module was omitted. The three connected components made up a roughly cylindrical spacecraft about 2.5 m in diameter and 8 m long. The term "Sovietsky Soyuz" is translated as "Soviet Union," but the term Soyuz may also refer to the project mission of making union (docking) with the space station craft.

With the exception of Soyuz 2 (target for docking test) and Soyuz 20 and 34 (unmanned docks with Salyut 4 and 6), most flights appear to have included some manner of meteorological observations in their planning, many of which may have been only logged visual observations. Soyuz 22 was an 8-day test of a newly developed six-channel, multispectral, high-speed camera (MKF-6) with stereo capabilities. This equipment was a joint U.S.S.R.-Democratic Republic of Germany development manufactured by Zeiss of the DRG. This Raduga (rainbow) experiment had two IR and four visible channels. It was intended to photograph earth surfaces for studies primarily in geology, geography, agriculture, and forestry. Secondary considerations were meteorological, oceanographic, and cryospheric studies. This experiment was similar to the Skylab Experiment S109.

In nearly all flights, successfully docked equipment and experiments used the Soyuz for transportation and accomplished the observations during their Salyut residence. Flights of less than 4 days were usually rendezvous, tests, or failed docking flights. Flights of 4 to 8 days usually consisted of successful dockings and visiting crews. Long-term residence on the Salyut space station ranged from 16 days (Soyuz 14 and Salyut 2) to 185 days (Soyuz 35/37 and Salyut 6). Salyut 4 and 5 each had two long-term visiting crews for over 70 hours total on each space station. Salyut 4 occupancy was during early and mid-1975, while Salyut 5 was occupied during periods from mid-1976 to early 1977. Salyut 6 was the first truly operational space station. Its equipment and activities included two docking ports, frequent docking of two spacecraft at one time, 15 visiting crews, unmanned supply and refueling dockings, and three long-term scientific crew residencies. Considering only Salyut 6 and 7, observations have been made frequently ever since December 1977.

The first 11 Soyuz were designed for three astronauts. Subsequent to crew deaths on Soyuz 11, the spacecraft were redesigned to allow for only two crew members. The last numbered Soyuz (Soyuz 40) was flown in May 1981 to dock with Salyut 6. The new T (transport) series Soyuz, redesigned for crews of three, was first flown in December 1979, and Soyuz T-5 was the first spacecraft docked to Salyut 7.

Since the Soyuz flights are related to meteorological research only indirectly through supply to, and residence on the Salyut series, no spacecraft listings or descriptions are provided here. It is suggested that the interested reader investigate references to Salyut spacecraft (especially Salyut 6 and 7) for more detail on meteorological experiments and observations related to the Soyuz program. Table 13 lists known Soyuz flights with related information, including identification of those with meteorological experiments.

TABLE 13

SOYUZ PROGRAM

NSSDC ID	SOYUZ NUMBER	DATES LAUNCH		RETURN	SCIENCE MISSION*	SALYUT CONTACT†	CREW	REMARKS
67-037A	1	67-04-23	to	04-24			1	Descent parachute failure. Astronaut killed during reentry/landing.
68-093A	2	68-10-25	to	10-28			0	Target for Soyuz 3.
68-094A	3	68-10-26	to	10-30	M A		1	Rendezvous with Soyuz 2.
69-004A	4	69-01-14	to	01-17	M A		1-3	Received 2 cosmonauts by EVA from Soyuz 5.
69-005A	5	69-01-15	to	01-18	A		3-1	Docked with Soyuz 4.
69-085A	6	69-10-11	to	10-16	G		2	Soyuz 6, 7, 8 rendezvous.
69-086A	7	69-10-12	to	10-17	G		3	Soyuz 6, 7, 8 rendezvous.
69-087A	8	69-10-13	to	10-18			2	Soyuz 6, 7, 8 rendezvous.
70-041A	9	70-06-02	to	06-19	M A		2	
71-034A	10	71-04-02	to	04-04		1,d,5 1/2 hours	3	Salyut not boarded.
71-053A	11	71-06-06	to	06-30	M G	1,d,3 weeks	3	Astronauts killed during reentry/landing.
73-067A	12	73-09-27	to	09-29	G		2	
73-103A	13	73-12-18	to	12-23	G		2	
74-051A	14	74-07-03	to	07-19	A G	3,d,16 days		
74-067A	15	74-08-26	to			3,r		
74-096A	16	74-12-02	to	12-08			2	Apollo-Soyuz checkout.
75-001A	17	75-01-11	to	02-09	M A G	4,d,30 days	2	
75-044A	18	75-05-24	to	07-26	M A G	4,d,63 days	2	

* M = Meteorological observations
A = other Atmospheric observations
G = Geology, geography, earth resources, biology, etc.

† Salyut ID, rendezvous (r) or docked (d), time docked.

TABLE 13

SOYUZ PROGRAM (continued)

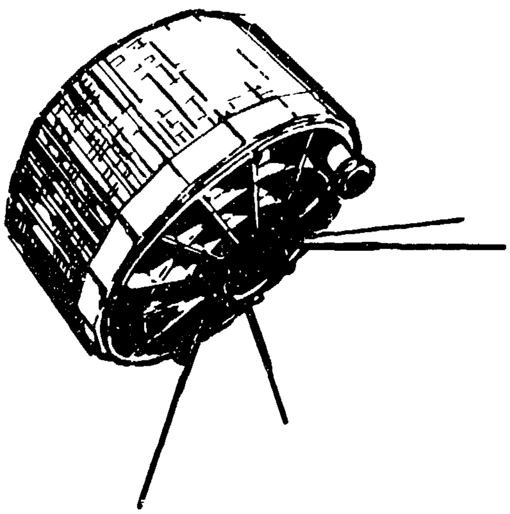
NSSDC ID	SOYUZ NUMBER	DATES LAUNCH		RETURN	SCIENCE MISSION*	SALYUT CONTACT†	CREW	REMARKS
75-065A	19	75-15-07	to	07-21	M A G		2	Apollo docking.
75-106A	20	75-11-17	to	76-02-16		4,d,91 days	0	
76-064A	21	76-07-06	to	08-24	M A G	5,d,48 days	2	
76-093A	22	76-09-15	to	09-23	M A G		2	Test flight for new multi-spectral camera MKF-6.
76-100A	23	76-10-14	to	10-16		5,r	2	Docking system malfunction.
77-008A	24	77-02-07	to	02-25	M A	5,d,16 days	2	
77-099A	25	77-10-09	to	10-11		6,r	2	Docking problems.
77-113A	26	77-12-10	to	01-16	M G	6,d,37 days	2	Crew returned in Soyuz 27 after 96 days in Salyut 1.
78-003A	27	78-01-10	to	03-16		6,d,65 days	2	Crew returned in Soyuz 26. Dual docking ports both in use.
78-023A	28	78-03-02	to	03-10	A G	6,d, 8 days	2	
78-061A	29	78-06-15	to	09-03	M G	6,d,80 days	2	Reactivated Salyut 6 after 3-month shutdown. Crew returned to Soyuz 31.
78-065A	30	78-06-27	to	07-05	A G	6,d, 7 days	2	
78-081A	31	78-08-26	to	11-02	M A G	6,d,94 days	2	Crew returned in Soyuz 29 after 140 days in Salyut.
79-018A	32	79-02-25	to	06-13	M G	6,d,109 days	2	
79-029A	33	79-04-10	to	04-12	M G	6,r, 2 days	2	
79-049A	34	79-06-06	to	06-14		6,d, 8 days	0	
79-103A	T-1	79-12-16	to	80-03-26		6,d,10 days	0	
80-027A	35	80-04-09	to	06-03	M A G	6,d,55 days	2	Crew returned in Soyuz 37.
80-041A	36	80-05-26	to	07-31	M G	6,d	2	Crew returned in Soyuz 35.
80-045A	T-2	80-06-05	to	06-09		6,d, 4 days	2	

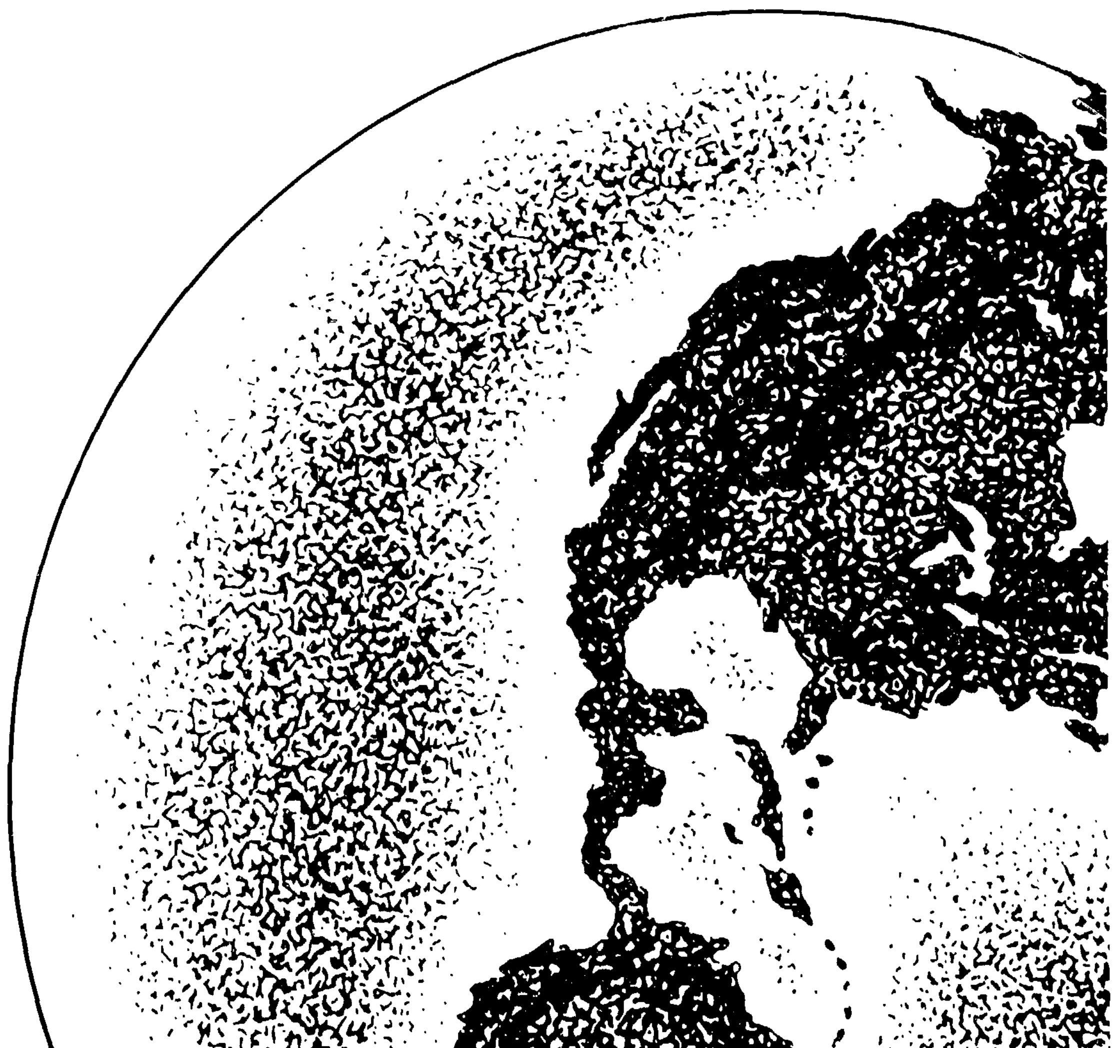
TABLE 13

SOYUZ PROGRAM (concluded)

NSSDC ID	SOYUZ NUMBER	DATES LAUNCH		DATES RETURN	SCIENCE MISSION*			SALYUT CONTACT†	CREW	REMARKS
80-064A	37	80-07-23	to	10-11	M		G	6,d,80 days	2	Crew returned in Soyuz 36.
80-075A	38	80-09-18	to	11-27			G	6,d, 9 days	2	Repair mission.
80-094A	T-3	80-11-27							3	
81-023A	T-4	81-03-12			M	A	G	6,d	2	
81-029A	39	81-03-22					G	6,r	2	
81-042A	40	81-05-14						6,d	4	
82-042A	T-5	82-05-13						7,d	2	
82-063A	T-6	82-06-24						7,d	3	
82-080A	T-7	82-08-19						7,d	3	
83-035A	T-8	83-04-20						7,r	3	
83-062A	T-9	83-06-27						7,d	2	
84-014A	T-10	84-02-08						7,d	3	
84-032A	T-11	84-04-03						7,d	3	
84-073A	T-12	84-07-17						7,d	3	

TIROS





TIROS (TELEVISION AND IR OPERATIONAL SATELLITE) PROGRAM

The development of a meteorological satellite was first begun by the Advanced Research Projects Agency (ARPA) of the Department of Defense and was later transferred to NASA. On April 1, 1960, TIROS 1, the first full-time meteorological satellite, was launched. TIROS 1 and nine TIROS spacecraft subsequently launched were equipped with a dual TV camera system each consisting of a camera, a vidicon tube, a tape recorder, and a transmitter. Pictures could either be stored on board or transmitted directly to a command and data acquisition (CDA) station depending on whether the satellite was beyond or within the communication range of a ground station. TIROS 2, 3, 4, and 7 each carried, in addition, a five-channel scanning medium-resolution infrared radiometer for measuring emitted radiation from the earth and its atmosphere. Two other infrared sensors were also flown on TIROS spacecraft: a wide-field radiometer (TIROS 3 and 4) and a low-resolution omnidirectional radiometer (TIROS 3, 4, and 7). These last two sensors provided low-resolution infrared data for radiation budget studies.

The first four TIROS satellites were launched into near-circular orbits with an orbit inclination of 48 deg, which provided TV coverage of the sunlit portion of the earth between 55 deg N and 55 deg S latitude. The orbit inclination on TIROS 5 through 8 was increased to provide TV coverage for the area between 65 deg N to 65 deg S latitude. The orbits of TIROS 9 and 10 were intended to be near-polar and sun-synchronous to extend the sensor coverage to the entire sunlit portion of the earth and also allow observations to be taken over areas at approximately the same local time each day. Only TIROS 10 achieved this desired orbit. A failure in the guidance system placed TIROS 9 in a nonsynchronous elliptical orbit.

All ten TIROS satellites were spin stabilized. With the exception of TIROS 9, TIROS satellites had both of their TV cameras mounted on the satellite base with their optical axes parallel to the spacecraft spin axis. Since the spin axis lay in the orbital plane, the cameras were directed earthward for only approximately one fourth of each orbit. To overcome this problem, TIROS 9 was placed in a cartwheel mode in which the spacecraft spin axis was normal to the orbital plane. The two TV cameras were relocated with their optical axes normal to the spacecraft spin axis so the earth could be viewed once during each satellite revolution. With this arrangement, it was possible for the first time to monitor the daytime global cloud cover on a nearly continuous basis.

TIROS 8 was the first satellite to be equipped with Automatic Picture Transmission (APT) capabilities. On the previous TIROS satellites, direct TV transmission was possible only when the satellite was in communication range with either of two ground stations (Wallops Island, VA, and the Western Test Range). The APT system on TIROS 8 was capable of transmitting local, daytime, cloud-cover pictures directly to any properly equipped ground station in the global APT network.

The TIROS research and development program was intended to produce "research" satellites constructed and operated for the purpose of developing an "operational" satellite for use by the Weather Bureau. The immediate realization of the operational utility of TIROS 1 products led to the adoption of the TIROS satellites as an operational facility soon after TIROS 1 was launched.

These first 10 TIROS satellites yielded information on global cloud cover, extended man's knowledge of the distribution and formation of various cloud systems, provided valuable data on global heat balance and water vapor distribution, and supplied meteorologists with near real-time photographs of weather systems influencing their local areas, thereby permitting more accurate forecasts. These satellites were also responsible for the detection of many hurricanes long before conventional meteorological observation networks could have done so, thus enabling the National Weather Service to issue timely storm advisories and warnings that saved countless lives. The TIROS name continued to be used as a series satellite name for two satellite types; namely, the TIROS-N/NOAA series and the ADVANCED TIROS-N (ATN) series, whose descriptions can be found under "NOAA (6-D)/TIROS N" and "NOAA (8-J)/ATN," respectively. A summary of the usage of the name "TIROS" in various programs is included in Table 14.

TABLE 14

TIROS-RELATED SATELLITE NAMES

Six different acronyms have been used with satellites related to the TIROS meteorological satellite development. Acronym definitions are noted below, followed by a listing identifying these satellites and the relationship of the prelaunch names to the postlaunch names.

ATN - Advanced TIROS-N, funded by NOAA. Refers to NOAA 8-10, H-J.

ESSA - Funded by Environmental Science Services Administration.

ITOS - Improved TOS.

NOAA - Funded by the National Oceanic and Atmospheric Administration (successor to ESSA).

OT - Operational TIROS.

TIROS - Television and InfraRed Operational Satellite.

TOS - TIROS Operational Satellite.

PRELAUNCH NAME		POSTLAUNCH NAME	
TIROS	A through I	TIROS	1 through 9
OT	1	TIROS	10
OT	2, 3	ESSA	2, 1
TOS	A through G	ESSA	3 through 9
TIROS	M	ITOS	1
ITOS	A, D, F, G, H	NOAA	1 through 5
TIROS	N	TIROS	N
NOAA	A, C, E, F, G	NOAA	6, 7, 8, 9, 10
NOAA	H, I, J, K, L, M		(to be launched)

********************************** TIROS 1-10 **********************************

Spacecraft Name - TIROS 1-10

S/C	Alternate Name	NSSDC ID	Launch Date	Inc. (deg)	Perig. (km)	Apog. (km)	Pd. (min)
TIROS 1	TIROS-A	60-002B	04/01/60	48.4	693	750	99.2
TIROS 2	TIROS-B	60-016A	11/23/60	48.6	609	742	98.3
TIROS 3	TIROS-C	61-017A	07/12/61	47.9	742	812	100.4
TIROS 4	TIROS-D	62-002A	02/08/62	48.3	712	840	100.0
TIROS 5	TIROS-E	62-025A	06/19/62	58.1	586	972	100.0
TIROS 6	TIROS-F	62-047A	09/18/62	58.3	686	713	98.7
TIROS 7	TIROS-G	63-024A	06/19/63	58.2	621	649	97.4
TIROS 8	TIROS-H	63-054A	12/21/63	58.5	691	765	99.3
TIROS 9	TIROS-I	65-004A	01/22/65	96.4	705	2582	119.2
TIROS 10	TIROS-J	65-051A	07/02/65	98.6	751	837	100.8

S/C	PM	PS
TIROS 1	W. G. Stroud NASA/GSFC	H. I. Butler NASA/GSFC
TIROS 2	R. A. Stampf (NLA) NASA/GSFC	Aero. and Meteor. Div. NASA/GSFC
TIROS 3-10	R. M. Rados (Retired)	Aero. and Meteor. Div. NASA/GSFC

Brief Description

TIROS 1-10 (Television and Infrared Observation Satellite) were spin-stabilized meteorological spacecraft designed to test experimental television techniques and infrared equipment. The satellites were in the form of an 18-sided right prism, 48 or 56 cm high and 107 cm in diameter. The top and sides of the spacecraft were covered with approximately 9200 1- by 2-cm silicon solar cells. The TIROS satellites were equipped with a television camera system and an automatic picture transmission system for taking cloud-cover pictures, three radiometers (two-channel wide-field, omnidirectional, and five-channel scanning) for measuring radiation from the earth and its atmosphere, and an electron temperature probe. The satellite spin rate was maintained between 8 and 12 rpm by the use of five diametrically opposed pairs of small solid-fuel thrusters. TIROS 2-10 were equipped with a magnetic attitude-control device. The first four TIROS were launched into near-circular orbits with an orbit inclination of 48 deg to provide TV coverage of the sunlit portion of the earth between 55 deg N and 55 deg S lat. The orbit inclination on TIROS 5-8 was increased to provide TV coverage between 65 deg N to 65 deg S lat. The orbits of TIROS 9-10 were intended to be near-polar and sun-synchronous to extend the sensor coverage to the entire sunlit portion of the earth, but only TIROS 10 achieved this desired orbit. A failure in the guidance system placed TIROS 9 in a nonsynchronous elliptical orbit. TIROS 1-8 and 10 were designed for a fixed attitude relative to space. TIROS 9 was placed in a cartwheel mode in which the spacecraft spin axis was normal to the orbital plane. With two TV cameras on its rim, the TIROS 9 spacecraft rolled along its near-polar orbit at a rate of 10 revolutions a minute to provide daily global cloud cover on a nearly continuous basis. A more detailed description and performance summary can be found in A. Schnapf, "TIROS: The Television and Infrared Observation Satellite," J. of British Interplanetary Society, v. 19, pp. 386-409, 1963-64, and R. M.Rados, "The Evolution of the TIROS Meteorological Satellite Operational System," Bull. Amer. Meteor. Soc., v. 48, pp. 326-337, 1967.

-- TIROS 1-10, Barksdale, Rados --

Investigation Name - Scanning Radiometer (SR)

S/C	NSSDC ID	PI	OI
TIROS 2, 4	60-016A-02 62-002A-03	J. D. Barksdale NASA/GSFC	
TIROS 3	61-017A-03	R. M. Rados (Retired) NASA/GSFC	J. D. Barksdale NASA/GSFC
TIROS 7	63-024A-02	J. D. Barksdale NASA/GSFC	

Brief Description

This radiometer measured the emitted and reflected radiation of the earth and its atmosphere. The five-channel radiometer scanned the earth and space as the satellite spun about its axis. The radiometer's bidirectional optical axes were inclined to the satellite spin axis at angles of 45 and 135 deg. 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 infrared spectrum. The spectral bands of five channels were: (1) 6.0 to 6.5 micrometers (water vapor absorption), (2) 8.0 to 12.0 micrometers (atmospheric window), (3) 0.2 to 6.0 micrometers, (4) 8 to 13 micrometers (TIROS 4 used this channel to transmit a redundant time reference signal), and (5) 0.5 to 0.75 micrometer for reference and comparison with the TV systems. The water vapor absorption band was replaced by a 14- to 16-micrometer carbon dioxide band on TIROS 3. The major limitation of the experiment was the uncertainty in the absolute value of the measurements, resulting from the degradation of the sensors. A more detailed description of the instrument was given in R. W. Astheimer, et al., "Infrared Radiometric Instruments on TIROS II," J. of Opt. Soc., v. 51, pp. 1386-1393, 1961.

---------------------------------- TIROS 1-10, Butler, NESDIS Staff ----------------------------------

Investigation Name - Television Camera System

S/C	NSSDC ID	PI	OI
TIROS 1, 2	60-002B-01 60-016A-03	H. I. Butler NASA/GSFC	
TIROS 3	61-017A-04	NESDIS Staff NOAA/NESDIS	R. M. Rados (Retired) NASA/GSFC
TIROS 4-10	62-002A-04 62-025A-01 62-047A-01 63-024A-04 63-054A-01 65-004A-01 65-051A-01	NESDIS Staff NOAA/NESDIS	

Brief Description

The TV system was developed to obtain cloud-cover pictures for operational meteorological use. The experiment consisted of one or two independent camera chains, each containing a television camera, a magnetic-tape recorder, and a television transmitter. The two sensor units were capable of concurrent or independent operation. Three different lens systems were used on the TIROS spacecraft. On TIROS 1 and 2, the TV system had one narrow-angle (12-deg) lens and one wide-angle (104-deg) lens. TIROS 3, 7, 9, and 10 had two wide-angle lens systems. TIROS 4, 5, and 6 had one medium-angle (78-deg) lens system and one wide-angle system. TIROS 8 had only one wide-angle lens. Except on TIROS 9, the cameras were mounted on the baseplate of the spacecraft with their optical axes parallel to the spacecraft spin axis. Since the spin axis lay in the orbital plane, the cameras were directed earthward for only approximately one-fourth of each orbit. The two cameras on TIROS 9 were mounted 180 deg apart on the side of the spacecraft and canted 64 deg from the spacecraft spin axis. The cameras were automatically triggered into action only when they came in view of the earth. The TV 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. Each recorder could store up to 32 (48 for TIROS 9) frames of pictures. Transmission of the 32-frame sequence was accomplished in 100 s of a 3-W FM transmitter operating at a nominal frequency of 235 MHz. At nominal attitude and altitude (approximately 700 km), a picture taken by the wide-angle camera covered a 1200- x 1200-km square with a spatial resolution of 2.5 to 3.0 km at nadir. The medium-angle camera covered a 725-km x 725-km square and had a resolution of 2 km. Data from this experiment are available through SDSD. For a complete index of these data, see "Catalog of Meteorological Satellite Data - TIROS 1 Television Cloud Photography," "Catalog of Meteorological Satellite Data - TIROS 2 Television Cloud Photography," etc.

--TIROS 1-10, Hanel --

Investigation Name - Widefield Radiometer

Flown on - TIROS 2, 3, 4

NSSDC ID - 60-016A-01, 61-017A-02, 62-002A-02

PI - R. A. Hanel NASA/GSFC

Brief Description

The low-resolution, nonscanning, two-channel radiometer measured the thermal and reflected solar radiation from the earth-atmosphere system. The radiometer consisted of two detectors: one black and one white thermistor bolometer. Each of the detectors was mounted in the apex of a highly reflective Mylar cone. The black detector responded equally to reflected solar radiation and long-wave terrestrial radiation (0.2 to 50 micrometers). The white detector reflected solar and visible radiation and measured only long-wave thermal radiation (5 to 50 micrometers). The optical axis of each detector was parallel to the satellite spin axis. The field of view (50 deg) of the detectors when viewing the earth directly below the satellite was a circle of 832 km diameter. This area was within the field observed by the wide-angle television camera, and thus a direct measure of the heat balance of the earth-atmosphere system viewed in any of the pictures was provided. The radiation data were recorded on a continuously running endless loop magnetic tape that completed its cycle in about 100 min. Data older than 100 min were erased as newer data were recorded. The experiment performed normally, but the quality of the data was very poor because of decreased sensitivity of the detectors, detector-spacecraft thermal coupling, and less than nominal radiative characteristics. Thus, the collected data were too ambiguous for reduction or analysis. The experiment was described in "The TIROS Low Resolution Radiometer," NASA TN-D-614, 1964.

--TIROS 1-10, Hunter--

Investigation Name - Automatic Picture Transmission (APT)

Flown on - TIROS 8

NSSDC ID - 63-054A-02

PI - C. M. Hunter NASA/GSFC

Brief Description

This system was a camera and transmitter combination designed to test the feasibility of transmitting local daytime pictures of cloud cover to properly equipped ground-receiving stations on a real-time basis. The system consisted of a single camera with a 2.54-cm-diameter vidicon. The camera used a 108-deg wide-angle f/1.8 objective lens with a focal length of 5.7 mm, and was mounted on the satellite baseplate with its optical axis parallel to the spacecraft spin axis. The actual picture taking required 8 s and the transmission 200 s. Earth-cloud images retained on the photosensitive surface of the vidicon were read out at four lines per second to produce an 800-line picture. A 5-W TV transmitter (136.95 MHz) relayed the pictures to local APT stations within communication range. The faceplate of the vidicon had reticle marks that appeared on the picture format to aid in relating the picture to its geographical position on the earth's surface. At nominal satellite attitude and altitude (approximately 700 km), a picture covered a 1200-km x 1200-km square with a horizontal resolution of 7.5 km at nadir. The experiment performed normally, and good quality pictures were obtained until the experiment was terminated owing to degradation of the APT camera. The APT experiment successfully demonstrated the feasibility of using weather satellites to provide meteorologists with local cloud-cover data on a near real-time basis, requiring only the use of a photofacsimile machine and a relatively inexpensive antenna and receiver. APT data were primarily intended for operational use by the local APT acquisition stations and generally are not available for follow-on scientific studies.

-- TIROS 1-10, Suomi --

Investigation Name - Omnidirectional Radiometer

Flown on - TIROS 3, 4, 7

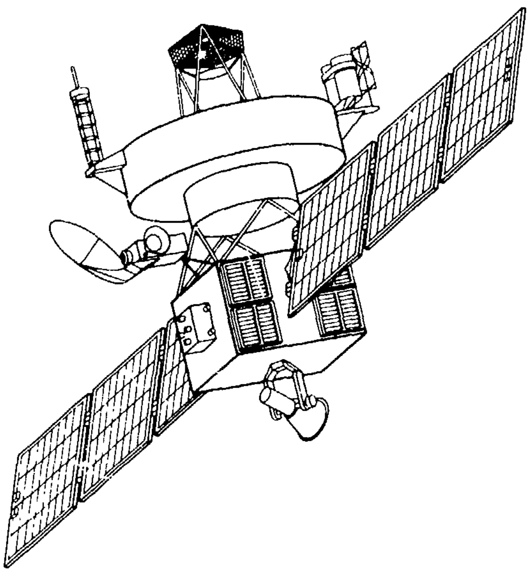
NSSDC ID - 61-017A-01, 62-002A-01, 63-024A-01

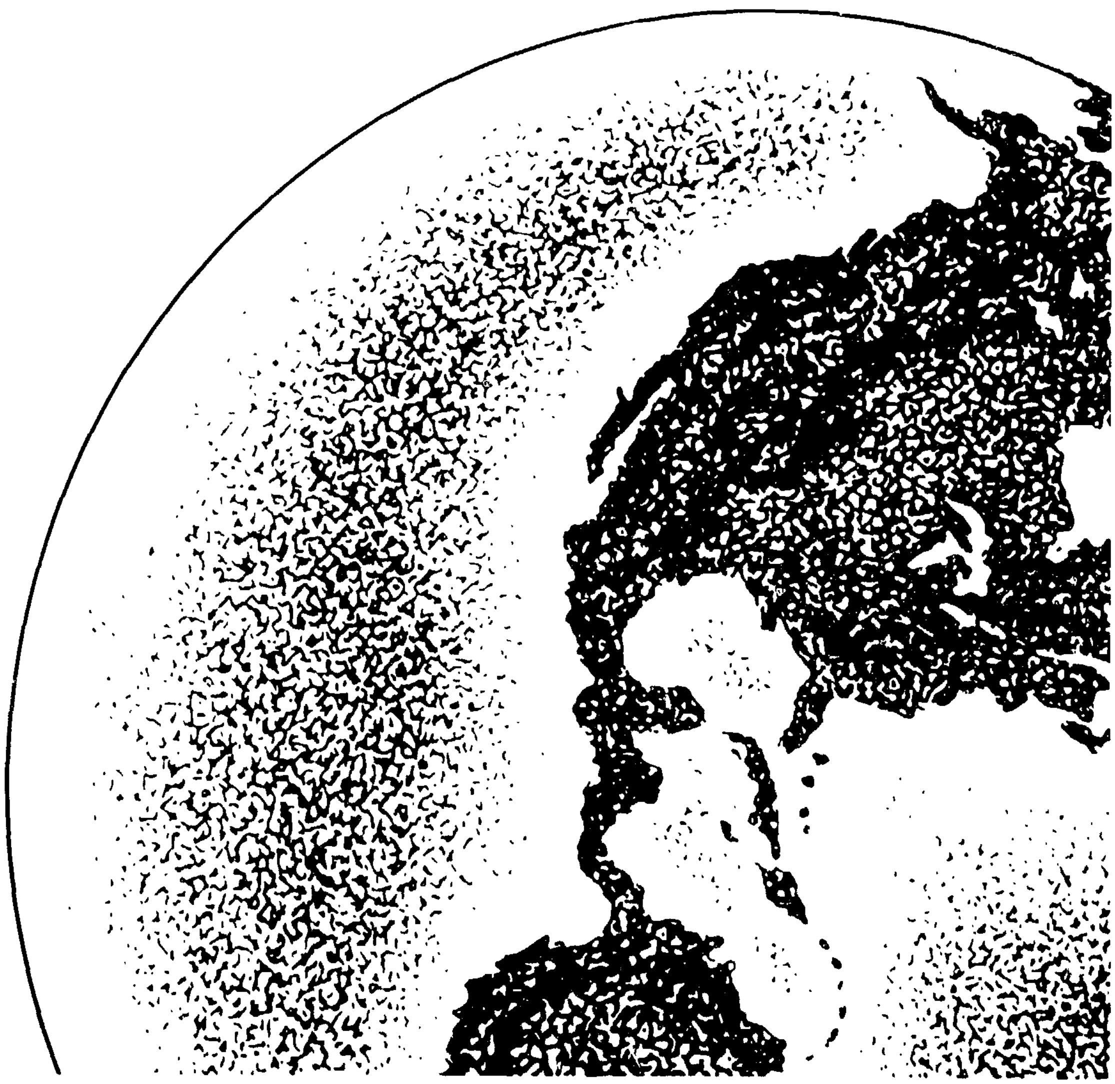
PI - V. E. Suomi U. of Wisconsin

Brief Description

This experiment was designed to measure the amount of solar energy absorbed, reflected, and emitted by the earth and its atmosphere. The experiment consisted primarily of two sets of bolometers in the form of hollow aluminum hemispheres, mounted on opposite sides of the spacecraft, whose optical axes were parallel to the spin axis. The bolometers were mounted on mirror surfaces so that the hemispheres behaved very much like isolated spheres in space. One bolometer in each set was painted black, and one was painted white. The black bolometer absorbed most of the incident radiation while the white bolometer was sensitive mainly to radiation with wavelengths longer than approximately 4 micrometers. The reflected and emitted radiation could thus be separated. The sensor temperatures were measured by thermistors fastened to the inside of the hollow hemispheres. The sensor temperatures, taken every 29 s, were an average of the two temperatures from the matched thermistors. A similar experiment was carried on Explorer 7.

TOPEX





TOPEX PROGRAM

The Ocean Topography Experiment (TOPEX) is a joint U.S.-France mission which provides precise global observations of the oceans. Managed by the Jet Propulsion Laboratory for NASA, the project was developed in the early 1980's and expanded in 1984 to include both U.S. and French instrumentation. The approved TOPEX/Poseidon mission will be launched in 1991 by an Ariane launch vehicle.

The main objective of the mission is to measure the satellite-to-sea-surface range, from which the topography of the sea surface can be computed to an accuracy of 14 cm. This will enable oceanographers to determine the ocean's general circulation as well as its mesoscale variability. This effort is closely coordinated with the World Ocean Circulation Experiment (WOCE) and the Tropical Oceans Global Atmospheres Experiment (TOGA).

The key instrument on the TOPEX satellite is the NASA dual-frequency (13.7 and 5.3 GHz) radar altimeter. It is an upgraded version of the altimeters previously flown on GOES 3 and Seasat. Besides making precise and accurate range measurements, the altimeter can also provide ice edge location, ice profiles, wave height, and surface wind speed from the shape and amplitude of the reflected pulse. Accuracy of the wave height and wind speed is comparable to that obtained from in situ measurement.

Besides the NASA altimeter, there is also a French-supplied, single-channel altimeter that will be sharing the NASA altimeter antenna and operating at 5% of the time. This sensor plus the DORIS dual-frequency tracking system receiver will make up the Poseidon portion of the satellite payload.

There are four other sensors that belong to the NASA payload: 1) a three-channel microwave radiometer for water vapor measurements; 2) a TRANET doppler beacon for tracking by the Defense Mapping Agency; 3) a laser retroflector array for height verification; and 4) a Global Positioning System (GPS) demonstration receiver.

By acquiring a comprehensive description of the global scale ocean circulation, climatologists and meteorologists hope to more precisely parameterize the effect of the oceans on climate and weather.

************************** TOPEX **************************

SPACECRAFT COMMON NAME- TOPEX
ALTERNATE NAMES- OCEAN TOPOGRAPHY EXPER.

NSSDC ID- TOPEX

LAUNCH DATE- 00/00/90 WEIGHT- KG
LAUNCH SITE-
LAUNCH VEHICLE- ARIANE

SPONSORING COUNTRY/AGENCY
UNITED STATES NASA
FRANCE CNES

PLANNED ORBIT PARAMETERS
ORBIT TYPE- GEOCENTRIC
ORBIT PERIOD- 120. MIN INCLINATION- 63.4 DEG
PERIAPSIS- 1334. KM ALT APOAPSIS- 1334. KM ALT

PERSONNEL
PM - C.A. YAMARONE NASA-JPL
PS - R.H. STEWART NASA-JPL

BRIEF DESCRIPTION

The Ocean Topography Experiment (TOPEX) satellite is part of a project planned to coincide with the World Ocean Circulation Experiment to be conducted in the early 1990's. The satellite is designed to collect altimetry data for determining precise global sea-surface elevations. The spacecraft carries a NASA payload as well as a French CNES payload. The NASA payload consists of two primary instruments: a dual-frequency altimeter and a three-channel, nonscanning microwave radiometer. Other NASA instruments include laser retroreflectors, a Doppler beacon, and an experimental GPS receiver. The CNES payload consists of a radar altimeter and a high-precision Doppler tracking system (DORIS). The spacecraft orbit is designed to cover the same ground track approximately every 10 days. The lifetime of the satellite is expected to be 3 to 5 years.

------- TOPEX, UNKNOWN--------------------------------------

INVESTIGATION NAME- DUAL-FREQUENCY ALTIMETER

NSSDC ID- TOPEX -01

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
NAVIGATION
GEODESY

PERSONNEL
PI - UNKNOWN

BRIEF DESCRIPTION

The TOPEX dual-frequency altimeter measures the satellite-to-sea-surface range, wave height, and wind speed directly beneath the spacecraft. The primary measurement frequency is 13.7 GHz (Ku-Band), and the secondary frequency is 5.3 GHz (C-Band). The subsequent range difference measured at these two frequencies provides a first-order correction for the influence of the ionosphere. Corrected accuracy is expected to be 2.4 cm. The instrument is an upgraded version of the type of altimeter that was flown on the GEOS 3 geodetic satellite and the SEASAT oceanographic satellite. Measurement precision is between 1 and 2 cm. Sharing its antenna with the CNES radar altimeter, the NASA experiment will be operating 95% of the time, with the CNES experiment operating approximately 5% of the time.

------- TOPEX, UNKNOWN--------------------------------------

INVESTIGATION NAME- MICROWAVE RADIOMETER

NSSDC ID- TOPEX -02

INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
METEOROLOGY

PERSONNEL
PI - UNKNOWN

BRIEF DESCRIPTION

The non-scanning microwave radiometer on TOPEX measures radiation emitted from water vapor between the satellite and the ocean. The instrument is a refurbished Nimbus 7 flight spare radiometer with two channels removed, retaining three channels that operate at 18, 21, and 37-GHz, respectively. Each channel has vertical polarization, and a redundant 21-GHz channel will be turned on if the primary channel fails. The radiometer uses a 79-cm Nadir-poined offset paraboloid reflecting antenna to measure atmospheric emissivity. It also uses a cold blackbody calibration with a sky horn looking at right angles to the sun line. The footprint of the 21-GHz channel is about 35 km. Measurements of the columnar water vapor along the satellite ground track are expected to have an accuracy of 0.2 gm/sq cm over a range of 0.2 to 6.0 gm/sq cm. They can provide corrections to altimeter height data for the effects of atmospheric water vapor to an uncertainty of 1.2 cm.

------- TOPEX, UNKNOWN--------------------------------------

INVESTIGATION NAME- CNES RADAR ALTIMETER

NSSDC ID- TOPEX -07

INVESTIGATIVE PROGRAM
CODE EE/CO-OP, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
OCEANOGRAPHY
NAVIGATION
GEODESY

PERSONNEL
PI - UNKNOWN

BRIEF DESCRIPTION

The CNES radar altimeter on TOPEX is a single-channel (Ku-Band) instrument used to m re sea surface height. It is a solid-state, low-power, and low-mass instrument of a new design. One of the goals is to have this altim ter as the forerunner of subsequent CNES designs. The CNES alti ter will share the NASA altimeter antenna by operating approximately 5% of the time with the NASA altimeter operating 95% of the time. Measurement accuracy is expected to be within 10 cm.

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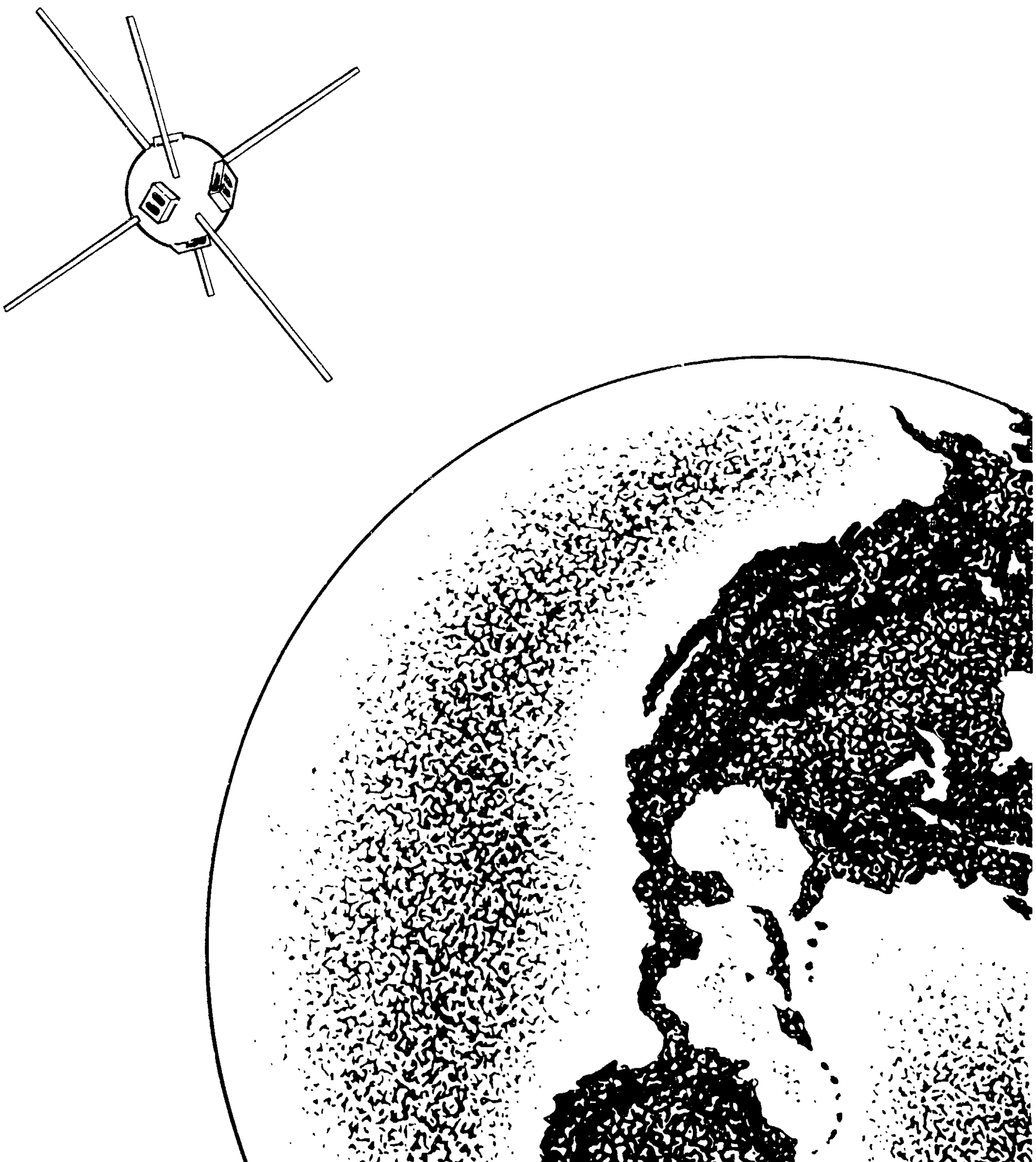
VANGUARD



VANGUARD SATELLITE PROGRAM

The Vanguard program was the initial U.S. (Navy) effort to launch satellites. It consisted of 11 satellite launch attempts, of which three were successful. Five of the launch attempts were made with test vehicles (TV) and their backups (BU), of which two were successful (Vanguard 1 and 3). The remaining attempts were made with the satellite launch vehicle (SLV). All launch attempts were made between December 6, 1957, and September 18, 1959. The initial success was with Vanguard 1 on March 17, 1958.

The program was authorized in September 1955, with the primary emphasis placed upon the technology of orbiting a satellite from a newly designed launch vehicle (based upon the Viking rocket design) and on operational experience. Vanguard 2 experimentation was directed toward study of earth cloud cover, while the other two successfully launched satellites carried experimentation designed to study micrometeorites, energetic particles, and magnetic fields.

In addition to Table 15, which summarizes the Vanguard program, the descriptions of Vanguard 2 and its experiment are included here.

TABLE 15

VANGUARD PROGRAM

NSSDC ID	OTHER NAMES	LAUNCH VEHICLE	LAUNCH DATE	ORBIT a/p	ORBIT pd	ORBIT inc	REMARKS
VAGT3		Vanguard TV-3	12-06-57				
VAGT3B		Vanguard TV-3BU	02-05-58				
58-002B	Vanguard 1 1958 β2	Vanguard TV-4	03-17-58	3968-650	34.3	134	1.47 kg, 0.16 m dia. sphere
VAGT5		Vanguard TV-5	04-28-58				
VAGSL1		Vanguard SLV-1	05-27-58				
VAGSL2		Vanguard SLV-2	06-26-58				
59-001A	Vanguard 2 1959 α1	Vanguard 3 Vanguard 4	09-26-58 02-17-59	3320-559	32.9	126	9.8 kg, 0.5 m dia. sphere
VAGSL5		Vanguard 5	04-13-59				
VAGSL6		Vanguard 6	06-22-59				
59-007A	Vanguard 3 1959 η	Vanguard TV-4BU	11-18-59	3744-512	33.4	130	Satellite did not separate from rocket; 45 kg (23 kg payload), 0.5 m dia., 2.5 m long cylinder/sphere

**************************** VANGUARD 2 ************************

SPACECRAFT COMMON NAME- VANGUARD 2
ALTERNATE NAMES- 1959 ALPHA 1, 00011
VANGUARD SLV 4

NSSDC ID- 59-001A

LAUNCH DATE- 02/17/59 WEIGHT- 9.8 KG
LAUNCH SITE- KENNEDY SPACE CENTER, UNITED STATES
LAUNCH VEHICLE- VANGUARD

SPONSORING COUNTRY/AGENCY
UNITED STATES DOD-NAVY

INITIAL ORBIT PARAMETERS

ORBIT TYPE- GEOCENTRIC EPOCH DATE- 02/17/59
ORBIT PERIOD- 125.60 MIN INCLINATION- 32.88 DEG
PERIAPSIS- 559. KM ALT APOAPSIS- 3320. KM ALT

PERSONNEL

PM - J.P. HAGEN(NLA) US NAVAL RESEARCH LAB
PS - J.P. HAGEN(NLA) US NAVAL RESEARCH LAB

BRIEF DESCRIPTION

Vanguard 2 was an earth-orbiting satellite designed to measure cloud-cover distribution over the daylight portion of its orbit. The spacecraft was a 9.8 kg magnesium sphere 50.8 cm in diameter. It contained two optical telescopes with two photocells. The sphere was internally gold-plated and externally covered with an aluminum deposit coated with silicon oxide of sufficient thickness to provide thermal control for the instrumentation. Radio communication was provided by a 1-W, 108.03-MHz telemetry transmitter and a 10-mW, 108-MHz beacon transmitter that sent a continuous signal for tracking purposes. A command receiver was used to activate a tape recorder that relayed telescope experiment data to the telemetry transmitter. Both transmitters functioned normally for 19 days. The satellite was spin stabilized at 50 rpm, but telemetry data were poor because of an unsatisfactory orientation of the spin axis. The power supply for the instrumentation was provided by mercury batteries.

------- VANGUARD 2, STROUD ---------------------------------

INVESTIGATION NAME- OPTICAL SCANNER

NSSDC ID- 59-001A-01 INVESTIGATIVE PROGRAM
CODE EE, APPLICATIONS

INVESTIGATION DISCIPLINE(S)
METEOROLOGY

PERSONNEL

PI - W.G. STROUD NASA-GSFC

BRIEF DESCRIPTION

The optical scanner experiment was designed to obtain cloud-cover data between the equator and 35 to 45 deg N latitude. As the satellite circled the earth, two photocells located at the focus of two optical telescopes aimed in diametrically opposite directions, measured the intensity of sunlight reflected from clouds (about 80%), from land masses (15 to 20%), and from sea areas (5%). The satellite motion and rotation caused the photocells to scan the earth in successive "lines." Separate solar batteries turned on a recorder only when the earth beneath the satellite was in sunlight and about 50 min of data per orbit were obtained. The measured reflection intensities were stored on tape. Ground stations interrogated the satellite by signaling its command receiver, which caused the entire tape to be played back in 60 s. The tape was then erased and rewound. Experiment equipment functioned normally, but data were poor because of an unsatisfactory satellite spin axis orientation.

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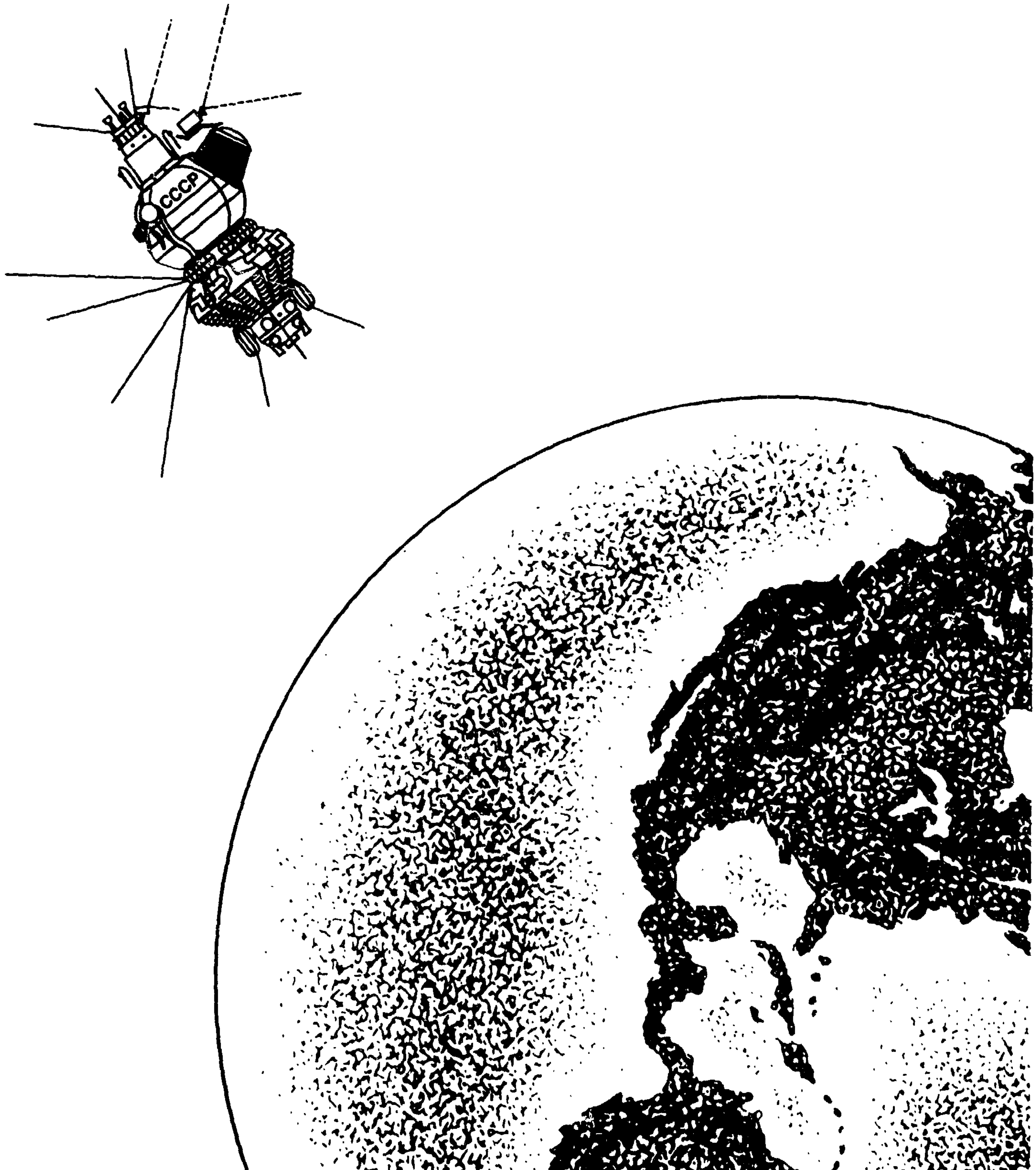
OF POOR QUALITY

VOSKHOD



VOSKHOD (SUNRISE) PROGRAM

The Voskhod program was an extension of the Vostok program, utilizing a modified Vostok spacecraft. The major change was a replacement of a rather heavy ejection and descent system, with seating space for two or three astronauts. Parachute descent of individual astronauts was replaced by parachute descent of the capsule supplemented by braking rockets used during the final moments before landing. As many as five flights, including Cosmos 47, 57, and 110, utilized this modified Vostok spacecraft and may be included in this series. Only two were manned and provided meteorological data. As with the Vostok series, primary emphasis was upon biological studies related to the space environment. Voskhod 1 was the first multimanned spacecraft, and the Voskhod 2 flight included the first EVA in its schedule.

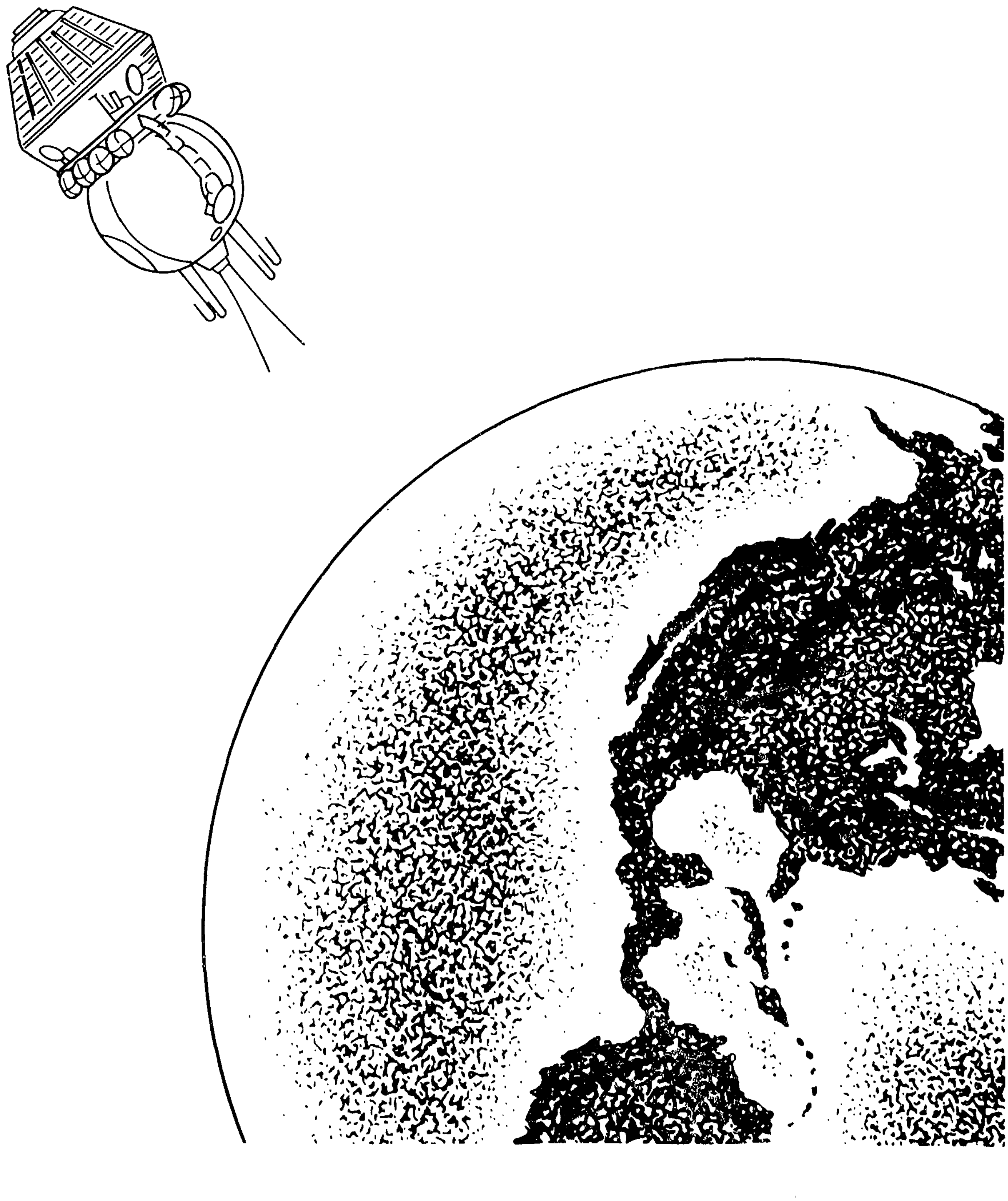
Engineer K. Feoktistor, the science observer on the Voskhod 1 flight, had a movie camera available; specific reference has been made to his visual observations of earth, cloud cover, and photometric studies during orbits 5 and 6. During the Voskhod 2 flight, A. Leonov carried a three-lens movie camera on his 20-minute EVA. It is doubtful that a significant number of meteorological photographs were obtained, since Leonov's space suit was quite cumbersome, and only 10 minutes (on tether) were spent free of the spaceship. Postflight publicity statements, however, indicated that "observations and studies of the earth's atmosphere" were made and that earth photographs were made during the EVA. Since the information on meteorological observations is so very limited, the spacecraft and experiment description for this program is replaced by Table 16.

TABLE 16

VOSKHOD PROGRAM

NSSDC ID	COMMON NAME AND ORBIT INFORMATION		REMARKS
64-062A	Cosmos 47		
	Launch	10-06-64	
	Performance	1 day	
	a/p	413/177 km	
	inc	64 deg	
	pd	90 min	
64-065A	Voskhod 1		Astronauts V. Komarov, Y. Yegarov, and K. Feoktistor. Visual observations were made of nighttime thunderstorms over Africa.
	Launch	10-12-64	
	Performance	1 day	
	a/p	409/178 km	
	inc	65 deg	
	pd	90 min	
65-012A	Cosmos 57		Probably exploded in space.
	Launch	02-22-65	
	Performance	1 day	
	a/p	512/175 km	
	inc	64 deg	
	pd	91 min	
65-022A	Voskhod 2		Astronauts P. Belyayev and A. Leonov (first EVA).
	Launch	03-18-65	
	Performance	1 day	
	a/p	495/173 km	
	inc	65 deg	
	pd	91min	
66-015A	Cosmos 110		Dogs Veterok and Ugolek recovered.
	Launch	02-22-66	
	Performance	23 days	
	a/p	904/187 km	
	inc	52 deg	
	pd	95 min	

VOSTOK



VOSTOK (EAST)

The Vostok series of six manned spacecraft was the U.S.S.R.'s first manned flight program (11 spacecraft total) and is somewhat analagous to the U.S. Mercury program. Its first manned orbital flight preceded A. Sheppard's first U.S. suborbital flight by about 3 weeks and J. Glenn's first U.S. orbital flight by about 10 months. Both programs were completed in the early summer of 1963, each with six successful manned orbital flights. Four Vostok flights with dogs preceded the manned flights. The Vostok 1 flight with Y. Gagarin was the sixth spacecraft of the U.S.S.R. man-in-space program. As in the case of the Mercury program, the major emphasis of the Vostok program was biological, i.e., research into the effects of spaceflight on man. Cameras and television equipment were used primarily to observe the astronauts.

The spacecraft and reentry vehicle was spherical, and approximately 2 1/2 meters (6 ft) in diameter. It was connected to a double cone-shaped (base-to-base) support module with spherical gas cannisters between the spacecraft and the support module. There was a fairing enclosing both structures that gave the total appearance of a cylinder capped by a cone with a rounded apex. An escape and landing system allowed ejection of the astronaut for parachute descent.

No evidence has been found in the literature referring to earth or cloud photography from Vostok 1. This is not at all surprising in view of the short, one-orbit duration of the flight. On flights 2 through 6, a hand-held movie camera was used. For the Vostok 2 flight, the camera was identified as a Konvas cine, three-lens (presumably 16 mm) camera loaded with color film. Cloud and earth photography are reported to be of good quality, and a few of the pictures have been published. It should be noted that flights 3/4 and 5/6 were tandem flights, Vostok 5 and 6 coming as close as 5 km to each other in flight. Also to be noted is that the Vostok 6 astronaut was the first female astronaut, that her primary qualification was that of a parachutist (no pilot training), and that she made specific reference to visual observation of a thunderstorm during the sixth orbit.

Since little information is available on these spacecraft and their cloud photography experiments, the individual spacecraft and experiment descriptions will be replaced by Table 17 which contains a tabular summary of the manned flight program.

TABLE 17

VOSTOK PROGRAM

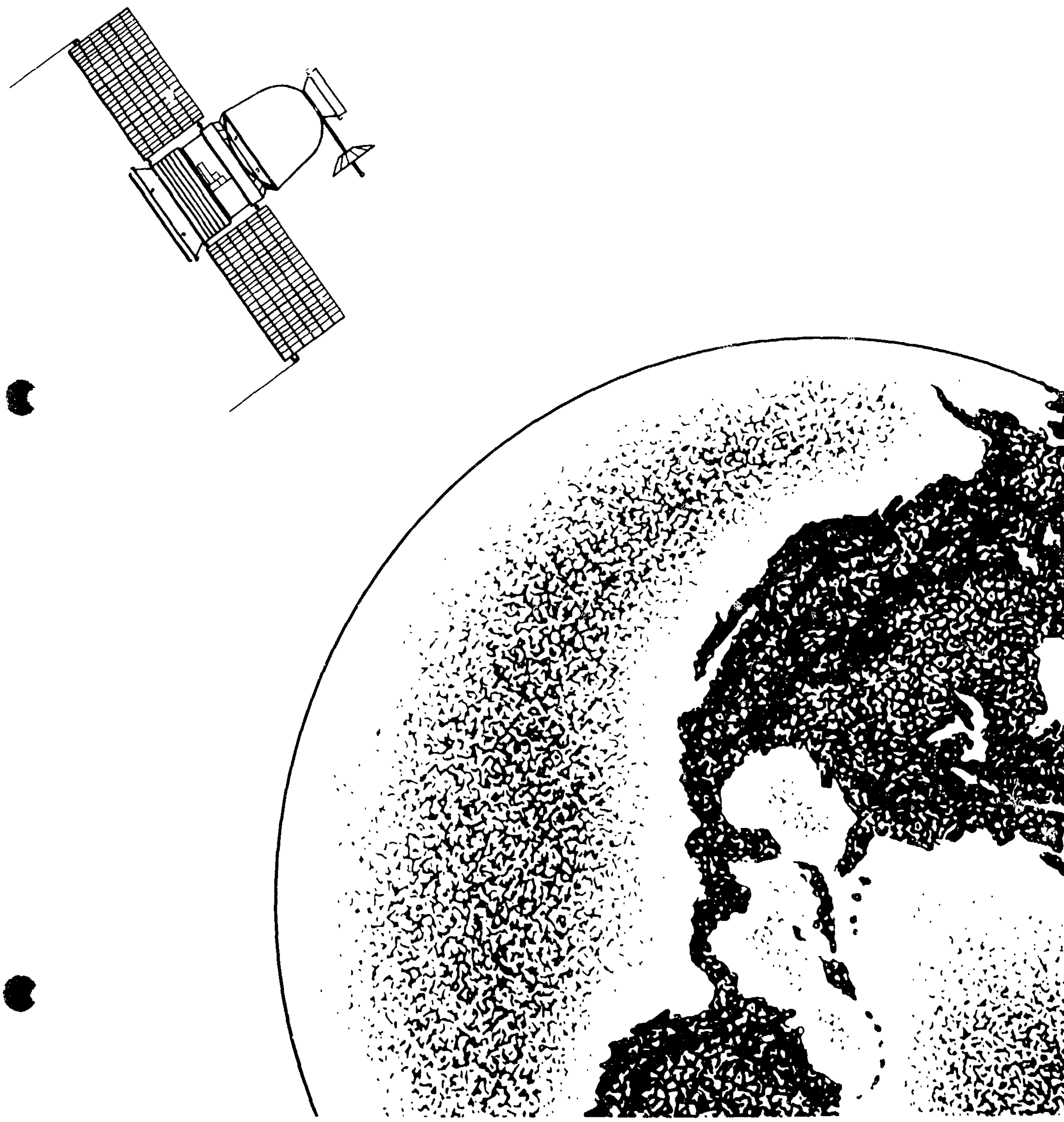
NSSDC ID	COMMON NAMES	ORBIT INFORMATION		REMARKS
60-005A	60-Epsilon 1	Launch	05-15-60	Recovery failed.
	Korabl Sputnik 1	Performance	4 days	
	Sputnik 4	a/p	369/312 km	
	Kedr	inc	65 deg	
		pd	91.2 min	
60-011A	60-Lambda	Launch	08-19-60	Dogs Belka and Strelka recovered.
	Korabl Sputnik 2	Performance	1 day	
	Sputnik 5	a/p	339/306 km	
		inc	65 deg	
		pd	90.7 min	
60-017A	60-Rho 1	Launch	12-01-60	Dogs Pchelka and Mushka (recovery failed).
	Korabl Sputnik 3	Performance	1 day	
	Sputnik 6	a/p	265/187 km	
		inc	65 deg	
		pd	88.6 min	
60-008A	61-Theta 1	Launch	03-09-61	Dog Chernushka recovered.
	Korabl Sputnik 4	Performance	1 orbit	
	Sputnik 9	a/p	249/184 km	
		inc	65 deg	
		pd	88.5 min	
61-009A	61-Iota 1	Launch	03-25-61	Dog Zvezdochka recovered.
	Korabl Sputnik 5	Performance	1 orbit	
	Sputnik 10	a/p	241/178 km	
		inc	65 deg	
		pd	88.4 min	
61-012A	61-Mu 1	Launch	04-12-61	Astronaut Y. Gagarin.
	Vostok 1	Performance	1 orbit	
	Sputnik 11	a/p	327/181 km	
		inc	65 deg	
		pd	89.1 min	
61-019A	61-Tau 1	Launch	08-06-61	Astronaut G. Tito.
	Vostok 2	Performance	1 day	
	Sputnik 12	a/p	257/178 km	
		inc	65 deg	
		pd	88.6 min	

TABLE 17

VOSTOK PROGRAM (concluded)

NSSDC ID	COMMON NAMES	ORBIT INFORMATION		REMARKS
62-036A	62-Alpha Mu 1 Vostok 3	Launch Performance a/p inc pd	08-11-62 4 days 251/183 km 65 deg 88.5 min	Astronaut A. Nickolayev.
62-037A	62-Alpha Nu 1 Vostok 4	Launch Performance a/p inc pd	08-12-62 3 days 254/180 km 65 deg 88.5 min	Astronaut P. Popovitch.
63-020A	Vostok 5	Launch Performance a/p inc pd	06-15-63 5 days 222/175 km 65 deg 88.3 min	Astronaut V. Bykovskiy.
63-023A	Vostok 6	Launch Performance a/p inc pd	06-16-63 3 days 233/183 km 65 deg 88.3 min	Astronaut V. Tereshkova.

ZOND



ZOND PROGRAM

The Zond (probe) program developed out of a series of launch attempts to Venus and Mars beginning in 1961. With Zond 4 launched in 1968, the program became identified as an effort toward manned planetary (lunar) flight. All of the successful flights were unmanned, and the program produced several important accomplishments, including the first circumlunar flight, first far-side lunar pictures, first U.S.S.R. water recovery, complex skip-reentry, and stereographic lunar photos. Zond 5-8 laid heavy emphasis on technical problems associated with lunar flight and reentry. On these flights, there was also considerable emphasis on the biological aspects of space flight. A variety of biological specimens (including turtles, worms, flies, and seeds) was flown.

Earth photographs were taken from Zond 5-8, although as in the U.S. Apollo program this photography was from a relatively distant location, was subordinate in importance to the lunar photography, and was accomplished with the same cameras used for the lunar photos. Use of the limited earth photography from these flights has probably provided only minor contributions to meteorological research. For this reason and due to the lack of more detailed information about the earth photography, the experiment descriptions for this program are replaced by Table 18, which summarizes and describes the Zond flights.

TABLE 18

ZOND PROGRAM

NSSDC ID	COMMON NAME AND ORBIT INFORMATION		REMARKS
64-016D	Zond 1		Venus probe/systems test.
	Launch	02-04-64	
	Orbit	Heliocentric	
64-078A	Zond 2		Mars probe/systems test.
	Launch	11-30-64	
	Orbit	Heliocentric	
65-056A	Zond 3		25 far-side lunar pictures obtained from approximately 10,000 km were transmitted to earth by radio facsimile.
	Launch	07-18-65	
	Orbit	Heliocentric	
68-013A	Zond 4		
	Launch	03-02-68	
	Orbit	Unknown	
68-076A	Zond 5		Earth full disk (centered on E. Africa) photography from 90,000 km.
	Launch	09-14-68	
	Performance	6 days	
	Trajectory	circumlunar	High-quality lunar (and Earth) pictures.
			First U.S.S.R. water recovery, Indian Ocean.
			First lunar fly-around.
68-101A	Zond 6		Lunar pictures from 3500 to 10,000 km, a few lunar stereographic pictures, and earth pictures from 388,000 km.
	Launch	11-10-68	
	Performance	7 days	
	Trajectory	circumlunar	Standard 13x18 cm frame, 400 mm aerial camera with resolution 50 lines per mm.
69-067A	Zond 7		Color and B/W pictures taken on Aug. 8, from about 70,000 km, were centered on central Asia near the Caspian Sea.
	Launch	08-07-69	
	Performance	6 days	
	Trajectory	circumlunar	Lunar and earth pictures centered on the Indian Ocean were taken on August 11.
70-088A	Zond 8		Live TV earth images made on Oct. 21-23.
	Launch	10-20-70	
	Performance	7 days	Lunar color and B/W pictures taken on Oct. 24.
	Trajectory	circumlunar	

III. APPENDIXES

APPENDIX A

LISTING OF PROPOSED AND PLANNED SPACECRAFT

SPACECRAFT NAME	TENTATIVE LAUNCH DATE	AGENCY OR COUNTY	REMARKS
DMSP 5D-2/S08		USAF	
DMSP 5D-2/S10		USAF	
DMSP 5D-2/S11		USAF	
DMSP 5D-2/S12		USAF	
DMSP 5D-2/S13		USAF	
DMSP 5D-2/S14		USAF	
ERS-1	12/00/89	ESA	sea surface temperature, wind
GOES-I	10/01/89	NASA/NOAA	
GOES-J	03/01/90	NASA/NOAA	
GOES-K	02/01/92	NASA/NOAA	
INSAT-2		India	
IRS-1 series		India	Landsat type
JERS-1		Japan	
Landsat 6		U.S.	
Landsat 7		U.S.	
Meteosat-2 series		ESA	
MOS-1 series		Japan	
NOAA-K		NOAA	
NOAA-L		NOAA	
NOAA-M		NOAA	
RADARSAT			
SIR-C	00/00/91 00/00/92	U.S./Europe	
SPOT-2	12/00/87	France	Landsat type
TRMM	00/00/94	U.S./Japan	

APPENDIX B

ABBREVIATIONS AND ACRONYMS

A/D	analog to digital
AEM	Applications Explorer Missions (NASA)
AFB	air force base
AFGL	Air Force Geophysical Laboratory
AFGWC	Air Force Global Weather Central (USAF-AWS)
AFTAC	Air Force Technical Application Center (USAF-AWS)
ALT	altitude, radar altimeter
APL	Applied Physics Laboratory of Johns Hopkins University
APT	Automatic Picture Transmission
apog	apogee
a/p	apogee/perigee
ARDC	Air Research and Development Command, now Air Force Systems Command
ASTP	Apollo-Soyuz Test Project (U.S.-U.S.S.R.)
atm	atmosphere
ATN	Advanced TIROS-N (NOAA)
ATS	Applications Technology Satellite (NASA)
AVCS	Advanced Vidicon Camera System
AVHRR	Advanced Very High Resolution Radiometer
AWS	Air Weather Service (USAF)
BUV	Backscatter Ultraviolet Spectrometer
B/W	black and white
CAS	Cooperative Applications Satellite, more commonly referred to as EOLE
CCD	charge-coupled device
CCR	Cloud-Cover Radiometer
CNES	Centre National d'Etudes Spatiales (French space agency)
COSPAR	Committee on Space Research (ICSU)
CZCS	Coastal Zone Color Scanner
DAC	data acquisition camera
DFVLR	Deutsche Forschungs- und Versuchsanstalt fur Luft- und Raumfahrt (Research Laboratory for Aeronautics and Astronautics, Federal Republic of Germany)
DMSP	Defense Meteorological Satellite Program (USAF)
DODGE	Department of Defense Gravity Experiment (DOD satellite)
DRG	Democratic Republic of Germany
DRID	Direct Readout Image Dissector
DRIR	Direct Readout Infrared Radiometer
DSCS	Defense Satellite Communications System
EOLE	French meteorological satellite
ERBE	Earth Radiation Budget Experiment (also program name)
ERBS	Earth Radiation Budget Satellite (NASA)
EREP	Earth Resources Experiment Package
ERL	Environmental Research Laboratory (NOAA)
EROS	Earth Resources Observation System

ERS	Earth Remote Sensing Satellite (ESA)
ERTS	Earth Resources Technology Satellite, now Landsat
ESA	European Space Agency, formerly ESRO
ESMR	Electronic Scanning Microwave Radiometer (NASA)
ESRO	European Space Research Organization, now ESA
ESSA	Environmental Science Services Administration, now NOAA(satellite or agency)
ESTEC	European Space Research and Technology Centre (ESA)
EVA	extravehicular activities
FGGE	First GARP Global Experiment
FOV	field of view
FPR	Flat Plate Radiometer
GAC	global area coverage
GARP	Global Atmospheric Research Program
GATE	GARP Atlantic Tropical Experiment
GISS	Goddard Institute for Space Studies
GMS	Geostationary Meteorological Satellite (NASDA)
GOES	Geostationary Operational Environmental Satellite (NASA-NOAA)
GSFC	Goddard Space Flight Center (NASA)
GSTDN	Ground Spaceflight Tracking and Data Network (NASA)
HCMM	Heat Capacity Mapping Mission (NASA satellite)
HIRS	High-Resolution Infrared Sounder
HRIR	High-Resolution Infrared Radiometer
HRPT	High-Resolution Picture Transmission
ICSU	International Council of Scientific Unions
IDCS	Image Dissector Camera System
IDSCS	Initial Defense Satellite Communications System
IGY	International Geophysical Year
inc or incl	inclination
INSAT	Indian Satellite System (ISO)
IR	infrared
IRIS	Infrared Interferometer Spectrometer
IRS	Indian Remote Sensing Satellite Program
ISRO	Indian Space Research Organization
ITOS	Improved TIROS Operational Satellite (ESSA)
IU	instrument unit
JERS	Japanese Earth Remote Sensing
JPL	Jet Propulsion Laboratory (NASA)
JSC	Johnson Space Center (NASA)
kbs	kilobits per second
KSC	Kennedy Space Center (NASA)
LAC	local area coverage
Landsat	Land Resources Satellite, formerly ERTS (NASA-NOAA)
LaRC	Langley Research Center (NASA)
lat	latitude
LES	Lincoln Experimental Satellite (USAF)
LFC	Large Format Camera

LIMS	Limb Infrared Monitor of the Stratosphere
LISS	Linear Imaging Self-Scanning Radiometer
LRIR	Limb Radiance Inversion Radiometer
MAC	Military Airlift Command
MAPS	Measurement of Air Pollution from Satellites
mb	millibar, also abbreviated as mbar
MBB	Messerschmitt-Bolkow-Blohm
MESSR	Multispectral Electronic Self-Scanning Radiometer
Meteosat	Meteorological Satellite Program (ESA)
MOMS	Modular Optoelectric Multispectral Scanner
MOS	Marine Observation Satellite (NASDA)
MRSE	Microwave Remote Sensing Experiment
MSC	Manned Space Center, now Johnson Space Center
MSFC	Marshall Space Flight Center (NASA)
MSR	Microwave Scanning Radiometer
MSSCC	Multicolor Spin-Scan Cloud-Cover Camera
MSU	Microwave Sounding Unit
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NCAR	National Center for Atmospheric Research (NSF)
NCC	National Climate Center, now NCDC (NOAA)
NCDC	National Climate Data Center, formerly NCC (NOAA)
NEMS	Nimbus-E Microwave Spectrometer
NESDIS	National Environmental Satellite, Data, and Information Service, formerly NESS (NOAA)
NMC	National Meteorological Center (NOAA)
NOAA	National Oceanic and Atmospheric Administration, formerly ESSA (satellite or agency)
NOESS	National Operational Environmental Satellite System (NOAA)
NORAD	North American Air Defense Command
NOS	National Ocean Survey (NOAA)
NOSL	Night-Day Optical Survey of Lighting
NRL	Naval Research Laboratory
NSF	National Science Foundation
NSSDC	National Space Science Data Center (NASA)
NWS	National Weather Service (NOAA)
OSSA	Office of Space Science and Applications (NASA)
OSTA	Office of Space and Terrestrial Applications, now part of OSSA (NASA)
OT	Operational TIROS (U.S. Weather Bureau; subsequently ESSA and NOAA)
OV	orbiting vehicle, also a DOD satellite series
PEOLE	Preliminary EOLE (NASA-France satellite)
PCM	pulse-coded modulation
pd	period
perig	perigee
PMEL	Pacific Marine Environmental Laboratory (NOAA)
PMR	Pressure Modulated Radiometer
RBV	Return Beam Vidicon Camera

SAGE	Stratospheric Aerosol and Gas Experiment (NASA spacecraft or experiment)
SAMOS	Satellite and Missile Observation System (DOD)
SAMS	Stratospheric and Mesospheric Sounder
SAO	Smithsonian Astrophysical Observatory (Smithsonian Institution)
SAR	Synthetic Aperture Radar; Search and Rescue
SARSAT	Search and Rescue Satellite-Aided Tracking
SAS	Soviet Academy of Science
SASS	Seasat-A Satellite Scatterometer
SBUV	Solar Backscatter Ultraviolet Radiometer
SCAMS	Scanning Microwave Spectrometer
SCEL	Signal Corps Engineering Laboratories
SDSD	Satellite Data Services Division (NOAA)
Seasat	Ocean Dynamics Satellite (NASA)
SECOR	Sequential Collection of Range (DOD)
SEM	Space Environment Monitor
SESP	Space Environmental Satellite Program (DOD-USAF)
SIR	Shuttle Imaging Radar
SIRS	Satellite Infrared Spectrometer
SMMR	Scanning Multispectral Microwave Radiometer
SMS	Synchronous Meteorological Satellite (NASA)
SOLRAD	Solar Radiation Satellite (DOD-USAF)
SR	Scanning Radiometer
SSU	Stratospheric Sounding Unit
STP	Space Test Program (DOD-USAF)
STS	Space Transportation System
STDN	Spaceflight Tracking and Data Network (NASA)
S/C	spacecraft
S/N	signal to noise
TDRS	Tracking and Data Relay Satellite (NASA)
TDRSS	Tracking and Data Relay Satellite System (NASA)
THIR	Temperature-Humidity Infrared Radiometer
TIROS	Television and Infrared Observations Satellite (NASA)
TM	Thematic Mapper
TOGA	Tropical Oceans Global Atmospheres Experiment
TOMS	Total Ozone Mapping Spectrometer
TOS	TIROS Operational Satellite or System (NASA)
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Mapping Mission (NASA-NASDA)
TWERLE	Tropical Wind Energy Conversion and Reference Level Experiment
USAF	United States Air Force
USN	United States Navy
UV	ultraviolet
VAS	VISSR Atmospheric Sounder
VHRR	Very High Resolution Radiometer
VIRR	Visible/IR Radiometer
VIS	Visual Imaging Spectrometer
VISSR	Visible Infrared Spin-Scan Radiometer
VTIR	Visible and Thermal Infrared Radiometer
VTPR	Vertical Temperature Profile Radiometer

WDC	World Data Center
WDC-A-R&S	World Data Center A for Rockets and Satellites
WEFAX	weather facsimile
WFC	Wallops Flight Center (NASA)
WFF	Wallops Flight Facility (NASA)
WMO	World Meteorological Organization (UN)
WOCE	World Ocean Circulation Experiment
WSMR	White Sands Missile Range
WTR	Western Test Range

APPENDIX C

DEFINITIONS UNIQUE TO NSSDC FILES

Investigative Program	Code of the cognizant NASA Headquarters office, or name of other sponsoring agency program. Code EE stands for Earth and Science Applications. "CO-OP" added to a code indicates a cooperative effort with another agency or a foreign country.
MG	Program Manager. For NASA missions, "Program" usually refers to the NASA Headquarters level.
NLA	No longer affiliated. Used in the spacecraft personnel section to indicate that the person had the specified affiliation at the time of participation in the project but is no longer there. Used in the investigation personnel section to indicate that the affiliation shown is the last known scientific affiliation and that the given person is no longer there.
NSSDC ID	An identification code used in the NSSDC information system. In this system, each successfully launched spacecraft and experiment is assigned a code based on the launch sequence of the spacecraft. Subsequent to 1962, this code (e.g., 66-008A for the spacecraft ESSA 1) corresponds to the COSPAR international designation. The experiment codes are based on the spacecraft code. For example, the experiments carried aboard the spacecraft 66-008A are numbered 66-008A-01, 66-008A-02, etc. Each prelaunch spacecraft and experiment is also assigned an NSSDC ID code based on the name of the spacecraft. Prior to launch, for example, the approved NASA launch Earth Radiation Budget Satellite was coded ERBS. The experiments carried aboard this spacecraft were coded ERBS-01 and ERBS-02. Once it was launched, its prelaunch designation was changed to a postlaunch ID: 84-108B.
OI	Other Investigator.
PI	Principal Investigator.
PM	Project Manager. If a spacecraft has had several project managers, the initial and latest project managers are both indicated in the spacecraft personnel section. For NASA missions, "Project" usually refers to NASA field center (e.g., GSFC) level. For international programs, there is usually a project manager in each of the two or more participating nations. The current or more recent PM is listed first.
PS	Project Scientist. The above comments for project managers also apply to project scientists.
SC	Program Scientist. The above comment for MG (program managers) also applies to program scientists.
TL	Team Leader.
TM	Team Member.

APPENDIX D

INDEXES

For convenient access to records of interest, three sets of indexes are included: two each for (A) the entire file, (B) spacecraft only, and (C) experiments only. A master index was created, and all other indexes are resorted and edited copies of this master index. When using any index, the location of the text desired is found by use of the "project" designation.

A. Spacecraft and Experiment (SE) Indexes

1. SE-PRO: The project (PRO) index is the only index containing all entries mentioned in the text. It is in the same order as the text material.

2. SE-CO: The country (CO) index duplicates the index SE-PRO except that all U.S. and U.S.S.R. spacecraft are omitted, and the remaining entries are sorted by the sponsoring country. The abbreviation "CO" includes Europe in the case of ESA sponsorship.

B. Spacecraft (S) Indexes

1. S-LD: This index includes all spacecraft entries and is sorted by launch date (LD). The launch date order is identical with the ID order except for planned satellites.

2. S-SC: This index duplicates index S-LD except that it is sorted by spacecraft name (SC).

C. Experiment (E) Indexes

1. E-EX: This index alphabetically lists all experiment (EX) entries. Parentheses are used to note commonly known acronyms and descriptive titles (when no other title is known). These parenthesized titles appear first. Following are all named experiments listed alphabetically, which have no commonly known acronym.

2. E-PI: This index duplicates E-EX except that it is sorted alphabetically by principal investigator (PI). Entries have been omitted when the principal investigator is unknown.

INDEX OF SPACECRAFT AND EXPERIMENTS
SORTED BY PROJECT (11111) AND LAUNCH DATE (22222)

SE-PRO

NSSDC ID	22222 L-DATE	11111 PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
78-041A	04/26/78	AEM	HCMM			US
78-041A	04/26/78	AEM	AEM-A	(SEE HCMM)		US
78-041A-01	04/26/78	AEM	HCMM	(HCMM)HEAT CAPACITY MAP RAD	BARNES	US
79-013A	02/18/79	AEM	SAGE			US
79-013A	02/18/79	AEM	AEM-B	(SEE SAGE)		US
79-013A-01	02/18/79	AEM	SAGE	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
67-113A	11/09/67	APOLLO	APOLLO 04			US
67-113A-	11/09/67	APOLLO	APOLLO 04	(EARTH PHOTOGRAPHY)	NASA	US
68-025A	04/04/68	APOLLO	APOLLO 06			US
68-025A-	04/04/68	APOLLO	APOLLO 06	(EARTH PHOTOGRAPHY)	NASA	US
68-089A	10/11/68	APOLLO	APOLLO 07			US
68-089A-01	10/11/68	APOLLO	APOLLO 07	EARTH CLOUD PHOTOGRAPHY	ALLENBY	US
68-118A	12/21/68	APOLLO	APOLLO 08			US
68-118A-01	12/21/68	APOLLO	APOLLO 08	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-018A	03/03/69	APOLLO	APOLLO 09			US
69-018A-01	03/03/69	APOLLO	APOLLO 09	SPECTRAL TERRAIN PHOTOS	ALLENBY	US
69-043A	05/18/69	APOLLO	APOLLO 10			US
69-043A-01	05/18/69	APOLLO	APOLLO 10	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-059A	07/16/69	APOLLO	APOLLO 11			US
69-059A-01	07/16/69	APOLLO	APOLLO 11	PHOTOS, 70,16 & 35 MM	ALLENBY	US
69-099A	11/14/69	APOLLO	APOLLO 12			US
69-099A-01	11/14/69	APOLLO	APOLLO 12	PHOTOS, 70,16 & 35 MM	ALLENBY	US
69-099A-09	11/14/69	APOLLO	APOLLO 12	PHOTOS,MULTISPECTRAL, 70 MM	GOETZ	US
70-029A	04/11/70	APOLLO	APOLLO 13			US
70-029A-01	04/11/70	APOLLO	APOLLO 13	PHOTOS, 70MM & 16 MM	ALLENBY	US
71-008A	01/31/71	APOLLO	APOLLO 14			US
71-008A-01	01/31/71	APOLLO	APOLLO 14	PHOTOGRAPHY	EL BAZ	US
71-063A	07/26/71	APOLLO	APOLLO 15			US
71-063A-01	07/26/71	APOLLO	APOLLO 15	HANDHELD PHOTOGRAPHY	DOYLE	US
71-063A-02	07/26/71	APOLLO	APOLLO 15	PANORAMIC PHOTOGRAPHY	DOYLE	US
71-063A-03	07/26/71	APOLLO	APOLLO 15	METRIC PHOTOGRAPHY	DOYLE	US
72-031A	04/17/72	APOLLO	APOLLO 16			US
72-031A-01	04/17/72	APOLLO	APOLLO 16	HANDHELD PHOTOGRAPHY	DOYLE	US
72-031A-02	04/17/72	APOLLO	APOLLO 16	PANORAMIC PHOTOGRAPHY	DOYLE	US
72-031A-03	04/17/72	APOLLO	APOLLO 16	METRIC PHOTOGRAPHY	DOYLE	US
72-096A	12/07/72	APOLLO	APOLLO 17			US
72-096A-05	12/07/72	APOLLO	APOLLO 17	HANDHELD PHOTOGRAPHY	DOYLE	US
72-096A-06	12/07/72	APOLLO	APOLLO 17	PANORAMIC PHOTOGRAPHY	DOYLE	US
72-096A-07	12/07/72	APOLLO	APOLLO 17	METRIC PHOTOGRAPHY	DOYLE	US
75-066A	07/15/75	APOLLO	APOLLO 18	(SEE ASTP-APOLLO)		US
75-066A	07/15/75	APOLLO	ASTP APOLLO			US
75-066A-19	07/15/75	APOLLO	ASTP APOLLO	STRAT AEROSOLS(MA-007)	PEPIN	US
75-066A-21	07/15/75	APOLLO	ASTP APOLLO	EARTH OBS & PHOTOS(MA-136)	EL BAZ	US
66-110A	12/07/66	ATS	ATS 1			US
66-110A-09	12/07/66	ATS	ATS 1	(SSCC)SPIN SCAN CLOUD CAMERA	SUOMI	US
67-031A	04/06/67	ATS	ATS 2			US
67-031A-10	04/06/67	ATS	ATS 2	(AVCS)VIDICON CAMERA SYSTEM	RCA	US
67-111A	11/05/67	ATS	ATS 3			US
67-111A-01	11/05/67	ATS	ATS 3	(MSSCC)MULTI COLOR SSCC	SUOMI	US
67-111A-03	11/05/67	ATS	ATS 3	(IDC)IMAGE DISSECTOR CAMERA	BRANCHFLOWER	US
68-068A	08/10/68	ATS	ATS 4			US
68-068A-03	08/10/68	ATS	ATS 4	IMAGE ORTHICON CAMERA	HAZELTINE	US
74-039A	05/30/74	ATS	ATS 6			US
74-039A-08	05/30/74	ATS	ATS 6	(VHRR)VERY HIGH RES RAD	SHENK	US
79-051A	06/07/79	BHASKARA	BHASKARA			INDIA
79-051A-01	06/07/79	BHASKARA	BHASKARA	(SAMIR)SATELLITE MW RAD	JOSEPH	INDIA
79-051A-02	06/07/79	BHASKARA	BHASKARA	TV CAMERA	JOSEPH	INDIA

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NSSDC ID	L-DATE	PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
	22222	11111				
81-115A	11/20/81	BHASKARA	BHASKARA 2			INDIA
81-115A-01	11/20/81	BHASKARA	BHASKARA 2	DUAL TV CAMERA	CALLA	INDIA
81-115A-02	11/20/81	BHASKARA	BHASKARA 2	(SAMIR)SATELLITE MW RAD	CALLA	INDIA
66-057A	06/25/66	COSMOS	COSMOS 122			USSR
66-057A-01	06/25/66	COSMOS	COSMOS 122	DUAL VIDECON CAMERAS		USSR
66-057A-02	06/25/66	COSMOS	COSMOS 122	SCANNING HRIR RADIOMETER		USSR
66-057A-03	06/25/66	COSMOS	COSMOS 122	ACTINOMETRIC INSTRUMENT		USSR
67-024A	03/21/67	COSMOS	COSMOS 149			USSR
67-024A-01	03/21/67	COSMOS	COSMOS 149	3-CHANNEL TELEPHOTOMETER		USSR
67-024A-02	03/21/67	COSMOS	COSMOS 149	NARROW ANGLE HRIR		USSR
67-024A-03	03/21/67	COSMOS	COSMOS 149	3-CHANNEL RADIOMETERS		USSR
67-024A-04	03/21/67	COSMOS	COSMOS 149	TV CAMERA SYSTEM		USSR
67-039A	04/27/67	COSMOS	COSMOS 156			USSR
67-039A-01	04/27/67	COSMOS	COSMOS 156	DUAL VIDECON CAMERAS		USSR
67-039A-02	04/27/67	COSMOS	COSMOS 156	SCANNING HRIR RADIOMETER		USSR
67-039A-03	04/27/67	COSMOS	COSMOS 156	ACTINOMETRIC INSTRUMENT		USSR
70-105A	12/10/70	COSMOS	COSMOS 384			USSR
70-105A-01	12/10/70	COSMOS	COSMOS 384	MICROWAVE RADIOMETER		USSR
70-105A-02	12/10/70	COSMOS	COSMOS 384	IR RADIOMETER		USSR
61-030A	11/15/61	DISCOVERER	DISCOVERER 35			US
61-030A-02	11/15/61	DISCOVERER	DISCOVERER 35	SCANNING RADIOMETER	JURSA	US
66-082A	09/15/66	DMSP	DMSP 4A/F1			US
66-082A-01	09/15/66	DMSP	DMSP 4A/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
66-082A-02	09/15/66	DMSP	DMSP 4A/F1	C-SYSTEM	AFGWC STAFF	US
67-010A	02/08/67	DMSP	DMSP 4A/F2			US
67-010A-01	02/08/67	DMSP	DMSP 4A/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-010A-02	02/08/67	DMSP	DMSP 4A/F2	C-SYSTEM	AFGWC STAFF	US
67-080A	08/22/67	DMSP	DMSP 4A/F3			US
67-080A-01	08/22/67	DMSP	DMSP 4A/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-080A-02	08/22/67	DMSP	DMSP 4A/F3	C-SYSTEM	AFGWC STAFF	US
67-096A	10/11/67	DMSP	DMSP 4A/F4			US
67-096A-01	10/11/67	DMSP	DMSP 4A/F4	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-096A-02	10/11/67	DMSP	DMSP 4A/F4	C-SYSTEM	AFGWC STAFF	US
68-042A	05/22/68	DMSP	DMSP 4B/F1			US
68-042A-01	05/22/68	DMSP	DMSP 4B/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-042A-02	05/22/68	DMSP	DMSP 4B/F1	C-SYSTEM	AFGWC STAFF	US
68-092A	10/22/68	DMSP	DMSP 4B/F2			US
68-092A-01	10/22/68	DMSP	DMSP 4B/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-092A-02	10/22/68	DMSP	DMSP 4B/F2	C-SYSTEM	AFGWC STAFF	US
69-062A	07/22/69	DMSP	DMSP 4B/F3			US
69-062A-01	07/22/69	DMSP	DMSP 4B/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
69-062A-02	07/22/69	DMSP	DMSP 4B/F3	C-SYSTEM	AFGWC STAFF	US
70-012A	02/11/70	DMSP	DMSP 5A/F1			US
70-012A-01	02/11/70	DMSP	DMSP 5A/F1	SCANNING RADIOMETER	AFGWC STAFF	US
70-070A	09/03/70	DMSP	DMSP 5A/F2			US
70-070A-01	09/03/70	DMSP	DMSP 5A/F2	SCANNING RADIOMETER	AFGWC STAFF	US
71-012A	02/17/71	DMSP	DMSP 5A/F3			US
71-012A-01	02/17/71	DMSP	DMSP 5A/F3	SCANNING RADIOMETER	AFGWC STAFF	US
71-087A	10/14/71	DMSP	DMSP 5B/F1			US
71-087A-01	10/14/71	DMSP	DMSP 5B/F1	SCANNING RADIOMETER	AFGWC STAFF	US
72-018A	03/24/72	DMSP	DMSP 5B/F2			US
72-018A-01	03/24/72	DMSP	DMSP 5B/F2	SCANNING RADIOMETER	AFGWC STAFF	US
72-018A-02	03/24/72	DMSP	DMSP 5B/F2	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
72-089A	11/09/72	DMSP	DMSP 5B/F3			US
72-089A-01	11/09/72	DMSP	DMSP 5B/F3	SCANNING RADIOMETER	AFGWC STAFF	US
72-089A-02	11/09/72	DMSP	DMSP 5B/F3	(SSE) VERT TEMP PROFILE RAD	AFGWC STAFF	US
73-054A	08/17/73	DMSP	DMSP 5B/F4			US

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73-054A-01	08/17/73	DMSP	DMSP 5B/F4	SCANNING RADIOMETER	AFGWC STAFF	US
74-015A	03/16/74	DMSP	DMSP 5B/F5			US
74-015A-01	03/16/74	DMSP	DMSP 5B/F5	SCANNING RADIOMETER	AFGWC STAFF	US
74-015A-02	03/16/74	DMSP	DMSP 5B/F5	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
74-063A	08/09/74	DMSP	DMSP 5C/F1			US
74-063A-01	08/09/74	DMSP	DMSP 5C/F1	SCANNING RADIOMETER	AFGWC STAFF	US
75-043A	05/24/75	DMSP	DMSP 5C/F2			US
75-043A-01	05/24/75	DMSP	DMSP 5C/F2	SCANNING RADIOMETER	AFGWC STAFF	US
76-091A	09/11/76	DMSP	DMSP 5D-1/F1			US
76-091A-01	09/11/76	DMSP	DMSP 5D-1/F1	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
76-091A-02	09/11/76	DMSP	DMSP 5D-1/F1	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
77-044A	06/05/77	DMSP	DMSP 5D-1/F2			US
77-044A-01	06/05/77	DMSP	DMSP 5D-1/F2	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
77-044A-02	06/05/77	DMSP	DMSP 5D-1/F2	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
78-042A	05/01/78	DMSP	DMSP 5D-1/F3			US
78-042A-01	05/01/78	DMSP	DMSP 5D-1/F3	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
78-042A-02	05/01/78	DMSP	DMSP 5D-1/F3	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
79-050A	06/06/79	DMSP	DMSP 5D-1/F4			US
79-050A-01	06/06/79	DMSP	DMSP 5D-1/F4	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
79-050A-02	06/06/79	DMSP	DMSP 5D-1/F4	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
79-050A-06	06/06/79	DMSP	DMSP 5D-1/F4	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
79-050A-08	06/06/79	DMSP	DMSP 5D-1/F4	(SSC)SNOW/CLOUD DISCRIM	AFGWC STAFF	US
82-118A	12/21/82	DMSP	DMSP 5D-2/F6			US
82-118A-01	12/21/82	DMSP	DMSP 5D-2/F6	(OLS)LINE SCAN SYSTEM	AFGWC STAFF	US
82-118A-02	12/21/82	DMSP	DMSP 5D-2/F6	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
83-113A	11/18/83	DMSP	DMSP 5D-2/F7			US
83-113A-01	11/18/83	DMSP	DMSP 5D-2/F7	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
83-113A-03	11/18/83	DMSP	DMSP 5D-2/F7	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
87-053A	06/20/87	DMSP	DMSP 5D-2/F8			US
87-053A-01	06/20/87	DMSP	DMSP 5D-2/F8	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
87-053A-05	06/20/87	DMSP	DMSP 5D-2/F8	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
87-053A-06	06/20/87	DMSP	DMSP 5D-2/F8	(SSM/I)MW IMAGER	AFGWC STAFF	US
66-082A	09/15/66	DMSP	DSAP	(SEE DMSP)		US
67-080A	08/22/67	DMSP	DSAP	(SEE DMSP)		US
67-096A	10/11/67	DMSP	DSAP	(SEE DMSP)		US
68-042A	05/22/68	DMSP	DSAP	(SEE DMSP)		US
68-092A	10/22/68	DMSP	DSAP	(SEE DMSP)		US
69-062A	07/22/69	DMSP	DSAP	(SEE DMSP)		US
70-012A	02/11/70	DMSP	DSAP	(SEE DMSP)		US
70-070A	09/03/70	DMSP	DSAP	(SEE DMSP)		US
71-012A	02/17/71	DMSP	DSAP	(SEE DMSP)		US
71-087A	10/14/71	DMSP	DSAP	(SEE DMSP)		US
72-018A	03/24/72	DMSP	DSAP	(SEE DMSP)		US
72-089A	11/09/72	DMSP	DSAP	(SEE DMSP)		US
73-054A	08/17/73	DMSP	DSAP	(SEE DMSP)		US
74-015A	03/16/74	DMSP	DSAP	(SEE DMSP)		US
74-063A	08/09/74	DMSP	DSAP	(SEE DMSP)		US
75-043A	05/24/75	DMSP	DSAP	(SEE DMSP)		US
60-006A	05/24/60	DOD(OTHER)	MIDAS 2			US
60-006A-03	05/24/60	DOD(OTHER)	MIDAS 2	NON-SCANNING RADIOMETER	JURSA	US
61-018A	07/12/61	DOD(OTHER)	MIDAS 3			US
61-018A-04	07/12/61	DOD(OTHER)	MIDAS 3	SCANNING RADIOMETER	JURSA	US
61-028A	10/21/61	DOD(OTHER)	MIDAS 4			US
61-028A-02	10/21/61	DOD(OTHER)	MIDAS 4	SCANNING RADIOMETER	TODD	US
62-010A	04/09/62	DOD(OTHER)	MIDAS 5			US
62-010A-04	04/09/62	DOD(OTHER)	MIDAS 5	SCANNING RADIOMETER	JURSA	US
63-014A	05/09/63	DOD(OTHER)	MIDAS 6			US
63-014A-02	05/09/63	DOD(OTHER)	MIDAS 6	SCANNING RADIOMETER	TODD	US

SE-PRO

NSSDC ID	22222 L-DATE	11111 PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
67-066F	07/01/67	DODGE	DODGE			US
67-066F-01	07/01/67	DODGE	DODGE	COLOR TV OF EARTH	THOMPSON	US
71-071A	08/16/71	EOLE/PEOLE	EOLE 1			FRANCE/US
71-071A-01	08/16/71	EOLE/PEOLE	EOLE 1	UPPER ATMOS WEA RELAY SYS	MOREL/BANDEEN	FRANCE/US
70-109A	12/24/70	EOLE/PEOLE	PEOLE			FRANCE/US
84-108B	10/05/84	ERBE	ERBS			US
84-108B-01	10/05/84	ERBE	ERBS	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
84-108B-02	10/05/84	ERBE	ERBS	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
84-123A	12/12/84	ERBE	NOAA 09			US
84-123A-05	12/12/84	ERBE	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
86-073A	09/17/86	ERBE	NOAA 10			US
86-073A-05	09/17/86	ERBE	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
66-008A	02/03/66	ESSA	ESSA 1			US
66-008A-01	02/03/66	ESSA	ESSA 1	(VCS)VIDICON CAMERA SYS.	NESS STAFF	US
66-016A	02/28/66	ESSA	ESSA 2			US
66-016A-01	02/28/66	ESSA	ESSA 2	(APT)AUTOMATIC PIC TRANS	JONES	US
66-087A	10/02/66	ESSA	ESSA 3			US
66-087A-01	10/02/66	ESSA	ESSA 3	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
66-087A-02	10/02/66	ESSA	ESSA 3	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
67-006A	01/26/67	ESSA	ESSA 4			US
67-006A-01	01/26/67	ESSA	ESSA 4	(APT)AUTOMATIC PIC TRANS	ESSA	US
67-036A	04/20/67	ESSA	ESSA 5			US
67-036A-01	04/20/67	ESSA	ESSA 5	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
67-036A-02	04/20/67	ESSA	ESSA 5	(FPR)FLAT PLATE RADIOMETER	PARENT	US
67-114A	11/10/67	ESSA	ESSA 6			US
67-114A-01	11/10/67	ESSA	ESSA 6	(APT)AUTOMATIC PIC TRANS	ESSA	US
68-069A	08/16/68	ESSA	ESSA 7			US
68-069A-01	08/16/68	ESSA	ESSA 7	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
68-069A-02	08/16/68	ESSA	ESSA 7	(FPR)FLAT PLATE RADIOMETER	PARENT	US
68-114A	12/15/68	ESSA	ESSA 8			US
68-114A-01	12/15/68	ESSA	ESSA 8	(APT)AUTOMATIC PIC TRANS	ESSA	US
69-016A	02/26/69	ESSA	ESSA 9			US
69-016A-01	02/26/69	ESSA	ESSA 9	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
69-016A-02	02/26/69	ESSA	ESSA 9	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
						US
59-004A	08/07/59	EXPLORER	EXPLORER 6			US
59-004A-05	08/07/59	EXPLORER	EXPLORER 6	TELEVISION	BAKER	US
59-009A	10/13/59	EXPLORER	EXPLORER 7			US
59-009A-01	10/13/59	EXPLORER	EXPLORER 7	THERMAL RADIATION	SUOMI	US
						US
65-024A	03/23/65	GEMINI	GEMINI 03			US
65-024A-03	03/23/65	GEMINI	GEMIMI 03	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-043A	06/03/65	GEMINI	GEMINI 04			US
65-043A-01	06/03/65	GEMINI	GEMINI 04	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-043A-02	06/03/65	GEMINI	GEMINI 04	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-068A	08/21/65	GEMINI	GEMINI 05			US
65-068A-02	08/21/65	GEMINI	GEMINI 05	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-068A-03	08/21/65	GEMINI	GEMINI 05	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-068A-04	08/21/65	GEMINI	GEMINI 05	CLOUD TOP SPECTROMETER	SAIEDY	US
65-068A-06	08/21/65	GEMINI	GEMINI 05	SPACE OBJECT RADIOMETRY	BRENTNALL	US
65-104A	12/15/65	GEMINI	GEMINI 06			US
65-104A-01	12/15/65	GEMINI	GEMINI 06	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-104A-02	12/15/65	GEMINI	GEMINI 06	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-100A	12/04/65	GEMINI	GEMINI 07			US
65-100A-01	12/04/65	GEMINI	GEMINI 07	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-100A-02	12/04/65	GEMINI	GEMINI 07	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-100A-05	12/04/65	GEMINI	GEMINI 07	SPACE OBJECT RADIOMETRY	BRENTNALL	US

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66-020A	03/16/66	GEMINI	GEMINI 08			US
66-020A-01	03/16/66	GEMINI	GEMINI 08	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-020A-04	03/16/66	GEMINI	GEMINI 08	CLOUD TOP SPECTROMETER	ALISHOUSE	US
66-020A-07	03/16/66	GEMINI	GEMINI 08	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US
66-047A	06/03/66	GEMINI	GEMINI 09			US
66-047A-05	06/03/66	GEMINI	GEMINI 09	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-047A-06	06/03/66	GEMINI	GEMINI 09	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US
66-066A	07/18/66	GEMINI	GEMINI 10			US
66-066A-02	07/18/66	GEMINI	GEMINI 10	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-066A-03	07/18/66	GEMINI	GEMINI 10	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-081A	09/12/66	GEMINI	GEMINI 11			US
66-081A-06	09/12/66	GEMINI	GEMINI 11	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-081A-07	09/12/66	GEMINI	GEMINI 11	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-104A	11/11/66	GEMINI	GEMINI 12			US
66-104A-02	11/11/66	GEMINI	GEMINI 12	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-104A-03	11/11/66	GEMINI	GEMINI 12	SYNOPTIC WEATHER PHOTOS	NAGLER	US
77-065A	07/14/77	GMS	GMS			JAPAN
77-065A-01	07/14/77	GMS	GMS	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
81-076A	08/10/81	GMS	GMS 2			JAPAN
81-076A-01	08/10/81	GMS	GMS 2	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
84-080A	08/02/84	GMS	GMS 3			JAPAN
84-080A-01	08/02/84	GMS	GMS 3	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
74-033A	05/17/74	GOES/SMS	SMS 1			US
74-033A-01	05/17/74	GOES/SMS	SMS 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-011A	02/06/75	GOES/SMS	SMS 2			US
75-011A-04	02/06/75	GOES/SMS	SMS 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-100A	10/16/75	GOES/SMS	GOES 1			US
75-100A	10/16/75	GOES/SMS	SMS 3	(SEE GOES 1)		US
75-100A-01	10/16/75	GOES/SMS	GOES 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
77-048A	06/16/77	GOES/SMS	GOES 2			US
77-048A-01	06/16/77	GOES/SMS	GOES 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
78-062A	06/16/78	GOES/SMS	GOES 3			US
78-062A-01	06/16/78	GOES/SMS	GOES 3	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
80-074A	09/09/80	GOES/SMS	GOES 4			US
80-074A-01	09/09/80	GOES/SMS	GOES 4	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
81-049A	05/22/81	GOES/SMS	GOES 5			US
81-049A-01	05/22/81	GOES/SMS	GOES 5	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
83-041A	04/28/83	GOES/SMS	GOES 6			US
83-041A-01	04/28/83	GOES/SMS	GOES 6	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
87-022A	02/26/87	GOES/SMS	GOES 7			US
87-022A-01	02/26/87	GOES/SMS	GOES 7	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
82-031A	04/10/82	INSAT	INSAT 1A			INDIA
82-031A-01	04/10/82	INSAT	INSAT 1A	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
83-089B	08/31/83	INSAT	INSAT 1B			INDIA
83-089B-01	08/31/83	INSAT	INSAT 1B	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
INSAT1C	06/00/88	INSAT	INSAT 1C			INDIA
INSAT1C-01	06/00/88	INSAT	INSAT 1C	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
IRS-1A	10/00/87	IRS	IRS 1A			INDIA
IRS-1A-01	10/00/87	IRS	IRS 1A	(LISS)LIN IMG SELF-SCN SENS	ISRO	INDIA
72-058A	07/23/72	LANDSAT	ERTS-A	(SEE LANDSAT)		US
75-004A	01/22/75	LANDSAT	ERTS-B	(SEE LANDSAT)		US
78-026A	03/05/78	LANDSAT	ERTS-C	(SEE LANDSAT)		US
72-058A	07/23/72	LANDSAT	LANDSAT 1			US
72-058A-02	07/23/72	LANDSAT	LANDSAT 1	(MSS)MULTISPECT SCAN	ARLUSKAS	US
75-004A	01/22/75	LANDSAT	LANDSAT 2			US

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75-004A-02	01/22/75	LANDSAT	LANDSAT 2	(MSS)MULTISPECT SCAN	FREDEN	US
78-026A	03/05/78	LANDSAT	LANDSAT 3			US
78-026A-02	03/05/78	LANDSAT	LANDSAT 3	(MSS)MULTISPECT SCAN	FREDEN	US
82-072A	07/16/82	LANDSAT	LANDSAT 4			US
82-072A-02	07/16/82	LANDSAT	LANDSAT 4	(MSS)MULTISPECT SCAN	SALMONSEN	US
84-021A	03/01/84	LANDSAT	LANDSAT 5			US
84-021A-02	03/01/84	LANDSAT	LANDSAT 5	(MSS)MULTISPECT SCAN	SALMONSEN	US
61-025A	09/13/61	MERCURY	MA-4			US
61-025A-01	09/13/61	MERCURY	MA-4	EARTH PHOTOGRAPHY	NASA	US
61-033A	11/29/61	MERCURY	MA-5			US
61-033A-01	11/29/61	MERCURY	MA-5	EARTH PHOTOGRAPHY	NASA	US
62-003A	02/20/62	MERCURY	MA-6			US
62-003A-01	02/20/62	MERCURY	MA-6	EARTH PHOTOGRAPHY	NASA	US
62-019A	05/24/62	MERCURY	MA-7			US
62-019A-01	05/24/62	MERCURY	MA-7	EARTH PHOTOGRAPHY	NASA	US
62-052A	10/03/62	MERCURY	MA-8			US
62-052A-01	10/03/62	MERCURY	MA-8	EARTH PHOTOGRAPHY	NASA	US
63-015A	03/15/63	MERCURY	MA-9			US
63-015A-01	03/15/63	MERCURY	MA-9	EARTH PHOTOGRAPHY	NASA	US
69-029A	03/26/69	METEOR 1	METEOR 1-01			USSR
69-029A-01	03/26/69	METEOR 1	METEOR 1-01	DUAL VIDICON CAMERAS		USSR
69-029A-02	03/26/69	METEOR 1	METEOR 1-01	SCANNING HRIR RADIOMETER		USSR
69-029A-03	03/26/69	METEOR 1	METEOR 1-01	ACTINOMETRIC INSTRUMENT		USSR
69-084A	10/06/69	METEOR 1	METEOR 1-02			USSR
69-084A-01	10/06/69	METEOR 1	METEOR 1-02	DUAL VIDICON CAMERAS		USSR
69-084A-02	10/06/69	METEOR 1	METEOR 1-02	SCANNING HRIR RADIOMETER		USSR
69-084A-03	10/06/69	METEOR 1	METEOR 1-02	ACTINOMETRIC INSTRUMENT		USSR
70-019A	03/17/70	METEOR 1	METEOR 1-03			USSR
70-019A-01	03/17/70	METEOR 1	METEOR 1-03	DUAL VIDICON CAMERAS		USSR
70-019A-02	03/17/70	METEOR 1	METEOR 1-03	SCANNING HRIR RADIOMETER		USSR
70-019A-03	03/17/70	METEOR 1	METEOR 1-03	ACTINOMETRIC INSTRUMENT		USSR
70-037A	04/28/70	METEOR 1	METEOR 1-04			USSR
70-037A-01	04/28/70	METEOR 1	METEOR 1-04	DUAL VIDICON CAMERAS		USSR
70-037A-02	04/28/70	METEOR 1	METEOR 1-04	SCANNING HRIR RADIOMETER		USSR
70-037A-03	04/28/70	METEOR 1	METEOR 1-04	ACTINOMETRIC INSTRUMENT		USSR
70-047A	06/23/70	METEOR 1	METEOR 1-05			USSR
70-047A-01	06/23/70	METEOR 1	METEOR 1-05	DUAL VIDICON CAMERAS		USSR
70-047A-02	06/23/70	METEOR 1	METEOR 1-05	SCANNING HRIR RADIOMETER		USSR
70-047A-03	06/23/70	METEOR 1	METEOR 1-05	ACTINOMETRIC INSTRUMENT		USSR
70-085A	10/15/70	METEOR 1	METEOR 1-06			USSR
70-085A-01	10/15/70	METEOR 1	METEOR 1-06	DUAL VIDICON CAMERAS		USSR
70-085A-02	10/15/70	METEOR 1	METEOR 1-06	SCANNING HRIR RADIOMETER		USSR
70-085A-03	10/15/70	METEOR 1	METEOR 1-06	ACTINOMETRIC INSTRUMENT		USSR
71-003A	01/20/71	METEOR 1	METEOR 1-07			USSR
71-003A-01	01/20/71	METEOR 1	METEOR 1-07	DUAL VIDICON CAMERAS		USSR
71-003A-02	01/20/71	METEOR 1	METEOR 1-07	SCANNING HRIR RADIOMETER		USSR
71-003A-03	01/20/71	METEOR 1	METEOR 1-07	ACTINOMETRIC INSTRUMENT		USSR
71-031A	04/17/71	METEOR 1	METEOR 1-08			USSR
71-031A-01	04/17/71	METEOR 1	METEOR 1-08	DUAL VIDICON CAMERAS		USSR
71-031A-02	04/17/71	METEOR 1	METEOR 1-08	SCANNING HRIR RADIOMETER		USSR
71-031A-03	04/17/71	METEOR 1	METEOR 1-08	ACTINOMETRIC INSTRUMENT		USSR
71-059A	07/16/71	METEOR 1	METEOR 1-09			USSR
71-059A-01	07/16/71	METEOR 1	METEOR 1-09	DUAL VIDICON CAMERAS		USSR
71-059A-02	07/16/71	METEOR 1	METEOR 1-09	SCANNING HRIR RADIOMETER		USSR
71-059A-03	07/16/71	METEOR 1	METEOR 1-09	ACTINOMETRIC INSTRUMENT		USSR
71-059A-04	07/16/71	METEOR 1	METEOR 1-09	ATMOS THERMAL SOUNDER		USSR
71-120A	12/29/71	METEOR 1	METEOR 1-10			USSR
71-120A-01	12/29/71	METEOR 1	METEOR 1-10	DUAL VIDICON CAMERAS		USSR

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71-120A-02	12/29/71	METEOR 1	METEOR 1-10	SCANNING HRIR RADIOMETER		USSR
71-120A-03	12/29/71	METEOR 1	METEOR 1-10	ACTINOMETRIC INSTRUMENT		USSR
71-120A-04	12/29/71	METEOR 1	METEOR 1-10	ATMOS THERMAL SOUNDER		USSR
71-120A-05	12/29/71	METEOR 1	METEOR 1-10	(APT)AUTO PIC TRANSMISSION		USSR
72-022A	03/30/72	METEOR 1	METEOR 1-11			USSR
72-022A-01	03/30/72	METEOR 1	METEOR 1-11	DUAL VIDICON CAMERAS		USSR
72-022A-02	03/30/72	METEOR 1	METEOR 1-11	SCANNING HRIR RADIOMETER		USSR
72-022A-03	03/30/72	METEOR 1	METEOR 1-11	ACTINOMETRIC INSTRUMENT		USSR
72-022A-04	03/30/72	METEOR 1	METEOR 1-11	ATMOSTHERMAL SOUNDER		USSR
72-022A-05	03/30/72	METEOR 1	METEOR 1-11	(APT)AUTO PIC TRANSMISSION		USSR
72-049A	06/30/72	METEOR 1	METEOR 1-12			USSR
72-049A-01	06/30/72	METEOR 1	METEOR 1-12	DUAL VIDICON CAMERAS		USSR
72-049A-02	06/30/72	METEOR 1	METEOR 1-12	SCANNING HRIR RADIOMETER		USSR
72-049A-03	06/30/72	METEOR 1	METEOR 1-12	ACTINOMETRIC INSTRUMENT		USSR
72-049A-04	06/30/72	METEOR 1	METEOR 1-12	ATMOSTHERMAL SOUNDER		USSR
72-049A-05	06/30/72	METEOR 1	METEOR 1-12	(APT)AUTO PIC TRANSMISSION		USSR
72-085A	10/27/72	METEOR 1	METEOR 1-13			USSR
72-085A-01	10/27/72	METEOR 1	METEOR 1-13	DUAL VIDICON CAMERAS		USSR
72-085A-02	10/27/72	METEOR 1	METEOR 1-13	SCANNING HRIR RADIOMETER		USSR
72-085A-03	10/27/72	METEOR 1	METEOR 1-13	ACTINOMETRIC INSTRUMENT		USSR
72-085A-04	10/27/72	METEOR 1	METEOR 1-13	ATMOS THERMAL SOUNDER		USSR
72-085A-05	10/27/72	METEOR 1	METEOR 1-13	(APT)AUTO PIC TRANSMISSION		USSR
73-015A	03/20/73	METEOR 1	METEOR 1-14			USSR
73-015A-01	03/20/73	METEOR 1	METEOR 1-14	DUAL VIDICON CAMERAS		USSR
73-015A-02	03/20/73	METEOR 1	METEOR 1-14	SCANNING HRIR RADIOMETER		USSR
73-015A-03	03/20/73	METEOR 1	METEOR 1-14	ACTINOMETRIC INSTRUMENT		USSR
73-015A-04	03/20/73	METEOR 1	METEOR 1-14	ATMOS THERMAL SOUNDER		USSR
73-034A	05/29/73	METEOR 1	METEOR 1-15			USSR
73-034A-01	05/29/73	METEOR 1	METEOR 1-15	DUAL VIDICON CAMERAS		USSR
73-034A-02	05/29/73	METEOR 1	METEOR 1-15	SCANNING HRIR RADIOMETER		USSR
73-034A-03	05/29/73	METEOR 1	METEOR 1-15	ACTINOMETRIC INSTRUMENT		USSR
73-034A-04	05/29/73	METEOR 1	METEOR 1-15	ATMOSTHERMAL SOUNDER		USSR
74-011A	03/05/74	METEOR 1	METEOR 1-16			USSR
74-011A-01	03/05/74	METEOR 1	METEOR 1-16	DUAL VIDICON CAMERAS		USSR
74-011A-02	03/05/74	METEOR 1	METEOR 1-16	SCANNING HRIR RADIOMETER		USSR
74-011A-03	03/05/74	METEOR 1	METEOR 1-16	ACTINOMETRIC INSTRUMENT		USSR
74-011A-04	03/05/74	METEOR 1	METEOR 1-16	ATMOS THERMAL SOUNDER		USSR
74-025A	04/24/74	METEOR 1	METEOR 1-17			USSR
74-025A-01	04/24/74	METEOR 1	METEOR 1-17	DUAL VIDICON CAMERAS		USSR
74-025A-02	04/24/74	METEOR 1	METEOR 1-17	SCANNING HRIR RADIOMETER		USSR
74-025A-03	04/24/74	METEOR 1	METEOR 1-17	ACTINOMETRIC INSTRUMENT		USSR
74-025A-04	04/24/74	METEOR 1	METEOR 1-17	ATMOS THERMAL SOUNDER		USSR
74-052A	07/09/74	METEOR 1	METEOR 1-18			USSR
74-052A-01	07/09/74	METEOR 1	METEOR 1-18	DUAL VIDICON CAMERAS		USSR
74-052A-02	07/09/74	METEOR 1	METEOR 1-18	SCANNING HRIR RADIOMETER		USSR
74-052A-03	07/09/74	METEOR 1	METEOR 1-18	ACTINOMETRIC INSTRUMENT		USSR
74-052A-04	07/09/74	METEOR 1	METEOR 1-18	ATMOS THERMAL SOUNDER		USSR
74-052A-05	07/09/74	METEOR 1	METEOR 1-18	(APT)AUTO PIC TRANSMISSION		USSR
74-083A	10/28/74	METEOR 1	METEOR 1-19			USSR
73-083A-01	10/28/74	METEOR 1	METEOR 1-19	DUAL VIDICON CAMERAS		USSR
74-083A-02	10/28/74	METEOR 1	METEOR 1-19	SCANNING HRIR RADIOMETER		USSR
74-083A-03	10/28/74	METEOR 1	METEOR 1-19	ACTINOMETRIC INSTRUMENT		USSR
74-083A-04	10/28/74	METEOR 1	METEOR 1-19	ATMOS THERMAL SOUNDER		USSR
74-083A-05	10/28/74	METEOR 1	METEOR 1-19	(APT)AUTO PIC TRANSMISSION		USSR
74-099A	12/17/74	METEOR 1	METEOR 1-20			USSR
74-099A-01	12/17/74	METEOR 1	METEOR 1-20	DUAL VIDICON CAMERAS		USSR
74-099A-02	12/17/74	METEOR 1	METEOR 1-20	SCANNING HRIR RADIOMETER		USSR
74-099A-03	12/17/74	METEOR 1	METEOR 1-20	ACTINOMETRIC INSTRUMENT		USSR
74-099A-04	12/17/74	METEOR 1	METEOR 1-20	ATMOS THERMAL SOUNDER		USSR
75-023A	04/01/75	METEOR 1	METEOR 1-21			USSR

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75-023A-01	04/01/75	METEOR 1	METEOR 1-21	DUAL VIDICON CAMERAS		USSR
75-023A-02	04/01/75	METEOR 1	METEOR 1-21	SCANNING HRIR RADIOMETER		USSR
75-023A-03	04/01/75	METEOR 1	METEOR 1-21	ACTINOMETRIC INSTRUMENT		USSR
75-023A-04	04/01/75	METEOR 1	METEOR 1-21	ATMOS THERMAL SOUNDER		USSR
75-087A	09/18/75	METEOR 1	METEOR 1-22			USSR
75-087A-01	09/18/75	METEOR 1	METEOR 1-22	DUAL VIDICON CAMERAS		USSR
75-087A-02	09/18/75	METEOR 1	METEOR 1-22	SCANNING HRIR RADIOMETER		USSR
75-087A-03	09/18/75	METEOR 1	METEOR 1-22	ACTINOMETRIC INSTRUMENT		USSR
75-087A-04	09/18/75	METEOR 1	METEOR 1-22	ATMOS THERMAL SOUNDER		USSR
75-124A	12/25/75	METEOR 1	METEOR 1-23			USSR
75-124A-01	12/25/75	METEOR 1	METEOR 1-23	DUAL VIDICON CAMERAS		USSR
75-124A-02	12/25/75	METEOR 1	METEOR 1-23	SCANNING HRIR RADIOMETER		USSR
75-124A-03	12/25/75	METEOR 1	METEOR 1-23	ACTINOMETRIC INSTRUMENT		USSR
75-124A-04	12/25/75	METEOR 1	METEOR 1-23	ATMOS THERMAL SOUNDER		USSR
76-032A	04/07/76	METEOR 1	METEOR 1-24			USSR
76-032A-01	04/07/76	METEOR 1	METEOR 1-24	DUAL VIDICON CAMERAS		USSR
76-032A-02	04/07/76	METEOR 1	METEOR 1-24	SCANNING HRIR RADIOMETER		USSR
76-032A-03	04/07/76	METEOR 1	METEOR 1-24	ACTINOMETRIC INSTRUMENT		USSR
76-032A-04	04/07/76	METEOR 1	METEOR 1-24	ATMOS THERMAL SOUNDER		USSR
76-043A	05/15/76	METEOR 1	METEOR 1-25			USSR
76-043A-01	05/15/76	METEOR 1	METEOR 1-25	DUAL VIDICON CAMERAS		USSR
76-043A-02	05/15/76	METEOR 1	METEOR 1-25	SCANNING HRIR RADIOMETER		USSR
76-043A-03	05/15/76	METEOR 1	METEOR 1-25	ACTINOMETRIC INSTRUMENT		USSR
76-043A-04	05/15/76	METEOR 1	METEOR 1-25	ATMOS THERMAL SOUNDER		USSR
76-102A	10/16/76	METEOR 1	METEOR 1-26			USSR
76-102A-01	10/16/76	METEOR 1	METEOR 1-26	DUAL VIDICON CAMERAS		USSR
76-102A-02	10/16/76	METEOR 1	METEOR 1-26	SCANNING HRIR RADIOMETER		USSR
76-102A-03	10/16/76	METEOR 1	METEOR 1-26	ACTINOMETRIC INSTRUMENT		USSR
76-102A-04	10/16/76	METEOR 1	METEOR 1-26	ATMOS THERMAL SOUNDER		USSR
77-024A	04/05/77	METEOR 1	METEOR 1-27			USSR
77-024A-01	04/05/77	METEOR 1	METEOR 1-27	DUAL VIDICON CAMERAS		USSR
77-024A-02	04/05/77	METEOR 1	METEOR 1-27	SCANNING HRIR RADIOMETER		USSR
77-024A-03	04/05/77	METEOR 1	METEOR 1-27	ACTINOMETRIC INSTRUMENT		USSR
77-024A-04	04/05/77	METEOR 1	METEOR 1-27	ATMOS THERMAL SOUNDER		USSR
77-057A	06/29/77	METEOR 1	METEOR 1-28			USSR
77-057A-01	06/29/77	METEOR 1	METEOR 1-28	DUAL VIDICON CAMERAS		USSR
77-057A-02	06/29/77	METEOR 1	METEOR 1-28	SCANNING HRIR RADIOMETER		USSR
79-005A	01/25/79	METEOR 1	METEOR 1-29			USSR
79-005A-01	01/25/79	METEOR 1	METEOR 1-29	DUAL VIDICON CAMERAS		USSR
79-005A-02	01/25/79	METEOR 1	METEOR 1-29	SCANNING HRIR RADIOMETER		USSR
80-051A	06/18/80	METEOR 1	METEOR 1-30			USSR
80-051A-01	06/18/80	METEOR 1	METEOR 1-30	DUAL VIDICON CAMERAS		USSR
80-051A-02	06/18/80	METEOR 1	METEOR 1-30	SCANNING HRIR RADIOMETER		USSR
81-065A	07/10/81	METEOR 1	METEOR 1-31			USSR
81-065A-01	07/10/81	METEOR 1	METEOR 1-31	DUAL VIDICON CAMERAS		USSR
81-065A-02	07/10/81	METEOR 1	METEOR 1-31	SCANNING HRIR RADIOMETER		USSR
75-064A	07/11/75	METEOR 2	METEOR 2-01			USSR
77-002A	01/07/77	METEOR 2	METEOR 2-02			USSR
77-117A	12/14/77	METEOR 2	METEOR 2-03			USSR
79-021A	03/01/79	METEOR 2	METEOR 2-04			USSR
79-095A	10/31/79	METEOR 2	METEOR 2-05			USSR
80-073A	09/09/80	METEOR 2	METEOR 2-06			USSR
81-043A	05/14/81	METEOR 2	METEOR 2-07			USSR
82-025A	03/25/82	METEOR 2	METEOR 2-08			USSR
82-116A	12/14/82	METEOR 2	METEOR 2-09			USSR
83-109A	10/28/83	METEOR 2	METEOR 2-10			USSR
84-072A	07/18/84	METEOR 2	METEOR 2-11			USSR
85-013A	02/06/85	METEOR 2	METEOR 2-12			USSR
85-119A	12/26/85	METEOR 2	METEOR 2-13			USSR

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86-039A	05/27/86	METEOR 2	METEOR 2-14			USSR
87-001A	02/15/87	METEOR 2	METEOR 2-15			USSR
77-108A	11/23/77	METEOSAT	METEOSAT 1			EUROPE
77-108A-01	11/23/77	METEOSAT	METEOSAT 1	IMAGING RADIOMETER	SERENE	EUROPE
77-108A-02	11/23/77	METEOSAT	METEOSAT 1	(DCP)DATA COLL PLAT	PERA	EUROPE
81-057A	06/19/81	METEOSAT	METEOSAT 2			EUROPE
81-057A-01	06/19/81	METEOSAT	METEOSAT 2	IMAGING RADIOMETER	SERENE	EUROPE
81-057A-02	06/19/81	METEOSAT	METEOSAT 2	(DCP)DATA COLL PLAT	PERA	EUROPE
MTSATP2	01/00/88	METEOSAT	METEOSAT P2			EUROPE
MTSATP2-01	01/00/88	METEOSAT	METEOSAT P2	IMAGING RADIOMETER		EUROPE
MTSATP2-02	01/00/88	METEOSAT	METEOSAT P2	(DCP)DATA COLL PLAT		EUROPE
66-035A	04/25/66	MOLNIYA 1	MOLNIYA 1- 03			USSR
66-035A-	04/25/66	MOLNIYA 1	MOLNIYA 1- 03	(EARTH CLOUD PHOTOGRAPHY)		USSR
66-092A	10/20/66	MOLNIYA 1	MOLNIYA 1- 04			USSR
66-092A-	10/20/66	MOLNIYA 1	MOLNIYA 1- 04	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-052A	05/24/67	MOLNIYA 1	MOLNIYA 1- 05			USSR
67-052A-	05/24/67	MOLNIYA 1	MOLNIYA 1- 05	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-095A	10/03/67	MOLNIYA 1	MOLNIYA 1- 06			USSR
67-095A-	10/03/67	MOLNIYA 1	MOLNIYA 1- 06	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-101A	10/22/67	MOLNIYA 1	MOLNIYA 1- 07			USSR
67-101A-	10/22/67	MOLNIYA 1	MOLNIYA 1- 07	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-035A	04/21/68	MOLNIYA 1	MOLNIYA 1- 08			USSR
68-035A-	04/21/68	MOLNIYA 1	MOLNIYA 1- 08	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-057A	07/05/68	MOLNIYA 1	MOLNIYA 1- 09			USSR
68-057A-	07/05/68	MOLNIYA 1	MOLNIYA 1- 09	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-085A	10/05/68	MOLNIYA 1	MOLNIYA 1-10			USSR
68-085A-	10/05/68	MOLNIYA 1	MOLNIYA 1-10	(EARTH CLOUD PHOTOGRAPHY)		USSR
87-018A	02/19/87	MOS	MOS 1			JAPAN
87-018A-01	02/19/87	MOS	MOS 1	(MESSR)MSP ELE SELF-SCAN RAD.	NASDA	JAPAN
87-018A-02	02/19/87	MOS	MOS 1	(VTIR)VIS & THERMAL IR RAD	NASDA	JAPAN
87-018A-03	02/19/87	MOS	MOS 1	(MSR)MICROWAVE SCAN RAD	NASDA	JAPAN
87-018A-04	02/19/87	MOS	MOS 1	(DCS)DATA COLL SYS TRANSPNDR	NASDA	JAPAN
64-052A	08/28/64	NIMBUS	NIMBUS 1			US
64-052A-01	08/28/64	NIMBUS	NIMBUS 1	(AVCS)ADV VIDICON CAMERA SYS	BURDETT	US
64-052A-02	08/28/64	NIMBUS	NIMBUS 1	(APT)AUTO PIC TRANSMISSION	HUNTER	US
64-052A-03	08/28/64	NIMBUS	NIMBUS 1	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
66-040A	05/15/66	NIMBUS	NIMBUS 2			US
66-040A-01	05/15/66	NIMBUS	NIMBUS 2	(AVCS)ADV VIDICON CAMERA SYS	SCHULMAN	US
66-040A-02	05/15/66	NIMBUS	NIMBUS 2	(APT)AUTO PIC TRANSMISSION	SCHULMAN	US
66-040A-03	05/15/66	NIMBUS	NIMBUS 2	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
66-040A-04	05/15/66	NIMBUS	NIMBUS 2	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
69-037A	04/14/69	NIMBUS	NIMBUS 3			US
69-037A-02	04/14/69	NIMBUS	NIMBUS 3	(HRIR)HIGH RES IR RADIOMETER	CHERRIX	US
69-037A-03	04/14/69	NIMBUS	NIMBUS 3	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
69-037A-04	04/14/69	NIMBUS	NIMBUS 3	(SIRS)SAT IR SPECT	WARK	US
69-037A-05	04/14/69	NIMBUS	NIMBUS 3	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
69-037A-06	04/14/69	NIMBUS	NIMBUS 3	(IDC)IMAGE DISSECTOR CAMERA	BRACHFLOWER	US
70-025A	04/08/70	NIMBUS	NIMBUS 4			US
70-025A-02	04/08/70	NIMBUS	NIMBUS 4	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
70-025A-03	04/08/70	NIMBUS	NIMBUS 4	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
70-025A-04	04/08/70	NIMBUS	NIMBUS 4	(SIRS)SAT IR SPECT	WARK	US
70-025A-05	04/08/70	NIMBUS	NIMBUS 4	(BUV)BACKSCATTER UV SPEC	HEATH	US
70-025A-06	04/08/70	NIMBUS	NIMBUS 4	(IDC)IMAGE DISSECTOR CAMERA	BANCHFLOWER	US
70-025A-09	04/08/70	NIMBUS	NIMBUS 4	FILTER WEDGE SPECT	HOVIS	US
70-025A-10	04/08/70	NIMBUS	NIMBUS 4	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
72-097A	12/11/72	NIMBUS	NIMBUS 5			US

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72-097A-01	12/11/72	NIMBUS	NIMBUS 5	(ITPR)IR TEMP PROFILE RAD	SMITH	US
72-097A-02	12/11/72	NIMBUS	NIMBUS 5	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
72-097A-03	12/11/72	NIMBUS	NIMBUS 5	MICROWAVE SPECTROMETER	STAELIN	US
72-097A-04	12/11/72	NIMBUS	NIMBUS 5	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US
72-097A-05	12/11/72	NIMBUS	NIMBUS 5	(SCMR)SFC COMP MAPPING RAD	HOVIS	US
72-097A-08	12/11/72	NIMBUS	NIMBUS 5	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
75-052A	06/12/75	NIMBUS	NIMBUS 6			US
75-052A-01	06/12/75	NIMBUS	NIMBUS 6	(TWERLE)TRP WND ENG CONV	JULIAN	US
75-052A-02	06/12/75	NIMBUS	NIMBUS 6	(HIRS)HIGH RES IR SOUNDER	SMITH	US
75-052A-03	06/12/75	NIMBUS	NIMBUS 6	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US
75-052A-04	06/12/75	NIMBUS	NIMBUS 6	(LRIR)LIMB RAD INVER RAD	GILLE	US
75-052A-05	06/12/75	NIMBUS	NIMBUS 6	(ERB)EARTH RADIATION BUDGET	SMITH	US
75-052A-09	06/12/75	NIMBUS	NIMBUS 6	(PMR)PRESS MODULATED RAD	HOUGHTON	US
75-052A-10	06/12/75	NIMBUS	NIMBUS 6	(SCAMS)SCAN MICROWAVE RAD	STAELIN	US
75-052A-12	06/12/75	NIMBUS	NIMBUS 6	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
78-098A	10/24/78	NIMBUS	NIMBUS 7			US
78-098A-01	10/24/78	NIMBUS	NIMBUS 7	(LIMS)LIMB IR MON STRATO	RUSSELL	US
78-098A-02	10/24/78	NIMBUS	NIMBUS 7	(SAMS)STRAT + MESO SOUNDER	HOUGHTON	UK
78-098A-03	10/24/78	NIMBUS	NIMBUS 7	(CZCS)COAST ZONE COLOR SCAN	HOVIS	US
78-098A-06	10/24/78	NIMBUS	NIMBUS 7	(SAM-II)STRAT AEROSOL MEA	MCCORMICK	US
78-098A-07	10/24/78	NIMBUS	NIMBUS 7	(ERB)EARTH RADIATION BUDGET	JACOBOWITZ	US
78-098A-08	10/24/78	NIMBUS	NIMBUS 7	(SMMR)SCAN MICROWAVE RAD	GLOERSEN	US
78-098A-09	10/24/78	NIMBUS	NIMBUS 7	(SBUV/TOMS)-BACKSC UV/OZONE	HEATH	US
78-098A-10	10/24/78	NIMBUS	NIMBUS 7	(THIR)TEMP-HUMIDITY IR RAD	STOWE	US
70-008A	01/23/70	NOAA 1-5/ITOS	ITOS 1			US
70-008A-02	01/23/70	NOAA 1-5/ITOS	ITOS 1	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
70-008A-03	01/23/70	NOAA 1-5/ITOS	ITOS 1	SCANNING RADIOMETER SYSTEM	GEMUNDER	US
70-008A-04	01/23/70	NOAA 1-5/ITOS	ITOS 1	(AVCS)ADV VICICON CAMERA SYS	NESS STAFF	US
70-008A-05	01/23/70	NOAA 1-5/ITOS	ITOS 1	(APT)AUTO PIC TRANSMISSION	NESS STAFF	US
70-106A	12/11/70	NOAA 1-5/ITOS	NOAA 01			US
70-106A-02	12/11/70	NOAA 1-5/ITOS	NOAA 01	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
70-106A-03	12/11/70	NOAA 1-5/ITOS	NOAA 01	(SR)SCANNING RADIOMETER	GEMUNDER	US
70-106A-04	12/11/70	NOAA 1-5/ITOS	NOAA 01	(AVCS)ADV VIDICON CAMERA SYS	NESDIS	US
70-106A-05	12/11/70	NOAA 1-5/ITOS	NOAA 01	(APT)AUTO PIC TRANSM	NESDIS	US
72-082A	10/15/72	NOAA 1-5/ITOS	NOAA 02			US
72-082A-02	10/15/72	NOAA 1-5/ITOS	NOAA 02	(SR)SCANNING RADIOMETER	NESDIS	US
72-082A-03	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VHRR)VERY HIGH RES RAD	NESDIS	US
72-082A-04	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
73-086A	11/06/73	NOAA 1-5/ITOS	NOAA 03			US
73-086A-02	11/06/73	NOAA 1-5/ITOS	NOAA 03	(SR)SCANNING RADIOMETER	NESDIS	US
73-086A-03	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VHRR)VERY HIGH RES RAD	NESDIS	US
73-086A-04	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
74-089A	11/15/74	NOAA 1-5/ITOS	NOAA 04			US
74-089A-02	11/15/74	NOAA 1-5/ITOS	NOAA 04	(SR)SCANNING RADIOMETER	NESDIS	US
74-089A-03	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VHRR)VERY HIGH RES RAD	NESDIS	US
74-089A-04	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
76-077A	06/27/76	NOAA 1-5/ITOS	NOAA 05			US
76-077A-01	06/27/76	NOAA 1-5/ITOS	NOAA 05	(VHRR)VERY HIGH RES RAD	NESDIS	US
76-077A-02	06/27/76	NOAA 1-5/ITOS	NOAA 05	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
76-077A-03	06/27/76	NOAA 1-5/ITOS	NOAA 05	(SR)SCANNING RADIOMETER	NESDIS	US
78-096A	10/13/78	NOAA 6-D/T-N	TIROS N			US
78-096A-01	10/13/78	NOAA 6-D/T-N	TIROS N	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
78-096A-02	10/13/78	NOAA 6-D/T-N	TIROS N	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
79-057A	06/27/79	NOAA 6-D/T-N	NOAA 06			US
79-057A-01	06/27/79	NOAA 6-D/T-N	NOAA 06	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
79-057A-02	06/27/79	NOAA 6-D/T-N	NOAA 06	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
81-059A	06/23/81	NOAA 6-D/T-N	NOAA 07			US
81-059A-01	06/23/81	NOAA 6-D/T-N	NOAA 07	(AVHRR)ADV VERY HI RES RAD	NESDIS	US

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81-059A-02	06/23/81	NOAA 6-D/T-N	NOAA 07	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-D		NOAA 6-D/T-N	NOAA-D			US
NOAA-D-01		NOAA 6-D/T-N	NOAA-D	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-D-02		NOAA 6-D/T-N	NOAA-D	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
83-022A	03/28/83	NOAA 8-J/ATN	NOAA 08			US
83-022A-01	03/28/83	NOAA 8-J/ATN	NOAA 08	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
83-022A-02	03/28/83	NOAA 8-J/ATN	NOAA 08	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
84-123A	12/12/84	NOAA 8-J/ATN	NOAA 09			US
84-123A-01	12/12/84	NOAA 8-J/ATN	NOAA 09	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
84-123A-02	12/12/84	NOAA 8-J/ATN	NOAA 09	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
84-123A-05	12/12/84	NOAA 8-J/ATN	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
84-123A-07	12/12/84	NOAA 8-J/ATN	NOAA 09	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
86-073A	09/17/86	NOAA 8-J/ATN	NOAA 10			US
86-073A-01	09/17/86	NOAA 8-J/ATN	NOAA 10	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
86-073A-02	09/17/86	NOAA 8-J/ATN	NOAA 10	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
86-073A-05	09/17/86	NOAA 8-J/ATN	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
NOAA-H	02/00/88	NOAA 8-J/ATN	NOAA H			US
NOAA-H-01	02/00/88	NOAA 8-J/ATN	NOAA H	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-H-02	02/00/88	NOAA 8-J/ATN	NOAA H	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-H-05	12/12/84	NOAA 8-J/ATN	NOAA H	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
NOAA-I	06/00/90	NOAA 8-J/ATN	NOAA I			US
NOAA-I-01	06/00/90	NOAA 8-J/ATN	NOAA I	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-I-02	06/00/90	NOAA 8-J/ATN	NOAA I	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-J	09/00/91	NOAA 8-J/ATN	NOAA J			US
NOAA-J-01	09/00/91	NOAA 8-J/ATN	NOAA J	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-J-02	09/00/91	NOAA 8-J/ATN	NOAA J	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-J-05	12/12/84	NOAA 8-J/ATN	NOAA 09	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
71-032A	04/19/71	SALYUT	SALYUT 1			USSR
71-032A-	04/19/71	SALYUT	SALYUT 1	(CLOUD IMAGERY & VISUAL OBS)		USSR
74-046A	06/25/74	SALYUT	SALYUT 3			USSR
74-046A-	06/25/74	SALYUT	SALYUT 3	(CLOUD IMAGERY)		USSR
74-104A	12/26/74	SALYUT	SALYUT 4			USSR
74-104A-	12/26/74	SALYUT	SALYUT 4	(MULTISPECTRAL IMAGERY)		USSR
74-104A-	12/26/74	SALYUT	SALYUT 4	(ATMOSPHERIC SOUNDING)		USSR
76-057A	06/22/76	SALYUT	SALYUT 5			USSR
76-057A-	06/22/76	SALYUT	SALYUT 5	(IR OBSERVATIONS:SFC TEMP)		USSR
77-057A-	06/22/76	SALYUT	SALYUT 5	(POLLUTION STUDIES)		USSR
77-097A	09/29/77	SALYUT	SALYUT 6			USSR
77-097A-	09/29/77	SALYUT	SALYUT 6	(MULTISPECTRAL IMAGERY)		USSR
82-033A	04/19/82	SALYUT	SALYUT 7			USSR
78-064A	06/27/78	SEASAT	SEASAT 1			US
78-064A-01	06/27/78	SEASAT	SEASAT 1	(ALT)RADAR ALT	SMITH	US
78-064A-02	06/27/78	SEASAT	SEASAT 1	(SAR)SYNTHETIC AP RADAR	TELEKI	US
78-064A-03	06/27/78	SEASAT	SEASAT 1	(SASS)SEASAT-A-SAT SCATMTR	PIERSON	US
78-064A-04	06/27/78	SEASAT	SEASAT 1	(VIRR)SCAN VIS/IR RADIOMETER	FELLERMAN	US
78-064A-05	06/27/87	SEASAT	SEASAT 1	(SMMR)SCAN MICROWAVE RAD	STEPHANIDES	US
83-116A	11/28/83	SHUTTLE	SPACELAB 1			US
83-116A-38	11/28/83	SHUTTLE	SPACELAB 1	METRIC CAMERA FACILITY	REYNOLDS	EUROPE
83-116A-39	11/28/83	SHUTTLE	SPACELAB 1	(MRSE)MICROWAVE FACILITY	DIETERLE	EUROPE
81-111A	11/12/81	SHUTTLE	STS-02			US
81-111A-01	11/12/81	SHUTTLE	STS-02	(SIR-A)SHUTTLE IMAGING RADAR	ELACHI	US
81-111A-04	11/12/81	SHUTTLE	STS-02	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
81-111A-06	11/12/81	SHUTTLE	STS-02	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
82-065A	06/27/82	SHUTTLE	STS-04			US
82-065A-01	06/27/82	SHUTTLE	STS-04	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
83-026A	04/04/83	SHUTTLE	STS-06			US

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83-026A-01	04/04/83	SHUTTLE	STS-06	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
83-059A	06/18/83	SHUTTLE	STS-07			US
83-059A-06	06/18/83	SHUTTLE	STS-07	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
83-116A	11/28/83	SHUTTLE	STS-09	(SEE SPACELAB 1)		US
84-011A	02/03/84	SHUTTLE	STS-11			US
84-011A-01	02/03/84	SHUTTLE	STS-11	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
84-108A	10/05/84	SHUTTLE	STS-41G			US
84-108A-01	10/05/84	SHUTTLE	STS-41G	(SIR-B)SHUTTLE IMAGING RADAR	ELACHI	US
84-108A-02	10/05/84	SHUTTLE	STS-41G	(LFC)LARGE FORMAT CAMERA	MOLLBERG	US
84-108A-03	10/05/84	SHUTTLE	STS-41G	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
73-027A	05/14/73	SKYLAB	SKYLAB			US
73-027A-17	05/14/73	SKYLAB	SKYLAB	(EREP)M-SPECT. PHOTOG.(S-190)	DEMEL	US
73-027A-18	05/14/73	SKYLAB	SKYLAB	(EREP)IR SPECTROMETER(S-191)	BARNETT	US
73-027A-19	05/14/73	SKYLAB	SKYLAB	(EREP)BAND SCANNER(S-192)	KORB	US
73-027A-20	05/14/73	SKYLAB	SKYLAB	(EREP)MICROWAVE SCATT(S-193)	EVANS	US
73-027A-21	05/14/73	SKYLAB	SKYLAB	(EREP)L-BAND RADIOMTR(S-194)	EVANS	US
68-094A	10/26/68	SOYUZ	SOYUZ 03			USSR
68-094A-	10/26/68	SOYUZ	SOYUZ 03	(METEOROLOGICAL OBS)		USSR
69-004A	01/14/69	SOYUZ	SOYUZ 04			USSR
69-004A-	01/14/69	SOYUZ	SOYUZ 04	(METEOROLOGICAL OBS)		USSR
70-041A	06/02/70	SOYUZ	SOYUZ 09			USSR
70-041A-	06/02/70	SOYUZ	SOYUZ 09	(METEOROLOGICAL OBS)		USSR
71-053A	06/06/71	SOYUZ	SOYUZ 11			USSR
71-053A-	06/06/71	SOYUZ	SOYUZ 11	(METEOROLOGICAL OBS)		USSR
75-001A	01/11/75	SOYUZ	SOYUZ 17			USSR
75-001A-	01/11/75	SOYUZ	SOYUZ 17	(METEOROLOGICAL OBS)		USSR
75-044A	05/24/75	SOYUZ	SOYUZ 18			USSR
75-044A-	05/24/75	SOYUZ	SOYUZ 18	(METEOROLOGICAL OBS)		USSR
75-065A	07/15/75	SOYUZ	SOYUZ 19			USSR
75-065A-	07/15/75	SOYUZ	SOYUZ 19	(METEOROLOGICAL OBS)		USSR
76-064A	07/06/76	SOYUZ	SOYUZ 21			USSR
76-064A-	07/06/76	SOYUZ	SOYUZ 21	(METEOROLOGICAL OBS)		USSR
76-093A	09/15/76	SOYUZ	SOYUZ 22			USSR
76-093A-	09/15/76	SOYUZ	SOYUZ 22	(METEOROLOGICAL OBS)		USSR
77-008A	02/07/77	SOYUZ	SOYUZ 24			USSR
77-008A-	02/07/77	SOYUZ	SOYUZ 24	(METEOROLOGICAL OBS)		USSR
77-113A	12/10/77	SOYUZ	SOYUZ 26			USSR
77-113A-	12/10/77	SOYUZ	SOYUZ 26	(METEOROLOGICAL OBS)		USSR
78-061A	06/15/78	SOYUZ	SOYUZ 29			USSR
78-061A-	06/15/78	SOYUZ	SOYUZ 29	(METEOROLOGICAL OBS)		USSR
78-081A	08/26/78	SOYUZ	SOYUZ 31			USSR
78-081A-	08/26/78	SOYUZ	SOYUZ 31	(METEOROLOGICAL OBS)		USSR
79-018A	02/25/79	SOYUZ	SOYUZ 32			USSR
79-018A-	02/25/79	SOYUZ	SOYUZ 32	(METEOROLOGICAL OBS)		USSR
79-029A	04/10/79	SOYUZ	SOYUZ 33			USSR
79-029A-	04/10/79	SOYUZ	SOYUZ 33	(METEOROLOGICAL OBS)		USSR
80-027A	04/09/80	SOYUZ	SOYUZ 35			USSR
80-027A-	04/09/80	SOYUZ	SOYUZ 35	(METEOROLOGICAL OBS)		USSR
80-041A	05/26/80	SOYUZ	SOYUZ 36			USSR
80-041A-	05/26/80	SOYUZ	SOYUZ 36	(METEOROLOGICAL OBS)		USSR
80-064A	07/23/80	SOYUZ	SOYUZ 37			USSR
80-064A-	07/23/80	SOYUZ	SOYUZ 37	(METEOROLOGICAL OBS)		USSR
81-023A	03/12/81	SOYUZ	SOYUZ T-4			USSR
81-023A-	03/12/81	SOYUZ	SOYUZ T-4	(METEOROLOGICAL OBS)		USSR
60-002B	04/01/60	TIROS	TIROS 01			US
60-002B-01	04/01/60	TIROS	TIROS 01	TELEVISION	BUTLER	US
60-016A	11/23/60	TIROS	TIROS 02			US

NSSDC ID	22222 L-DATE	11111 PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
60-016A-01	11/23/60	TIROS	TIROS 02	WIDEFIELD RADIOMETER	HANEL	US
60-016A-02	11/23/60	TIROS	TIROS 02	(SR)SCANNING RADIOMETER	BARKSDALE	US
60-016A-03	11/23/60	TIROS	TIROS 02	TELEVISION	BUTLER	US
61-017A	07/12/61	TIROS	TIROS 03			US
61-017A-01	07/12/61	TIROS	TIROS 03	OMNI RADIOMETER	SUOMI	US
61-017A-02	07/12/61	TIROS	TIROS 03	WIDEFIELD RADIOMETER	HANEL	US
61-017A-03	07/12/61	TIROS	TIROS 03	(SR)SCANNING RADIOMETER	RADOS	US
61-017A-04	07/12/61	TIROS	TIROS 03	TELEVISION	RADOS	US
62-002A	02/08/62	TIROS	TIROS 04			US
62 002A-01	02/08/62	TIROS	TIROS 04	OMNI RADIOMETER	SUOMI	US
62-002A-02	02/08/62	TIROS	TIROS 04	WIDEFIELD RADIOMETER	HANEL	US
62-002A-03	02/08/62	TIROS	TIROS 04	(SR)SCANNING RADIOMETER	BARKSDALE	US
62-002A-04	02/08/62	TIROS	TIROS 04	TELEVISION	RADOS	US
62-025A	06/19/62	TIROS	TIROS 05			US
65-025A-01	06/19/62	TIROS	TIROS 05	TELEVISION	RADOS	US
62-047A	09/18/62	TIROS	TIROS 06			US
62-047A-01	09/18/62	TIROS	TIROS 06	TELEVISION	NESS STAFF	US
63-024A	06/19/63	TIROS	TIROS 07			US
63-024A-01	06/19/63	TIROS	TIROS 07	OMNI RADIOMETER	SUOMI	US
63-024A-02	06/19/63	TIROS	TIROS 07	(SR)SCANNING RADIOMETER	RADOS	US
63-024A-04	06/19/63	TIROS	TIROS 07	TELEVISION	NESS STAFF	US
63-054A	12/21/63	TIROS	TIROS 08			US
63-054A-01	12/21/63	TIROS	TIROS 08	TELEVISION	O'SULLIVAN	US
63-054A-02	12/21/63	TIROS	TIROS 08	(APT)AUTO PIC TRANSMISSION	HUNTER	US
65-004A	01/22/65	TIROS	TIROS 09			US
65-004A-01	01/22/65	TIROS	TIROS 09	TELEVISION	NESS STAFF	US
65-051A	07/02/65	TIROS	TIROS 10			US
65-051A-01	07/02/65	TIROS	TIROS 10	TELEVISION	NESS STAFF	US
TOPEX	00/00/90	TOPEX	TOPEX			US
TOPEX-02	00/00/90	TOPEX	TOPEX	MICROWAVE RADIOMETER		US
59-001A	02/17/59	VANGUARD	VANGUARD 2			US
59-001A-01	02/17/59	VANGUARD	VANGUARD 2	(OPTICAL SCANNER)	STROUD	US
64-065A	10/12/64	VOSKHOD	VOSKHOD 1			USSR
64-065A-	10/12/64	VOSKHOD	VOSKHOD 1	(EARTH CLOUD PHOTOGRAPHY)		USSR
65-022A	03/18/65	VOSKHOD	VOSKHOD 2			USSR
65 022A-	03/18/65	VOSKHOD	VOSKHOD 2	(EARTH CLOUD PHOTOGRAPHY)		USSR
61-019A	08/06/61	VOSTOK	SPUTNIK 12	(SEE VOSTOK 2)		USSR
61-019A	08/06/61	VOSTOK	VOSTOK 2			USSR
61-019A-	08/06/61	VOSTOK	VOSTOK 2	(HAND HELD CINE PHOTOGRAPHY)		USSR
62-036A	08/11/62	VOSTOK	VOSTOK 3			USSR
62-036A-	08/11/62	VOSTOK	VOSTOK 3	(HAND HELD CINE PHOTOGRAPHY)		USSR
62-037A	08/12/62	VOSTOK	VOSTOK 4			USSR
62-037A-	08/12/62	VOSTOK	VOSTOK 4	(HAND HELD CINE PHOTOGRAPHY)		USSR
63-020A	06/15/63	VOSTOK	VOSTOK 5			USSR
63-020A-	06/15/63	VOSTOK	VOSTOK 5	(HAND HELD CINE PHOTOGRAPHY)		USSR
63-023A	06/16/63	VOSTOK	VOSTOK 6			USSR
63-023A-	06/16/63	VOSTOK	VOSTOK 6	(HAND HELD CINE PHOTOGRAPHY)		USSR
68-076A	09/14/68	ZOND	ZOND 5			USSR
68-076A-02	09/14/68	ZOND	ZOND 5	(EARTH-CLOUD PHOTOGRAPHY)		USSR
68-101A	11/10/68	ZOND	ZOND 6			USSR
68-101A-01	11/10/68	ZOND	ZOND 6	(EARTH-CLOUD PHOTOGRAPHY)		USSR
69-067A	08/07/69	ZOND	ZOND 7			USSR
69-067A-01	08/07/69	ZOND	ZOND 7	(EARTH-CLOUD PHOTOGRAPHY)		USSR
70-088A	10/20/70	ZOND	ZOND 8			USSR
70-088A-01	10/20/70	ZOND	ZOND 8	(EARTH-CLOUD PHOTOGRAPHY)		USSR

INDEX OF (NON-US, NON-USSR) SPACECRAFT AND EXPERIMENTS SORTED BY SPONSOR (11111), PROJECT (22222), AND LAUNCH DATE (33333)

SE-CO

NSSDC ID	33333 L-DATE	22222 PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	11111 CO
77-108A	11/23/77	METEOSAT	METEOSAT 1			EUROPE
77-108A-01	11/23/77	METEOSAT	METEOSAT 1	IMAGING RADIOMETER	SERENE	EUROPE
77-108A-02	11/23/77	METEOSAT	METEOSAT 1	(DCP)DATA COLL PLAT	PERA	EUROPE
81-057A	06/19/81	METEOSAT	METEOSAT 2			EUROPE
81-057A-01	06/19/81	METEOSAT	METEOSAT 2	IMAGING RADIOMETER	SERENE	EUROPE
81-057A-02	06/19/81	METEOSAT	METEOSAT 2	(DCP)DATA COLL PLAT	PERA	EUROPE
83-116A-38	11/28/83	SHUTTLE	SPACELAB 1	METRIC CAMERA FACILITY	REYNOLDS	EUROPE
83-116A-39	11/28/83	SHUTTLE	SPACELAB 1	(MRSE)MICROWAVE FACILITY	DIETERLE	EUROPE
MTSATP2	01/00/88	METEOSAT	METEOSAT P2			EUROPE
MTSATP2-01	01/00/88	METEOSAT	METEOSAT P2	IMAGING RADIOMETER		EUROPE
MTSATP2-02	01/00/88	METEOSAT	METEOSAT P2	(DCP)DATA COLL PLAT		EUROPE
70-109A	12/24/70	EOLE/PEOLE	PEOLE			FRANCE/US
71-071A	08/16/71	EOLE/PEOLE	EOLE 1			FRANCE/US
71-071A-01	08/16/71	EOLE/PEOLE	EOLE 1	UPPER ATMOS WEA RELAY SYS	MOREL/BANDEEN	FRANCE/US
83-059A-06	06/18/83	SHUTTLE	STS-07	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
84-011A-01	02/03/84	SHUTTLE	STS-11	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
79-051A	06/07/79	BHASKARA	BHASKARA			INDIA
79-051A-01	06/07/79	BHASKARA	BHASKARA	(SAMIR)SATELLITE MW RAD	JOSEPH	INDIA
79-051A-02	06/07/79	BHASKARA	BHASKARA	TV CAMERA	JOSEPH	INDIA
81-115A	11/20/81	BHASKARA	BHASKARA 2			INDIA
81.115A-01	11/20/81	BHASKARA	BHASKARA 2	DUAL TV CAMERA	CALLA	INDIA
81-115A-02	11/20/81	BHASKARA	BHASKARA 2	(SAMIR)SATELLITE MW RAD	CALLA	INDIA
82-031A	04/10/82	INSAT	INSAT 1A			INDIA
82-031A-01	04/10/82	INSAT	INSAT 1A	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
83-089B	08/31/83	INSAT	INSAT 1B			INDIA
83-089B-01	08/31/83	INSAT	INSAT 1B	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
IRS-1A	10/00/87	IRS	IRS 1A			INDIA
IRS-1A-01	10/00/87	IRS	IRS 1A	(LISS)LIN IMG SELF-SCN SENS	ISRO	INDIA
INSAT1C	06/00/88	INSAT	INSAT 1C			INDIA
INSAT1C-01	06/00/88	INSAT	INSAT 1C	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
77-065A	07/14/77	GMS	GMS			JAPAN
77-065A-01	07/14/77	GMS	GMS	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
81-076A	08/10/81	GMS	GMS 2			JAPAN
81-076A-01	08/10/81	GMS	GMS 2	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
84-080A	08/02/84	GMS	GMS 3			JAPAN
84-080A-01	08/02/84	GMS	GMS 3	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
87-018A	02/19/87	MOS	MOS 1			JAPAN
87-018A-01	02/19/87	MOS	MOS 1	(MESSR)MSP ELE SELF-SCAN RAD.	NASDA	JAPAN
87-018A-02	02/19/87	MOS	MOS 1	(VTIR)VIS & THERMAL IR RAD	NASDA	JAPAN
87-018A-03	02/19/87	MOS	MOS 1	(MSR)MICROWAVE SCAN RAD	NASDA	JAPAN
87-018A-04	02/19/87	MOS	MOS 1	(DCS)DATA COLL SYS TRANSPNDR	NASDA	JAPAN
70-025A-10	04/08/70	NIMBUS	NIMBUS 4	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
72-097A-02	12/11/72	NIMBUS	NIMBUS 5	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
78-098A-02	10/24/78	NIMBUS	NIMBUS 7	(SAMS)STRAT + MESO SOUNDER	HOUGHTON	UK

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INDEX OF SPACECRAFT
SORTED BY LAUNCH DATE (11111)

S-LD

NSSDC ID	11111 L-DATE	PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
59-001A	02/17/59	VANGUARD	VANGUARD 2			US
59-004A	08/07/59	EXPLORER	EXPLORER 6			US
59-009A	10/13/59	EXPLORER	EXPLORER 7			US
60-002B	04/01/60	TIROS	TIROS 01			US
60-006A	05/24/60	DOD(OTHER)	MIDAS 2			US
60-016A	11/23/60	TIROS	TIROS 02			US
61-017A	07/12/61	TIROS	TIROS 03			US
61-018A	07/12/61	DOD(OTHER)	MIDAS 3			US
61-019A	08/06/61	VOSTOK	SPUTNIK 12	(SEE VOSTOK 2)		USSR
61-019A	08/06/61	VOSTOK	VOSTOK 2			USSR
61-025A	09/13/61	MERCURY	MA-4			US
61-028A	10/21/61	DOD(OTHER)	MIDAS 4			US
61-030A	11/15/61	DISCOVERER	DISCOVERER 35			US
61-033A	11/29/61	MERCURY	MA-5			US
62-002A	02/08/62	TIROS	TIROS 04			US
62-003A	02/20/62	MERCURY	MA-6			US
62-010A	04/09/62	DOD(OTHER)	MIDAS 5			US
62-019A	05/24/62	MERCURY	MA-7			US
62-025A	06/19/62	TIROS	TIROS 05			US
62-036A	08/11/62	VOSTOK	VOSTOK 3			USSR
62-037A	08/12/62	VOSTOK	VOSTOK 4			USSR
62-047A	09/18/62	TIROS	TIROS 06			US
62-052A	10/03/62	MERCURY	MA-8			US
63-015A	03/15/63	MERCURY	MA-9			US
63-014A	05/09/63	DOD(OTHER)	MIDAS 6			US
63-020A	06/15/63	VOSTOK	VOSTOK 5			USSR
63-023A	06/16/63	VOSTOK	VOSTOK 6			USSR
63-024A	06/19/63	TIROS	TIROS 07			US
63-054A	12/21/63	TIROS	TIROS 08			US
64-052A	08/28/64	NIMBUS	NIMBUS 1			US
64-065A	10 [illegible]2/64	VOSKHOD	VOSKHOD 1			USSR
65-004A	01/22/65	TIROS	TIROS 09			US
65-022A	03/18/65	VOSKHOD	VOSKHOD 2			USSR
65-024A	03/23/65	GEMINI	GEMINI 03			US
65-043A	06/03/65	GEMINI	GEMINI 04			US
65-051A	07/02/65	TIROS	TIROS 10			US
65-068A	08/21/65	GEMINI	GEMINI 05			US
65-100A	12/04/65	GEMINI	GEMINI 07			US
65-104A	12/15/65	GEMINI	GEMINI 06			US
66-008A	02/03/66	ESSA	ESSA 1			US
66-016A	02/28/66	ESSA	ESSA 2			US
66-020A	03/16/66	GEMINI	GEMINI 08			US
66-035A	04/25/66	MOLNIYA 1	MOLNIYA 1- 03			USSR
66-040A	05/15/66	NIMBUS	NIMBUS 2			US
66-047A	06/03/66	GEMINI	GEMINI 09			US
66-057A	06/25/66	COSMOS	COSMOS 122			USSR
66-066A	07/18/66	GEMINI	GEMINI 10			US
66-081A	09/12/66	GEMINI	GEMINI 11			US
66-082A	09/15/66	DMSP	DSAP	(SEE DMSP)		US
66-082A	09/15/66	DMSP	DMSP 4A/F1			US
66-087A	10/02/66	ESSA	ESSA 3			US
66-092A	10/20/66	MOLNIYA 1	MOLNIYA 1- 04			USSR
66-104A	11/11/66	GEMINI	GEMINI 12			US

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NSSDC ID	11111 L-DATE	PROJECT	S/C NAMES	EXP NAME	F /AGENCY	CO
66-110A	12/07/66	ATS	ATS 1			US
67-006A	01/26/67	ESSA	ESSA 4			US
67-010A	02/08/67	DMSP	DMSP 4A/F2			US
67-024A	03/21/67	COSMOS	COSMOS 149			USSR
67-031A	04/06/67	ATS	ATS 2			US
67-036A	04/20/67	ESSA	ESSA 5			US
67-039A	04/27/67	COSMOS	COSMOS 156			USSR
67-052A	05/24/67	MOLNIYA 1	MOLNIYA 1- 05			USSR
67-066F	07/01/67	DODGE	DODGE			US
67-080A	08/22/67	DMSP	DSAP	(SEE DMSP)		US
67-080A	08/22/67	DMSP	DMSP 4A/F3			US
67-095A	10/03/67	MOLNIYA 1	MOLNIYA 1- 06			USSR
67-096A	10/11/67	DMSP	DSAP	(SEE DMSP)		US
67-096A	10/11/67	DMSP	DMSP 4A/F4			US
67-101A	10/22/67	MOLNIYA 1	MOLNIYA 1- 07			USSR
67-111A	11/05/67	ATS	ATS 3			US
67-113A	11/09/67	APOLLO	APOLLO 04			US
67-114A	11/10/67	ESSA	ESSA 6			US
68-025A	04/04/68	APOLLO	APOLLO 06			US
68-035A	04/21/68	MOLNIYA 1	MOLNIYA 1- 08			USSR
68-042A	05/22/68	DMSP	DSAP	(SEE DMSP)		US
68-042A	05/22/68	DMSP	DMSP 4B/F1			US
68-057A	07/05/68	MOLNIYA 1	MOLNIYA 1- 09			USSR
68-068A	08/10/68	ATS	ATS 4			US
68-069A	08/16/68	ESSA	ESSA 7			US
68-076A	09/14/68	ZOND	ZOND 5			USSR
68-085A	10/05/68	MOLNIYA 1	MOLNIYA 1-10			USSR
68-089A	10/11/68	APOLLO	APOLLO 07			US
68-092A	10/22/68	DMSP	DSAP	(SEE DMSP)		US
68-092A	10/22/68	DMSP	DMSP 4B/F2			US
68-094A	10/26/68	SOYUZ	SOYUZ 03			USSR
68-101A	11/10/68	ZOND	ZOND 6			USSR
68-114A	12/15/68	ESSA	ESSA 8			US
68-118A	12/21/68	APOLLO	APOLLO 08			US
69-004A	01/14/69	SOYUZ	SOYUZ 04			USSR
69-016A	02/26/69	ESSA	ESSA 9			US
69-018A	03/03/69	APOLLO	APOLLO 09			US
69-029A	03/26/69	METEOR 1	METEOR 1-01			USSR
69-037A	04/14/69	NIMBUS	NIMBUS 3			US
69-043A	05/18/69	APOLLO	APOLLO 10			US
69-059A	07/16/69	APOLLO	APOLLO 11			US
69-062A	07/22/69	DMSP	DSAP	(SEE DMSP)		US
69-062A	07/22/69	DMSP	DMSP 4B/F3			US
69-067A	08/07/69	ZOND	ZOND 7			USSR
69-084A	10/06/69	METEOR 1	METEOR 1-02			USSR
69-099A	11/14/69	APOLLO	APOLLO 12			US
70-008A	01/23/70	NOAA 1-5/ITOS	ITOS 1			US
70-012A	02/11/70	DMSP	DSAP	(SEE DMSP)		US
70-012A	02/11/70	DMSP	DMSP 5A/F1			US
70-019A	03/17/70	METEOR 1	METEOR 1-03			USSR
70-025A	04/08/70	NIMBUS	NIMBUS 4			US
70-029A	04/11/70	APOLLO	APOLLO 13			US
70-037A	04/28/70	METEOR 1	METEOR 1-04			USSR
70-041A	06/02/70	SOYUZ	SOYUZ 09			USSR
70-047A	06/23/70	METEOR 1	METEOR 1-05			USSR
70-070A	09/03/70	DMSP	DSAP	(SEE DMSP)		US

NSSDC ID	11111 L-DATE	PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
70-070A	09/03/70	DMSP	DMSP 5A/F2			US
70-085A	10/15/70	METEOR 1	METEOR 1-06			USSR
70-088A	10/20/70	ZOND	ZOND 8			USSR
70-105A	12/10/70	COSMOS	COSMOS 384			USSR
70-106A	12/11/70	NOAA 1-5/ITOS	NOAA 01			US
70-109A	12/24/70	EOLE/PEOLE	PEOLE			FRANCE/US
71-003A	01/20/71	METEOR 1	METEOR 1-07			USSR
71-008A	01/31/71	APOLLO	APOLLO 14			US
71-012A	02/17/71	DMSP	DSAP	(SEE DMSP)		US
71-012A	02/17/71	DMSP	DMSP 5A/F3			US
71-031A	04/17/71	METEOR 1	METEOR 1-08			USSR
71-032A	04/19/71	SALYUT	SALYUT 1			USSR
71-053A	06/06/71	SOYUZ	SOYUZ 11			USSR
71-059A	07/16/71	METEOR 1	METEOR 1-09			USSR
71-063A	07/26/71	APOLLO	APOLLO 15			US
71-071A	08/16/71	EOLE/PEOLE	EOLE 1			FRANCE/US
71-087A	10/14/71	DMSP	DSAP	(SEE DMSP)		US
71-087A	10/14/71	DMSP	DMSP 5B/F1			US
71-120A	12/29/71	METEOR 1	METEOR 1-10			USSR
72-018A	03/24/72	DMSP	DSAP	(SEE DMSP)		US
72-018A	03/24/72	DMSP	DMSP 5B/F2			US
72-022A	03/30/72	METEOR 1	METEOR 1-11			USSR
72-031A	04/17/72	APOLLO	APOLLO 16			US
72-049A	06/30/72	METEOR 1	METEOR 1-12			USSR
72-058A	07/23/72	LANDSAT	ERTS-A	(SEE LANDSAT)		US
72-058A	07/23/72	LANDSAT	LANDSAT 1			US
72-082A	10/15/72	NOAA 1-5/ITOS	NOAA 02			US
72-085A	10/27/72	METEOR 1	METEOR 1-13			USSR
72-089A	11/09/72	DMSP	DSAP	(SEE DMSP)		US
72-089A	11/09/72	DMSP	DMSP 5B/F3			US
72-096A	12/07/72	APOLLO	APOLLO 17			US
72-097A	12/11/72	NIMBUS	NIMBUS 5			US
73-015A	03/20/73	METEOR 1	METEOR 1-14			USSR
73-027A	05/14/73	SKYLAB	SKYLAB			US
73-034A	05/29/73	METEOR 1	METEOR 1-15			USSR
73-054A	08/17/73	DMSP	DSAP	(SEE DMSP)		US
73-054A	08/17/73	DMSP	DMSP 5B/F4			US
73-086A	11/06/73	NOAA 1-5/ITOS	NOAA 03			US
74-011A	03/05/74	METEOR 1	METEOR 1-16			USSR
74-015A	03/16/74	DMSP	DSAP	(SEE DMSP)		US
74-015A	03/16/74	DMSP	DMSP 5B/F5			US
74-025A	04/24/74	METEOR 1	METEOR 1-17			USSR
74-033A	05/17/74	GOES/SMS	SMS 1			US
74-039A	05/30/74	ATS	ATS 6			US
74-046A	06/25/74	SALYUT	SALYUT 3			USSR
74-052A	07/09/74	METEOR 1	METEOR 1-18			USSR
74-063A	08/09/74	DMSP	DSAP	(SEE DMSP)		US
74-063A	08/09/74	DMSP	DMSP 5C/F1			US
74-083A	10/28/74	METEOR 1	METEOR 1-19			USSR
74-089A	11/15/74	NOAA 1-5/ITOS	NOAA 04			US
74-099A	12/17/74	METEOR 1	METEOR 1-20			USSR
74-104A	12/26/74	SALYUT	SALYUT 4			USSR
75-001A	01/11/75	SOYUZ	SOYUZ 17			USSR
75-004A	01/22/75	LANDSAT	ERTS-B	(SEE LANDSAT)		US
75-004A	01/22/75	LANDSAT	LANDSAT 2			US

NSSDC ID	11111 L-DATE	PROJECT	S/C NAMES	EXP NAME	PI/AGENCY	CO
75-011A	02/06/75	GOES/SMS	SMS 2			US
75-023A	04/01/75	METEOR 1	METEOR 1-21			USSR
75-044A	05/24/75	SOYUZ	SOYUZ 18			USSR
75-043A	05/24/75	DMSP	DMSP	(SEE DMSP)		US
75-043A	05/24/75	DMSP	DMSP 5C/F2			US
75-052A	06/12/75	NIMBUS	NIMBUS 6			US
75-064A	07/11/75	METEOR 2	METEOR 2-01			USSR
75-065A	07/15/75	SOYUZ	SOYUZ 19			USSR
75-066A	07/15/75	APOLLO	APOLLO 18	(SEE ASTP-APOLLO)		US
75-066A	07/15/75	APOLLO	ASTP APOLLO			US
75-087A	09/18/75	METEOR 1	METEOR 1-22			USSR
75-100A	10/16/75	GOES/SMS	SMS 3	(SEE GOES 1)		US
75-100A	10/16/75	GOES/SMS	GOES 1			US
75-124A	12/25/75	METEOR 1	METEOR 1-23			USSR
76-032A	04/07/76	METEOR 1	METEOR 1-24			USSR
76-043A	05/15/76	METEOR 1	METEOR 1-25			USSR
76-057A	06/22/76	SALYUT	SALYUT 5			USSR
76-064A	07/06/76	SOYUZ	SOYUZ 21			USSR
76-077A	07/29/76	NOAA 1-5/ITOS	NOAA 05			US
76-091A	09/11/76	DMSP	DMSP 5D-1/F1			US
76-093A	09/15/76	SOYUZ	SOYUZ 22			USSR
76-102A	10/16/76	METEOR 1	METEOR 1-26			USSR
77-002A	01/07/77	METEOR 2	METEOR 2-02			USSR
77-008A	02/07/77	SOYUZ	SOYUZ 24			USSR
77-024A	04/05/77	METEOR 1	METEOR 1-27			USSR
77-044A	06/05/77	DMSP	DMSP 5D-1/F2			US
77-048A	06/16/77	GOES/SMS	GOES 2			US
77-057A	06/29/77	METEOR 1	METEOR 1-28			USSR
77-065A	07/14/77	GMS	GMS			JAPAN
77-097A	09/29/77	SALYUT	SALYUT 6			USSR
77-108A	11/23/77	METEOSAT	METEOSAT 1			EUROPE
77-113A	12/10/77	SOYUZ	SOYUZ 26			USSR
77-117A	12/14/77	METEOR 2	METEOR 2-03			USSR
78-026A	03/05/78	LANDSAT	LANDSAT 3			US
78-026A	03/05/78	LANDSAT	ERTS-C	(SEE LANDSAT)		US
78-041A	04/26/78	AEM	HCMM			US
78-041A	04/26/78	AEM	AEM-A	(SEE HCMM)		US
78-042A	05/01/78	DMSP	DMSP 5D-1/F3			US
78-061A	06/15/78	SOYUZ	SOYUZ 29			USSR
78-062A	06/16/78	GOES/SMS	GOES 3			US
78-064A	06/27/78	SEASAT	SEASAT 1			US
78-081A	08/26/78	SOYUZ	SOYUZ 31			USSR
78-096A	10/13/78	NOAA 6-D/T-N	TIROS N			US
78-098A	10/24/78	NIMBUS	NIMBUS 7			US
79-005A	01/25/79	METEOR 1	METEOR 1-29			USSR
79-013A	02/18/79	AEM	AEM-B	(SEE SAGE)		US
79-013A	02/18/79	AEM	SAGE			US
79-018A	02/25/79	SOYUZ	SOYUZ 32			USSR
79-021A	03/01/79	METEOR 2	METEOR 2-04			USSR
79-029A	04/10/79	SOYUZ	SOYUZ 33			USSR
79-050A	06/06/79	DMSP	DMSP 5D-1/F4			US
79-051A	06/07/79	BHASKARA	BHASKARA			INDIA
79-057A	06/27/79	NOAA 6-D/T-N	NOAA 06			US
79-095A	10/31/79	METEOR 2	METEOR 2-05			USSR
80-027A	04/09/80	SOYUZ	SOYUZ 35			USSR

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80-041A	05/26/80	SOYUZ	SOYUZ 36			USSR
80-051A	06/18/80	METEOR 1	METEOR 1-30			USSR
80-064A	07/23/80	SOYUZ	SOYUZ 37			USSR
80-074A	09/09/80	GOES/SMS	GOES 4			US
80-073A	09/09/80	METEOR 2	METEOR 2-06			USSR
81-023A	03/12/81	SOYUZ	SOYUZ T-4			USSR
81-043A	05/14/81	METEOR 2	METEOR 2-07			USSR
81-049A	05/22/81	GOES/SMS	GOES 5			US
81-057A	06/19/81	METEOSAT	METEOSAT 2			EUROPE
81-059A	06/23/81	NOAA 6-D/T-N	NOAA 07			
81-065A	07/10/81	METEOR 1	METEOR 1-31			USSR
81-076A	08/10/81	GMS	GMS 2			JAPAN
81-111A	11/12/81	SHUTTLE	STS-02			US
81-115A	11/20/81	BHASKARA	BHASKARA 2			INDIA
82-025A	03/25/82	METEOR 2	METEOR 2-08			USSR
82-031A	04/10/82	INSAT	INSAT 1A			INDIA
82-033A	04/19/82	SALYUT	SALYUT 7			USSR
82-065A	06/27/82	SHUTTLE	STS-04			US
82-072A	07/16/82	LANDSAT	LANDSAT 4			US
82-116A	12/14/82	METEOR 2	METEOR 2-09			USSR
82-118A	12/21/82	DMSP	DMSP 5D-2/F6			US
83-022A	03/28/83	NOAA 8-J/ATN	NOAA 08			US
83-026A	04/04/83	SHUTTLE	STS-06			US
83-041A	04/28/83	GOES/SMS	GOES 6			US
83-059A	06/18/83	SHUTTLE	STS-07			US
83-089B	08/31/83	INSAT	INSAT 1B			INDIA
83-109A	10/28/83	METEOR 2	METEOR 2-10			USSR
83-113A	11/18/83	DMSP	DMSP 5D-2/F7			US
83-116A	11/28/83	SHUTTLE	STS-09	(SEE SPACELAB 1)		US
83-116A	11/28/83	SHUTTLE	SPACELAB 1			US
84-011A	02/03/84	SHUTTLE	STS-11			US
84-021A	03/01/84	LANDSAT	LANDSAT 5			US
84-072A	07/18/84	METEOR 2	METEOR 2-11			USSR
84-080A	08/02/84	GMS	GMS 3			JAPAN
84-108B	10/05/84	ERBE	ERBS			US
84-108A	10/05/84	SHUTTLE	STS-41G			US
84-123A	12/12/84	ERBE	NOAA 09			US
84-123A	12/12/84	NOAA 8-J/ATN	NOAA 09			US
85-013A	02/06/85	METEOR 2	METEOR 2-12			USSR
85-119A	12/26/85	METEOR 2	METEOR 2-13			USSR
86-039A	05/27/86	METEOR 2	METEOR 2-14			USSR
86-073A	09/17/86	ERBE	NOAA 10			US
86-073A	09/17/86	NOAA 8-J/ATN	NOAA 10			US
87-001A	02/15/87	METEOR 2	METEOR 2-15			USSR
87-018A	02/19/87	MOS	MOS 1			JAPAN
87-022A	02/26/87	GOES/SMS	GOES 7			US
87-053A	06/20/87	DMSP	DMSP 5D-2/F8			US
IRS-1A	10/00/87	IRS	IRS 1A			INDIA
MTSATP2	01/00/88	METEOSAT	METEOSAT P2			EUROPE
INSAT1C	06/00/88	INSAT	INSAT 1C			INDIA
NOAA-H	02/00/88	NOAA 8-J/ATN	NOAA H			US

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TOPEX	00/00/90	TOPEX	TOPEX			US
NOAA-I	06/00/90	NOAA 8-J/ATN	NOAA I			US
NOAA-J	J9/00/91	NOAA 8-J/ATN	NOAA J			US
NOAA-D		NOAA 6-D/T-N	NOAA-D			US
						US

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NSSDC ID	22222 L-DATE	PROJECT	11111 S/C NAMES	EXP NAME	PI/AGENCY	CO
78-041A	04/26/78	AEM	AEM-A	(SEE HCMM)		US
79-013A	02/18/79	AEM	AEM-B	(SEE SAGE)		US
67-113A	11/09/67	APOLLO	APOLLO 04			US
68-025A	04/04/68	APOLLO	APOLLO 06			US
68-089A	10/11/68	APOLLO	APOLLO 07			US
68-118A	12/21/68	APOLLO	APOLLO 08			US
69-018A	03/03/69	APOLLO	APOLLO 09			US
69-043A	05/18/69	APOLLO	APOLLO 10			US
69-059A	07/16/69	APOLLO	APOLLO 11			US
69-099A	11/14/69	APOLLO	APOLLO 12			US
70-029A	04/11/70	APOLLO	APOLLO 13			US
71-008A	01/31/71	APOLLO	APOLLO 14			US
71-063A	07/26/71	APOLLO	APOLLO 15			US
72-031A	04/17/72	APOLLO	APOLLO 16			US
72-096A	12/07/72	APOLLO	APOLLO 17			US
75-066A	07/15/75	APOLLO	APOLLO 18	(SEE ASTP-APOLLO)		US
75-066A	07/15/75	APOLLO	ASTP APOLLO			US
66-110A	12/07/66	ATS	ATS 1			US
67-031A	04/06/67	ATS	ATS 2			US
67-111A	11/05/67	ATS	ATS 3			US
68-068A	08/10/68	ATS	ATS 4			US
74-039A	05/30/74	ATS	ATS 6			US
79-051A	06/07/79	BHASKARA	BHASKARA			INDIA
81-115A	11/20/81	BHASKARA	BHASKARA 2			INDIA
66-057A	06/25/66	COSMOS	COSMOS 122			USSR
67-024A	03/21/67	COSMOS	COSMOS 149			USSR
67-039A	04/27/67	COSMOS	COSMOS 156			USSR
70-105A	12/10/70	COSMOS	COSMOS 384			USSR
61-030A	11/15/61	DISCOVERER	DISCOVERER 35			US
66-082A	09/15/66	DMSP	DMSP 4A/F1			US
67-010A	02/08/67	DMSP	DMSP 4A/F2			US
67-080A	08/22/67	DMSP	DMSP 4A/F3			US
67-096A	10/11/67	DMSP	DMSP 4A/F4			US
68-042A	05/22/68	DMSP	DMSP 4B/F1			US
68-092A	10/22/68	DMSP	DMSP 4B/F2			US
69-062A	07/22/69	DMSP	DMSP 4B/F3			US
70-012A	02/11/70	DMSP	DMSP 5A/F1			US
70-070A	09/03/70	DMSP	DMSP 5A/F2			US
71-012A	02/17/71	DMSP	DMSP 5A/F3			US
71-087A	10/14/71	DMSP	DMSP 5B/F1			US
72-018A	03/24/72	DMSP	DMSP 5B/F2			US
72-089A	11/09/72	DMSP	DMSP 5B/F3			US
73-054A	08/17/73	DMSP	DMSP 5B/F4			US
74-015A	03/16/74	DMSP	DMSP 5B/F5			US
74-063A	08/09/74	DMSP	DMSP 5C/F1			US
75-043A	05/24/75	DMSP	DMSP 5C/F2			US
76-091A	09/11/76	DMSP	DMSP 5D-1/F1			US
77-044A	06/05/77	DMSP	DMSP 5D-1/F2			US
78-042A	05/01/78	DMSP	DMSP 5D-1/F3			US
79-050A	06/06/79	DMSP	DMSP 5D-1/F4			US
82-118A	12/21/82	DMSP	DMSP 5D-2/F6			US
83-113A	11/18/83	DMSP	DMSP 5D-2/F7			US
87-053A	06/20/87	DMSP	DMSP 5D-2/F8			US

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67-066F	07/01/67	DODGE	DODGE			US
66-082A	09/15/66	DMSP	DSAP	(SEE DMSP)		US
67-080A	08/22/67	DMSP	DSAP	(SEE DMSP)		US
67-096A	10/11/67	DMSP	DSAP	(SEE DMSP)		US
68-042A	05/22/68	DMSP	DSAP	(SEE DMSP)		US
68-092A	10/22/68	DMSP	DSAP	(SEE DMSP)		US
69-062A	07/22/69	DMSP	DSAP	(SEE DMSP)		US
70-012A	02/11/70	DMSP	DSAP	(SEE DMSP)		US
70-070A	09/03/70	DMSP	DSAP	(SEE DMSP)		US
71-012A	02/17/71	DMSP	DSAP	(SEE DMSP)		US
71-087A	10/14/71	DMSP	DSAP	(SEE DMSP)		US
72-018A	03/24/72	DMSP	DSAP	(SEE DMSP)		US
72-089A	11/09/72	DMSP	DSAP	(SEE DMSP)		US
73-054A	08/17/73	DMSP	DSAP	(SEE DMSP)		US
74-015A	03/16/74	DMSP	DSAP	(SEE DMSP)		US
74-063A	08/09/74	DMSP	DSAP	(SEE DMSP)		US
75-043A	05/24/75	DMSP	DSAP	(SEE DMSP)		US
71-071A	08/16/71	EOLE/PEOLE	EOLE 1			FRANCE/US
84-108B	10/05/84	ERBE	ERBS			US
72-058A	07/23/72	LANDSAT	ERTS-A	(SEE LANDSAT)		US
75-004A	01/22/75	LANDSAT	ERTS-B	(SEE LANDSAT)		US
78-026A	03/05/78	LANDSAT	ERTS-C	(SEE LANDSAT)		US
66-008A	02/03/66	ESSA	ESSA 1			US
66-016A	02/28/66	ESSA	ESSA 2			US
66-087A	10/02/66	ESSA	ESSA 3			US
67-006A	01/26/67	ESSA	ESSA 4			US
67-036A	04/20/67	ESSA	ESSA 5			US
67-114A	11/10/67	ESSA	ESSA 6			US
68-069A	08/16/68	ESSA	ESSA 7			US
68-114A	12/15/68	ESSA	ESSA 8			US
69-016A	02/26/69	ESSA	ESSA 9			US
59-004A	08/07/59	EXPLORER	EXPLORER 6			US
59-009A	10/13/59	EXPLORER	EXPLORER 7			US
75-100A	10/16/75	GOES/SMS	GOES 1			US
65-024A	03/23/65	GEMINI	GEMINI 03			US
65-043A	06/03/65	GEMINI	GEMINI 04			US
65-068A	08/21/65	GEMINI	GEMINI 05			US
65-104A	12/15/65	GEMINI	GEMINI 06			US
65-100A	12/04/65	GEMINI	GEMINI 07			US
66-020A	03/16/66	GEMINI	GEMINI 08			US
66-047A	06/03/66	GEMINI	GEMINI 09			US
66-066A	07/18/66	GEMINI	GEMINI 10			US
66-081A	09/12/66	GEMINI	GEMINI 11			US
66-104A	11/11/66	GEMINI	GEMINI 12			US
77-065A	07/14/77	GMS	GMS			JAPAN
81-076A	08/10/81	GMS	GMS 2			JAPAN
84-080A	08/02/84	GMS	GMS 3			JAPAN
77-048A	06/16/77	GOES/SMS	GOES 2			US
78-062A	06/16/78	GOES/SMS	GOES 3			US

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80-074A	09/09/80	GOES/SMS	GOES 4			US
81-049A	05/22/81	GOES/SMS	GOES 5			US
83-041A	04/28/83	GOES/SMS	GOES 6			US
87-022A	02/26/87	GOES/SMS	GOES 7			US
78-041A	04/26/78	AEM	HCMM			US
82-031A	04/10/82	INSAT	INSAT 1A			INDIA
83-089B	08/31/83	INSAT	INSAT 1B			INDIA
INSAT1C	06/00/88	INSAT	INSAT 1C			INDIA
IRS-1A	10/00/87	IRS	IRS 1A			INDIA
70-008A	01/23/70	NOAA 1-5/ITOS	ITOS 1			US
72-058A	07/23/72	LANDSAT	LANDSAT 1			US
75-004A	01/22/75	LANDSAT	LANDSAT 2			US
78-026A	03/05/78	LANDSAT	LANDSAT 3			US
82-072A	07/16/82	LANDSAT	LANDSAT 4			US
84-021A	03/01/84	LANDSAT	LANDSAT 5			US
61-025A	09/13/61	MERCURY	MA-4			US
61-033A	11/29/61	MERCURY	MA-5			US
62-003A	02/20/62	MERCURY	MA-6			US
62-019A	05/24/62	MERCURY	MA-7			US
62-052A	10/03/62	MERCURY	MA-8			US
63-015A	03/15/63	MERCURY	MA-9			US
69-029A	03/26/69	METEOR 1	METEOR 1-01			USSR
69-084A	10/06/69	METEOR 1	METEOR 1-02			USSR
70-019A	03/17/70	METEOR 1	METEOR 1-03			USSR
70-037A	04/28/70	METEOR 1	METEOR 1-04			USSR
70-047A	06/23/70	METEOR 1	METEOR 1-05			USSR
70-085A	10/15/70	METEOR 1	METEOR 1-06			USSR
71-003A	01/20/71	METEOR 1	METEOR 1-07			USSR
71-031A	04/17/71	METEOR 1	METEOR 1-08			USSR
71-059A	07/16/71	METEOR 1	METEOR 1-09			USSR
71-120A	12/29/71	METEOR 1	METEOR 1-10			USSR
72-022A	03/30/72	METEOR 1	METEOR 1-11			USSR
72-049A	06/30/72	METEOR 1	METEOR 1-12			USSR
72-085A	10/27/72	METEOR 1	METEOR 1-13			USSR
73-015A	03/20/73	METEOR 1	METEOR 1-14			USSR
73-034A	05/29/73	METEOR 1	METEOR 1-15			USSR
74-011A	03/05/74	METEOR 1	METEOR 1-16			USSR
74-025A	04/24/74	METEOR 1	METEOR 1-17			USSR
74-052A	07/09/74	METEOR 1	METEOR 1-18			USSR
74-083A	10/28/74	METEOR 1	METEOR 1-19			USSR
74-099A	12/17/74	METEOR 1	METEOR 1-20			USSR
75-023A	04/01/75	METEOR 1	METEOR 1-21			USSR
75-087A	09/18/75	METEOR 1	METEOR 1-22			USSR
75-124A	12/25/75	METEOR 1	METEOR 1-23			USSR
76-032A	04/07/76	METEOR 1	METEOR 1-24			USSR
76-043A	05/15/76	METEOR 1	METEOR 1-25			USSR
76-102A	10/16/76	METEOR 1	METEOR 1-26			USSR
77-024A	04/05/77	METEOR 1	METEOR 1-27			USSR
77-057A	06/29/77	METEOR 1	METEOR 1-28			USSR
79-005A	01/25/79	METEOR 1	METEOR 1-29			USSR
80-051A	06/18/80	METEOR 1	METEOR 1-30			USSR
81-065A	07/10/81	METEOR 1	METEOR 1-31			USSR

NSSDC ID	22222 L-DATE	PROJECT	111'1 S/C NAMES	EXP NAME	PI/AGENCY	CO
75-064A	07/11/75	METEOR 2	METEOR 2-01			USSR
77-002A	01/07/77	METEOR 2	METEOR 2-02			USSR
77-117A	12/14/77	METEOR 2	METEOR 2-03			USSR
79-021A	03/01/79	METEOR 2	METEOR 2-04			USSR
79-095A	10/31/79	METEOR 2	METEOR 2-05			USSR
80-073A	09/09/80	METEOR 2	METEOR 2-06			USSR
81-043A	05/14/81	METEOR 2	METEOR 2-07			USSR
82-025A	03/25/82	METEOR 2	METEOR 2-08			USSR
82-116A	12/14/82	METEOR 2	METEOR 2-09			USSR
83-109A	10/28/83	METEOR 2	METEOR 2-10			USSR
84-072A	07/18/84	METEOR 2	METEOR 2-11			USSR
85-013A	02/06/85	METEOR 2	METEOR 2-12			USSR
85-119A	12/26/85	METEOR 2	METEOR 2-13			USSR
86-039A	05/27/86	METEOR 2	METEOR 2-14			USSR
87-001A	02/15/87	METEOR 2	METEOR 2-15			USSR
77-108A	11/23/77	METEOSAT	METEOSAT 1			EUROPE
81-057A	06/19/81	METEOSAT	METEOSAT 2			EUROPE
MTSATP2	01/00/88	METEOSAT	METEOSAT P2			EUROPE
60-006A	05/24/60	DOD(OTHER)	MIDAS 2			US
61-018A	07/12/61	DOD(OTHER)	MIDAS 3			US
61-028A	10/21/61	DOD(OTHER)	MIDAS 4			US
62-010A	04/09/62	DOD(OTHER)	MIDAS 5			US
63-014A	05/09/63	DOD(OTHER)	MIDAS 6			US
66-035A	04/25/66	MOLNIYA 1	MOLNIYA 1-03			USSR
66-092A	10/20/66	MOLNIYA 1	MOLNIYA 1-04			USSR
67-052A	05/24/67	MOLNIYA 1	MOLNIYA 1-05			USSR
67-095A	10/03/67	MOLNIYA 1	MOLNIYA 1-06			USSR
67-101A	10/22/67	MOLNIYA 1	MOLNIYA 1-07			USSR
68-035A	04/21/68	MOLNIYA 1	MOLNIYA 1-08			USSR
68-057A	07/05/68	MOLNIYA 1	MOLNIYA 1-09			USSR
68-085A	10/05/68	MOLNIYA 1	MOLNIYA 1-10			USSR
87-018A	02/19/87	MOS	MOS 1			JAPAN
64-052A	08/28/64	NIMBUS	NIMBUS 1			US
66-040A	05/15/66	NIMBUS	NIMBUS 2			US
69-037A	04/14/69	NIMBUS	NIMBUS 3			US
70-025A	04/08/70	NIMBUS	NIMBUS 4			US
72-097A	12/11/72	NIMBUS	NIMBUS 5			US
75-052A	06/12/75	NIMBUS	NIMBUS 6			US
78-098A	10/24/78	NIMBUS	NIMBUS 7			US
70-106A	12/11/70	NOAA 1-5/ITOS	NOAA 01			US
72-082A	10/15/72	NOAA 1-5/ITOS	NOAA 02			US
73-086A	11/06/73	NOAA 1-5/ITOS	NOAA 03			US
74-089A	11/15/74	NOAA 1-5/ITOS	NOAA 04			US
76-077A	06/27/76	NOAA 1-5/ITOS	NOAA 05			US
79-057A	06/27/79	NOAA 6-D/T-N	NOAA 06			US
81-059A	06/23/81	NOAA 6-D/T-N	NOAA 07			US
83-022A	03/28/83	NOAA 8-J/ATN	NOAA 08			US
84-123A	12/12/84	NOAA 8-J/ATN	NOAA 09			US
84-123A	12/12/84	ERBE	NOAA 09			US
86-073A	09/17/86	ERBE	NOAA 10			US
86-073A	09/17/86	NOAA 8-J/ATN	NOAA 10			US
NOAA-H	02/00/88	NOAA 8-J/ATN	NOAA H			US
NOAA-I	06/00/90	NOAA 8-J/ATN	NOAA I			US
NOAA-J	09/00/91	NOAA 8-J/ATN	NOAA J			US

NSSDC ID	22222 L-DATE	PROJECT	11111 S/C NAMES	EXP NAME	PI/AGENCY	CO
NOAA-D		NOAA 6-D/T-N	NOAA-D			US
70-109A	12/24/70	EOLE/PEOLE	PEOLE			FRANCE/US
79-013A	02/18/79	AEM	SAGE			US
71-032A	04/19/71	SALYUT	SALYUT 1			USSR
74-046A	06/25/74	SALYUT	SALYUT 3			USSR
74-104A	12/26/74	SALYUT	SALYUT 4			USSR
76-057A	06/22/76	SALYUT	SALYUT 5			USSR
77-097A	09/29/77	SALYUT	SALYUT 6			USSR
82-033A	04/19/82	SALYUT	SALYUT 7			USSR
78-064A	06/27/78	SEASAT	SEASAT 1			US
73-027A	05/14/73	SKYLAB	SKYLAB			US
74-033A	05/17/74	GOES/SMS	SMS 1			US
75-011A	02/06/75	GOES/SMS	SMS 2			US
75-100A	10/16/75	GOES/SMS	SMS 3	(SEE GOES 1)		US
68-094A	10/26/68	SOYUZ	SOYUZ 03			USSR
69-004A	01/14/69	SOYUZ	SOYUZ 04			USSR
70-041A	06/02/70	SOYUZ	SOYUZ 09			USSR
71-053A	06/06/71	SOYUZ	SOYUZ 11			USSR
75-001A	01/11/75	SOYUZ	SOYUZ 17			USSR
75-044A	05/24/75	SOYUZ	SOYUZ 18			USSR
75-065A	07/15/75	SOYUZ	SOYUZ 19			USSR
76-064A	07/06/76	SOYUZ	SOYUZ 21			USSR
76-093A	09/15/76	SOYUZ	SOYUZ 22			USSR
77-008A	02/07/77	SOYUZ	SOYUZ 24			USSR
77-113A	12/10/77	SOYUZ	SOYUZ 26			USSR
78-061A	06/15/78	SOYUZ	SOYUZ 29			USSR
78-081A	08/26/78	SOYUZ	SOYUZ 31			USSR
79-018A	02/25/79	SOYUZ	SOYUZ 32			USSR
79-029A	04/10/79	SOYUZ	SOYUZ 33			USSR
80-027A	04/09/80	SOYUZ	SOYUZ 35			USSR
80-041A	05/26/80	SOYUZ	SOYUZ 36			USSR
80-064A	07/23/80	SOYUZ	SOYUZ 37			USSR
81-023A	03/12/81	SOYUZ	SOYUZ T-4			USSR
83-116A	11/28/83	SHUTTLE	SPACELAB 1			US
61-019A	08/06/61	VOSTOK	SPUTNIK 12	(SEE VOSTOK 2)		USSR
81-111A	11/12/81	SHUTTLE	STS-02			US
82-065A	06/27/82	SHUTTLE	STS-04			US
83-026A	04/04/83	SHUTTLE	STS-06			US
83-059A	06/18/83	SHUTTLE	STS-07			US
83-116A	11/28/83	SHUTTLE	STS-09	(SEE SPACELAB 1)		US
84-011A	02/03/84	SHUTTLE	STS-11			US
84-108A	10/05/84	SHUTTLE	STS-41G			US
60-002B	04/01/60	TIROS	TIROS 01			US
60-016A	11/23/60	TIROS	TIROS 02			US
61-017A	07/12/61	TIROS	TIROS 03			US
62-002A	02/08/62	TIROS	TIROS 04			US
62-025A	06/19/62	TIROS	TIROS 05			US
62-047A	09/18/62	TIROS	TIROS 06			US
63-024A	06/19/63	TIROS	TIROS 07			US
63-054A	12/21/63	TIROS	TIROS 08			US

NSSDC ID	22222 L-DATE	PROJECT	11111 S/C NAMES	EXP NAME	PI/AGENCY	CO
65-004A	01/22/65	TIROS	TIROS 09			US
65-051A	07/02/65	TIROS	TIROS 10			US
78-096A	10/13/78	NOAA 6-D/T-N	TIROS N			US
TOPEX	00/00/90	TOPEX	TOPEX			US
59-001A	02/17/59	VANGUARD	VANGUARD 2			US
64-065A	10/12/64	VOSKHOD	VOSKHOD 1			USSR
65-022A	03/18/65	VOSKHOD	VOSKHOD 2			USSR
61-019A	08/06/61	VOSTOK	VOSTOK 2			USSR
62-036A	08/11/62	VOSTOK	VOSTOK 3			USSR
62-037A	08/12/62	VOSTOK	VOSTOK 4			USSR
63-020A	06/15/63	VOSTOK	VOSTOK 5			USSR
63-023A	06/16/63	VOSTOK	VOSTOK 6			USSR
68-076A	09/14/68	ZOND	ZOND 5			USSR
68-101A	11/10/68	ZOND	ZOND 6			USSR
69 067A	08/07/69	ZOND	ZOND 7			USSR
70-088A	10/20/70	ZOND	ZOND 8			USSR

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NSSDC ID	22222 L-DATE	PROJECT	S/C NAMES	11111 EXP NAME	PI/AGENCY	CO
78-064A-01	06/27/78	SEASAT	SEASAT 1	(ALT)RADAR ALT	SMITH	US
72-085A-05	10/27/72	METEOR 1	METEOR 1-13	(APT)AUTO PIC TRANSMISSION		USSR
74-052A-05	07/09/74	METEOR 1	METEOR 1-18	(APT)AUTO PIC TRANSMISSION		USSR
74-083A-05	10/28/74	METEOR 1	METEOR 1-19	(APT)AUTO PIC TRANSMISSION		USSR
64-052A-02	08/28/64	NIMBUS	NIMBUS 1	(APT)AUTO PIC TRANSMISSION	HUNTER	US
66-040A-02	05/15/66	NIMBUS	NIMBUS 2	(APT)AUTO PIC TRANSMISSION	SCHULMAN	US
70-106A-05	12/11/70	NOAA 1-5/ITOS	NOAA 01	(APT)AUTO PIC TRANSM	NESDIS	US
71-120A-05	12/29/71	METEOR 1	METEOR 1-10	(APT)AUTO PIC TRANSMISSION		USSR
72-022A-05	03/30/72	METEOR 1	METEOR 1-11	(APT)AUTO PIC TRANSMISSION		USSR
72-049A-05	06/30/72	METEOR 1	METEOR 1-12	(APT)AUTO PIC TRANSMISSION		USSR
70-008A-05	01/23/70	NOAA 1-5/ITOS	ITOS 1	(APT)AUTO PIC TRANSMISSION	NESS STAFF	US
63-054A-02	12/21/63	TIROS	TIROS 08	(APT)AUTO PIC TRANSMISSION	HUNTER	US
66-016A-01	02/28/66	ESSA	ESSA 2	(APT)AUTOMATIC PIC TRANS	JONES	US
67-006A-01	01/26/67	ESSA	ESSA 4	(APT)AUTOMATIC PIC TRANS	ESSA	US
67-114A-01	11/10/67	ESSA	ESSA 6	(APT)AUTOMATIC PIC TRANS	ESSA	US
68-114A-01	12/15/68	ESSA	ESSA 8	(APT)AUTOMATIC PIC TRANS	ESSA	US
74-104A-	12/26/74	SALYUT	SALYUT 4	(ATMOSPHERIC SOUNDING)		USSR
70-008A-04	01/23/70	NOAA 1-5/ITOS	ITOS 1	(AVCS)ADV VICICON CAMERA SYS	NESS STAFF	US
66-087A-01	10/02/66	ESSA	ESSA 3	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
67-036A-01	04/20/67	ESSA	ESSA 5	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
68-069A-01	08/16/68	ESSA	ESSA 7	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
69-016A-01	02/26/69	ESSA	ESSA 9	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
64-052A-01	08/28/64	NIMBUS	NIMBUS 1	(AVCS)ADV VIDICON CAMERA SYS	BURDETT	US
66-040A-01	05/15/66	NIMBUS	NIMBUS 2	(AVCS)ADV VIDICON CAMERA SYS	SCHULMAN	US
70-106A-04	12/11/70	NOAA 1-5/ITOS	NOAA 01	(AVCS)ADV VIDICON CAMERA SYS	NESDIS	US
67-031A-10	04/06/67	ATS	ATS 2	(AVCS)VIDICON CAMERA SYSTEM	RCA	US
78-096A-01	10/13/78	NOAA 6-D/T-N	TIROS N	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
79-057A-01	06/27/79	NOAA 6-D/T-N	NOAA 06	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
81-059A-01	06/23/81	NOAA 6-D/T-N	NOAA 07	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-D-01		NOAA 6-D/T-N	NOAA-D	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
83-022A-01	03/28/83	NOAA 8-J/ATN	NOAA 08	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
84-123A-01	12/12/84	NOAA 8-J/ATN	NOAA 09	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
86-073A-01	09/17/86	NOAA 8-J/ATN	NOAA 10	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-H-01		NOAA 8-J/ATN	NOAA H	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-I-01		NOAA 8-J/ATN	NOAA I	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-J-01		NOAA 8-J/ATN	NOAA J	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
70-025A-05	04/08/70	NIMBUS	NIMBUS 4	(BUV)BACKSCATTER UV SPEC	HEATH	US
71-032A-	04/19/71	SALYUT	SALYUT 1	(CLOUD IMAGERY & VISUAL OBS)		USSR
74-046A-	06/25/74	SALYUT	SALYUT 3	(CLOUD IMAGERY)		USSR
78-098A-03	10/24/78	NIMBUS	NIMBUS 7	(CZCS)COAST ZONE COLOR SCAN	HOVIS	US
77-108A-02	11/23/77	METEOSAT	METEOSAT 1	(DCP)DATA COLL PLAT	PERA	EUROPE
81-057A-02	06/19/81	METEOSAT	METEOSAT 2	(DCP)DATA COLL PLAT	PERA	EUROPE
MTSATP2-02	01/00/88	METEOSAT	METEOSAT P2	(DCP)DATA COLL PLAT		EUROPE
87-018A-04	02/19/87	MOS	MOS 1	(DCS)DATA COLL SYS TRANSPNDR	NASDA	JAPAN
66-035A-	04/25/66	MOLNIYA 1	MOLNIYA 1- 03	(EARTH CLOUD PHOTOGRAPHY)		USSR
66-092A-	10/20/66	MOLNIYA 1	MOLNIYA 1- 04	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-052A-	05/24/67	MOLNIYA 1	MOLNIYA 1- 05	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-095A-	10/03/67	MOLNIYA 1	MOLNIYA 1- 06	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-101A-	10/22/67	MOLNIYA 1	MOLNIYA 1- 07	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-035A-	04/21/68	MOLNIYA 1	MOLNIYA 1- 08	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-057A-	07/05/68	MOLNIYA 1	MOLNIYA 1- 09	(EARTH CLOUD PHOTOGRAPHY)		USSR
68-085A-	10/05/68	MOLNIYA 1	MOLNIYA 1-10	(EARTH CLOUD PHOTOGRAPHY)		USSR
64-065A-	10/12/64	VOSKHOD	VOSKHOD 1	(EARTH CLOUD PHOTOGRAPHY)		USSR
65-022A-	03/18/65	VOSKHOD	VOSKHOD 2	(EARTH CLOUD PHOTOGRAPHY)		USSR
67-113A-	11/09/67	APOLLO	APOLLO 04	(EARTH PHOTOGRAPHY)	NASA	US
68-025A-	04/04/68	APOLLO	APOLLO 06	(EARTH PHOTOGRAPHY)	NASA	US

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68-076A-02	09/14/68	ZOND	ZOND 5	(EARTH-CLOUD PHOTOGRAPHY)		USSR
68-101A-01	11/10/68	ZOND	ZOND 6	(EARTH-CLOUD PHOTOGRAPHY)		USSR
69-067A-01	08/07/69	ZOND	ZOND 7	(EARTH-CLOUD PHOTOGRAPHY)		USSR
70-088A-01	10/20/70	ZOND	ZOND 8	(EARTH-CLOUD PHOTOGRAPHY)		USSR
75-052A-05	06/12/75	NIMBUS	NIMBUS 6	(ERB)EARTH RADIATION BUDGET	SMITH	US
78-098A-07	10/24/78	NIMBUS	NIMBUS 7	(ERB)EARTH RADIATION BUDGET	JACOBOWITZ	US
84-108B-01	10/05/84	ERBE	ERBS	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
84-123A-05	12/12/84	ERBE	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
86-073A-05	09/17/86	ERBE	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
84-123A-05	12/12/84	NOAA 8-J/ATN	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
86-073A-05	09/17/86	NOAA 8-J/ATN	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
73-027A-19	05/14/73	SKYLAB	SKYLAB	(EREP)BAND SCANNER(S-192)	KORB	US
73-027A-18	05/14/73	SKYLAB	SKYLAB	(EREP)IR SPECTROMETER(S-191)	BARNETT	US
73-027A-21	05/14/73	SKYLAB	SKYLAB	(EREP)L-BAND RADIOMTR(S-194)	EVANS	US
73-027A-17	05/14/73	SKYLAB	SKYLAB	(EREP)M-SPECT. PHOTOG.(S-190)	DEMEL	US
73-027A-20	05/14/73	SKYLAB	SKYLAB	(EREP)MICROWAVE SCATT(S-193)	EVANS	US
72-097A-04	12/11/72	NIMBUS	NIMBUS 5	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US
75-052A-03	06/12/75	NIMBUS	NIMBUS 6	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US
66-087A-02	10/02/66	ESSA	ESSA 3	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
67-036A-02	04/20/67	ESSA	ESSA 5	(FPR)FLAT PLATE RADIOMETER	PARENT	US
68-069A-02	08/16/68	ESSA	ESSA 7	(FPR)FLAT PLATE RADIOMETER	PARENT	US
69-016A-02	02/26/69	ESSA	ESSA 9	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
70-008A-02	01/23/70	NOAA 1-5/ITOS	ITOS 1	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
70-106A-02	12/11/70	NOAA 1-5/ITOS	NOAA 01	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
61-019A-	08/06/61	VOSTOK	VOSTOK 2	(HAND HELD CINE PHOTOGRAPHY)		USSR
62-036A-	08/11/62	VOSTOK	VOSTOK 3	(HAND HELD CINE PHOTOGRAPHY)		USSR
62-037A-	08/12/62	VOSTOK	VOSTOK 4	(HAND HELD CINE PHOTOGRAPHY)		USSR
63-020A-	06/15/63	VOSTOK	VOSTOK 5	(HAND HELD CINE PHOTOGRAPHY)		USSR
63-023A-	06/16/63	VOSTOK	VOSTOK 6	(HAND HELD CINE PHOTOGRAPHY)		USSR
78-041A-01	04/26/78	AEM	HCMM	(HCMM)HEAT CAPACITY MAP RAD	BARNES	US
75-052A-02	06/12/75	NIMBUS	NIMBUS 6	(HIRS)HIGH RES IR SOUNDER	SMITH	US
64-052A-03	08/28/64	NIMBUS	NIMBUS 1	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
66-040A-03	05/15/66	NIMBUS	NIMBUS 2	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
69-037A-02	04/14/69	NIMBUS	NIMBUS 3	(HRIR)HIGH RES IR RADIOMETER	CHERRIX	US
67-111A-03	11/05/67	ATS	ATS 3	(IDC)IMAGE DISSECTOR CAMERA	BRANCHFLOWER	US
69-037A-06	04/14/69	NIMBUS	NIMBUS 3	(IDC)IMAGE DISSECTOR CAMERA	BRACHFLOWER	US
70-025A-06	04/08/70	NIMBUS	NIMBUS 4	(IDC)IMAGE DISSECTOR CAMERA	BANCHFLOWER	US
77-057A-	06/22/76	SALYUT	SALYUT 5	(IR OBSERVATIONS:SFC TEMP)		USSR
69-037A-03	04/14/69	NIMBUS	NIMBUS 3	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
70-025A-03	04/08/70	NIMBUS	NIMBUS 4	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
72-097A-01	12/11/72	NIMBUS	NIMBUS 5	(ITPR)IR TEMP PROFILE RAD	SMITH	US
84-108A-02	10/05/84	SHUTTLE	STS-41G	(LFC)LARGE FORMAT CAMERA	MOLLBERG	US
78-098A-01	10/24/78	NIMBUS	NIMBUS 7	(LIMS)LIMB IR MON STRATO	RUSSELL	US
IRS-1A-01	10/00/87	IRS	IRS 1A	(LISS)LIN IMG SELF-SCN SENS	ISRO	INDIA
75-052A-04	06/12/75	NIMBUS	NIMBUS 6	(LRIR)LIMB RAD INVER RAD	GILLE	US
81-111A-04	11/12/81	SHUTTLE	STS-02	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
84-108A-03	10/05/84	SHUTTLE	STS-41G	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
87-018A-01	02/19/87	MOS	MOS 1	(MESSR)MSP ELE SELF-SCAN RAD.	NASDA	JAPAN
68-094A-	10/26/68	SOYUZ	SOYUZ 03	(METEOROLOGICAL OBS)		USSR
69-004A-	01/14/69	SOYUZ	SOYUZ 04	(METEOROLOGICAL OBS)		USSR
70-041A-	06/02/70	SOYUZ	SOYUZ 09	(METEOROLOGICAL OBS)		USSR
71-053A-	06/06/71	SOYUZ	SOYUZ 11	(METEOROLOGICAL OBS)		USSR
75-001A-	01/11/75	SOYUZ	SOYUZ 17	(METEOROLOGICAL OBS)		USSR
75-044A-	05/24/75	SOYUZ	SOYUZ 18	(METEOROLOGICAL OBS)		USSR
75-065A-	07/15/75	SOYUZ	SOYUZ 19	(METEOROLOGICAL OBS)		USSR

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76-064A-	07/06/76	SOYUZ	SOYUZ 21	(METEOROLOGICAL OBS)		USSR
76-093A-	09/15/76	SOYUZ	SOYUZ 22	(METEOROLOGICAL OBS)		USSR
77-008A-	02/07/77	SOYUZ	SOYUZ 24	(METEOROLOGICAL OBS)		USSR
77-113A-	12/10/77	SOYUZ	SOYUZ 26	(METEOROLOGICAL OBS)		USSR
78-061A-	06/15/78	SOYUZ	SOYUZ 29	(METEOROLOGICAL OBS)		USSR
78-081A-	08/26/78	SOYUZ	SOYUZ 31	(METEOROLOGICAL OBS)		USSR
79-018A-	02/25/79	SOYUZ	SOYUZ 32	(METEOROLOGICAL OBS)		USSR
79-029A-	04/10/79	SOYUZ	SOYUZ 33	(METEOROLOGICAL OBS)		USSR
80-027A-	04/09/80	SOYUZ	SOYUZ 35	(METEOROLOGICAL OBS)		USSR
80-041A-	05/26/80	SOYUZ	SOYUZ 36	(METEOROLOGICAL OBS)		USSR
80-064A-	07/23/80	SOYUZ	SOYUZ 37	(METEOROLOGICAL OBS)		USSR
81-023A-	03/12/81	SOYUZ	SOYUZ T-4	(METEOROLOGICAL OBS)		USSR
83-059A-06	06/18/83	SHUTTLE	STS-07	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
84-011A-01	02/03/84	SHUTTLE	STS-11	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
66-040A-04	05/15/66	NIMBUS	NIMBUS 2	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
69-037A-05	04/14/69	NIMBUS	NIMBUS 3	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
83-116A-39	11/28/83	SHUTTLE	SPACELAB 1	(MRSE)MICROWAVE FACILITY	DIETERLE	EUROPE
87-018A-03	02/19/87	MOS	MOS 1	(MSR)MICROWAVE SCAN RAD	NASDA	JAPAN
72-058A-02	07/23/72	LANDSAT	LANDSAT 1	(MSS)MULTISPECT SCAN	ARLUSKAS	US
75-004A-02	01/22/75	LANDSAT	LANDSAT 2	(MSS)MULTISPECT SCAN	FREDEN	US
78-026A-02	03/05/78	LANDSAT	LANDSAT 3	(MSS)MULTISPECT SCAN	FREDEN	US
82-072A-02	07/16/82	LANDSAT	LANDSAT 4	(MSS)MULTISPECT SCAN	SALMONSEN	US
84-021A-02	03/01/84	LANDSAT	LANDSAT 5	(MSS)MULTISPECT SCAN	SALMONSEN	US
67-111A-01	11/05/67	ATS	ATS 3	(MSSCC)MULTI COLOR SSCC	SUOMI	US
74-104A-	12/26/74	SALYUT	SALYUT 4	(MULTISPECTRAL IMAGERY)		USSR
77-097A-	09/29/77	SALYUT	SALYUT 6	(MULTISPECTRAL IMAGERY)		USSR
81-111A-06	11/12/81	SHUTTLE	STS-02	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
82-065A-01	06/27/82	SHUTTLE	STS-04	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
83-026A-01	04/04/83	SHUTTLE	STS-06	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
82-118A-01	12/21/82	DMSP	DMSP 5D-2/F6	(OLS)LINE SCAN SYSTEM	AFGWC STAFF	US
76-091A-01	09/11/76	DMSP	DMSP 5D-1/F1	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
77-044A-01	06/05/77	DMSP	DMSP 5D-1/F2	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
78-042A-01	05/01/78	DMSP	DMSP 5D-1/F3	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
79-050A-01	06/06/79	DMSP	DMSP 5D-1/F4	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
83-113A-01	11/18/83	DMSP	DMSP 5D-2/F7	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
87-053A-01	06/20/87	DMSP	DMSP 5D-2/F8	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
59-001A-01	02/17/59	VANGUARD	VANGUARD 2	(OPTICAL SCANNER)	STROUD	US
75-052A-09	06/12/75	NIMBUS	NIMBUS 6	(PMR)PRESS MODULATED RAD	HOUGHTON	US
76-057A-	06/22/76	SALYUT	SALYUT 5	(POLLUTION STUDIES)		USSR
79-013A-01	02/18/79	AEM	SAGE	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
84-108B-02	10/05/84	ERBE	ERBS	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
78-098A-06	10/24/78	NIMBUS	NIMBUS 7	(SAM-II)STRAT AEROSOL MEA	MCCORMICK	US
79-051A-01	06/07/79	BHASKARA	BHASKARA	(SAMIR)SATELLITE MW RAD	JOSEPH	INDIA
81-115A-02	11/20/81	BHASKARA	BHASKARA 2	(SAMIR)SATELLITE MW RAD	CALLA	INDIA
78-098A-02	10/24/78	NIMBUS	NIMBUS 7	(SAMS)STRAT + MESO SOUNDER	HOUGHTON	UK
78-064A-02	06/27/78	SEASAT	SEASAT 1	(SAR)SYNTHETIC AP RADAR	TELEKI	US
78-064A-03	06/27/78	SEASAT	SEASAT 1	(SASS)SEASAT-A-SAT SCATMTR	PIERSON	US
84-123A-07	12/12/84	NOAA 8-J/ATN	NOAA 09	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
NOAA-H-05	12/12/84	NOAA 8-J/ATN	NOAA-H	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
NOAA-J-05	12/12/84	NOAA 8-J/ATN	NOAA-J	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
78-098A-09	10/24/78	NIMBUS	NIMBUS 7	(SBUV/TOMS)-BACKSC UV/OZONE	HEATH	US
75-052A-10	06/12/75	NIMBUS	NIMBUS 6	(SCAMS)SCAN MICROWAVE RAD	STAELIN	US
72-097A-05	12/11/72	NIMBUS	NIMBUS 5	(SCMR)SFC COMP MAPPING RAD	HOVIS	US
70-025A-10	04/08/70	NIMBUS	NIMBUS 4	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
72-097A-02	12/11/72	NIMBUS	NIMBUS 5	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
66-020A-07	03/16/66	GEMINI	GEMINI 08	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US

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66-047A-06	06/03/66	GEMINI	GEMINI 09	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US
81-111A-01	11/12/81	SHUTTLE	STS-02	(SIR-A)SHUTTLE IMAGING RADAR	ELACHI	US
84-108A-01	10/05/84	SHUTTLE	STS-41G	(SIR-B)SHUTTLE IMAGING RADAR	ELACHI	US
69-037A-04	04/14/69	NIMBUS	NIMBUS 3	(SIRS)SAT IR SPECT	WARK	US
70-025A-04	04/08/70	NIMBUS	NIMBUS 4	(SIRS)SAT IR SPECT	WARK	US
78-098A-08	10/24/78	NIMBUS	NIMBUS 7	(SMMR)SCAN MICROWAVE RAD	GLOERSEN	US
78-064A-05	06/27/87	SEASAT	SEASAT 1	(SMMR)SCAN MICROWAVE RAD	STEPHANIDES	US
70-106A-03	12/11/70	NOAA 1-5/ITOS	NOAA 01	(SR)SCANNING RADIOMETER	GEMUNDER	US
72-082A-02	10/15/72	NOAA 1-5/ITOS	NOAA 02	(SR)SCANNING RADIOMETER	NESDIS	US
73-086A-02	11/06/73	NOAA 1-5/ITOS	NOAA 03	(SR)SCANNING RADIOMETER	NESDIS	US
74-089A-02	11/15/74	NOAA 1-5/ITOS	NOAA 04	(SR)SCANNING RADIOMETER	NESDIS	US
76-077A-03	06/27/76	NOAA 1-5/ITOS	NOAA 05	(SR)SCANNING RADIOMETER	NESDIS	US
60-016A-02	11/23/60	TIROS	TIROS 02	(SR)SCANNING RADIOMETER	BARKSDALE	US
61-017A-03	07/12/61	TIROS	TIROS 03	(SR)SCANNING RADIOMETER	RADOS	US
62-002A-03	02/08/62	TIROS	TIROS 04	(SR)SCANNING RADIOMETER	BARKSDALE	US
63-024A-02	06/19/63	TIROS	TIROS 07	(SR)SCANNING RADIOMETER	RADOS	US
79-050A-08	06/06/79	DMSP	DMSP 5D-1/F4	(SSC)SNOW/CLOUD DISCRIM	AFGWC STAFF	US
66-110A-09	12/07/66	ATS	ATS 1	(SSCC)SPIN SCAN CLOUD CAMERA	SUOMI	US
72-089A-02	11/09/72	DMSP	DMSP 5B/F3	(SSE) VERT TEMP PROFILE RAD	AFGWC STAFF	US
72-018A-02	03/24/72	DMSP	DMSP 5B/F2	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
74-015A-02	03/16/74	DMSP	DMSP 5B/F5	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
76-091A-02	09/11/76	DMSP	DMSP 5D-1/F1	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
77-044A-02	06/05/77	DMSP	DMSP 5D-1/F2	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
78-042A-02	05/01/78	DMSP	DMSP 5D-1/F3	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
79-050A-02	06/06/79	DMSP	DMSP 5D-1/F4	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
82-118A-02	12/21/82	DMSP	DMSP 5D-2/F6	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
87-053A-05	06/20/87	DMSP	DMSP 5D-2/F8	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
79-050A-06	06/06/79	DMSP	DMSP 5D-1/F4	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
83-113A-03	11/18/83	DMSP	DMSP 5D-2/F7	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
87-053A-06	06/20/87	DMSP	DMSP 5D-2/F8	(SSM/I)MW IMAGER	AFGWC STAFF	US
70-025A-02	04/08/70	NIMBUS	NIMBUS 4	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
72-097A-08	12/11/72	NIMBUS	NIMBUS 5	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
75-052A-12	06/12/75	NIMBUS	NIMBUS 6	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
78-098A-10	10/24/78	NIMBUS	NIMBUS 7	(THIR)TEMP-HUMIDITY IR RAD	STOWE	US
78-096A-02	10/13/78	NOAA 6-D/T-N	TIROS N	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
79-057A-02	06/27/79	NOAA 6-D/T-N	NOAA 06	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
81-059A-02	06/23/81	NOAA 6-D/T-N	NOAA 07	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-D-02		NOAA 6-D/T-N	NOAA-D	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
83-022A-02	03/28/83	NOAA 8-J/ATN	NOAA 08	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
84-123A-02	12/12/84	NOAA 8-J/ATN	NOAA 09	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
86-073A-02	09/17/86	NOAA 8-J/ATN	NOAA 10	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-H-02		NOAA 8-J/ATN	NOAA H	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-I-02		NOAA 8-J/ATN	NOAA I	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-J-02		NOAA 8-J/ATN	NOAA J	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
75-052A-01	06/12/75	NIMBUS	NIMBUS 6	(TWERLE)TRP WND ENG CONV	JULIAN	US
80-074A-01	09/09/80	GOES/SMS	GOES 4	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
81-049A-01	05/22/81	GOES/SMS	GOES 5	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
83-041A-01	04/28/83	GOES/SMS	GOES 6	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
87-022A-01	02/26/87	GOES/SMS	GOES 7	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
66-008A-01	02/03/66	ESSA	ESSA 1	(VCS)VIDICON CAMERA SYS.	NESS STAFF	US
74-039A-08	05/30/74	ATS	ATS 6	(VHRR)VERY HIGH RES RAD	SHENK	US
82-031A-01	04/10/82	INSAT	INSAT 1A	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
83-089B-01	08/31/83	INSAT	INSAT 1B	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
INSAT1C-01	06/00/88	INSAT	INSAT 1C	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
72-082A-03	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VHRR)VERY HIGH RES RAD	NESDIS	US
73-086A-03	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VHRR)VERY HIGH RES RAD	NESDIS	US
74-089A-03	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VHRR)VERY HIGH RES RAD	NESDIS	US
76-077A-01	06/27/76	NOAA 1-5/ITOS	NOAA 05	(VHRR)VERY HIGH RES RAD	NESDIS	US

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78-064A-04	06/27/78	SEASAT	SEASAT 1	(VIRR)SCAN VIS/IR RADIOMETER	FELLERMAN	US
77-065A-01	07/14/77	GMS	GMS	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
81-076A-01	08/10/81	GMS	GMS 2	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
84-080A-01	08/02/84	GMS	GMS 3	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
74-033A-01	05/17/74	GOES/SMS	SMS 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-011A-04	02/06/75	GOES/SMS	SMS 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-100A-01	10/16/75	GOES/SMS	G0ES 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
77-048A-01	06/16/77	GOES/SMS	GOES 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
78-062A-01	06/16/78	GOES/SMS	GOES 3	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
87-018A-02	02/19/87	MOS	MOS 1	(VTIR)VIS & THERMAL IR RAD	NASDA	JAPAN
72-082A-04	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
73-086A-04	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
74-089A-04	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
76-077A-02	06/27/76	NOAA 1-5/ITOS	NOAA 05	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
67-024A-03	03/21/67	COSMOS	COSMOS 149	3-CHANNEL RADIOMETERS		USSR
67-024A-01	03/21/67	COSMOS	COSMOS 149	3-CHANNEL TELEPHOTOMETER		USSR
66-057A-03	06/25/66	COSMOS	COSMOS 122	ACTINOMETRIC INSTRUMENT		USSR
67-039A-03	04/27/67	COSMOS	COSMOS 156	ACTINOMETRIC INSTRUMENT		USSR
69-029A-03	03/26/69	METEOR 1	METEOR 1-01	ACTINOMETRIC INSTRUMENT		USSR
69-084A-03	10/06/69	METEOR 1	METEOR 1-02	ACTINOMETRIC INSTRUMENT		USSR
70-019A-03	03/17/70	METEOR 1	METEOR 1-03	ACTINOMETRIC INSTRUMENT		USSR
70-037A-03	04/28/70	METEOR 1	METEOR 1-04	ACTINOMETRIC INSTRUMENT		USSR
70-047A-03	06/23/70	METEOR 1	METEOR 1-05	ACTINOMETRIC INSTRUMENT		USSR
70-085A-03	10/15/70	METEOR 1	METEOR 1-06	ACTINOMETRIC INSTRUMENT		USSR
71-003A-03	01/20/71	METEOR 1	METEOR 1-07	ACTINOMETRIC INSTRUMENT		USSR
71-031A-03	04/17/71	METEOR 1	METEOR 1-08	ACTINOMETRIC INSTRUMENT		USSR
71-059A-03	07/16/71	METEOR 1	METEOR 1-09	ACTINOMETRIC INSTRUMENT		USSR
71-120A-03	12/29/71	METEOR 1	METEOR 1-10	ACTINOMETRIC INSTRUMENT		USSR
72-022A-03	03/30/72	METEOR 1	METEOR 1-11	ACTINOMETRIC INSTRUMENT		USSR
72-049A-03	06/30/72	METEOR 1	METEOR 1-12	ACTINOMETRIC INSTRUMENT		USSR
72-085A-03	10/27/72	METEOR 1	METEOR 1-13	ACTINOMETRIC INSTRUMENT		USSR
73-015A-03	03/20/73	METEOR 1	METEOR 1-14	ACTINOMETRIC INSTRUMENT		USSR
73-034A-03	05/29/73	METEOR 1	METEOR 1-15	ACTINOMETRIC INSTRUMENT		USSR
74-011A-03	03/05/74	METEOR 1	METEOR 1-16	ACTINOMETRIC INSTRUMENT		USSR
74-025A-03	04/24/74	METEOR 1	METEOR 1-17	ACTINOMETRIC INSTRUMENT		USSR
74-052A-03	07/09/74	METEOR 1	METEOR 1-18	ACTINOMETRIC INSTRUMENT		USSR
74-083A-03	10/28/74	METEOR 1	METEOR 1-19	ACTINOMETRIC INSTRUMENT		USSR
74-099A-03	12/17/74	METEOR 1	METEOR 1-20	ACTINOMETRIC INSTRUMENT		USSR
75-023A-03	04/01/75	METEOR 1	METEOR 1-21	ACTINOMETRIC INSTRUMENT		USSR
75-087A-03	09/18/75	METEOR 1	METEOR 1-22	ACTINOMETRIC INSTRUMENT		USSR
75-124A-03	12/25/75	METEOR 1	METEOR 1-23	ACTINOMETRIC INSTRUMENT		USSR
76-032A-03	04/07/76	METEOR 1	METEOR 1-24	ACTINOMETRIC INSTRUMENT		USSR
76-043A-03	05/15/76	METEOR 1	METEOR 1-25	ACTINOMETRIC INSTRUMENT		USSR
76-102A-03	10/16/76	METEOR 1	METEOR 1-26	ACTINOMETRIC INSTRUMENT		USSR
77-024A-03	04/05/77	METEOR 1	METEOR 1-27	ACTINOMETRIC INSTRUMENT		USSR
71-059A-04	07/16/71	METEOR 1	METEOR 1-09	ATMOS THERMAL SOUNDER		USSR
71-120A-04	12/29/71	METEOR 1	METEOR 1-10	ATMOS THERMAL SOUNDER		USSR
72-085A-04	10/27/72	METEOR 1	METEOR 1-13	ATMOS THERMAL SOUNDER		USSR
73-015A-04	03/20/73	METEOR 1	METEOR 1-14	ATMOS THERMAL SOUNDER		USSR
74-011A-04	03/05/74	METEOR 1	METEOR 1-16	ATMOS THERMAL SOUNDER		USSR
74-025A-04	04/24/74	METEOR 1	METEOR 1-17	ATMOS THERMAL SOUNDER		USSR
74-052A-04	07/09/74	METEOR 1	METEOR 1-18	ATMOS THERMAL SOUNDER		USSR
74-083A-04	10/28/74	METEOR 1	METEOR 1-19	ATMOS THERMAL SOUNDER		USSR
74-099A-04	12/17/74	METEOR 1	METEOR 1-20	ATMOS THERMAL SOUNDER		USSR
75-023A-04	04/01/75	METEOR 1	METEOR 1-21	ATMOS THERMAL SOUNDER		USSR
75-087A-04	09/18/75	METEOR 1	METEOR 1-22	ATMOS THERMAL SOUNDER		USSR
75-124A-04	12/25/75	METEOR 1	METEOR 1-23	ATMOS THERMAL SOUNDER		USSR
76-032A-04	04/07/76	METEOR 1	METEOR 1-24	ATMOS THERMAL SOUNDER		USSR

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76-043A-04	05/15/76	METEOR 1	METEOR 1-25	ATMOS THERMAL SOUNDER		USSR
76-102A-04	10/16/76	METEOR 1	METEOR 1-26	ATMOS THERMAL SOUNDER		USSR
77-024A-04	04/05/77	METEOR 1	METEOR 1-27	ATMOS THERMAL SOUNDER		USSR
72-022A-04	03/30/72	METEOR 1	METEOR 1-11	ATMOSTHERMAL SOUNDER		USSR
72-049A-04	06/30/72	METEOR 1	METEOR 1-12	ATMOSTHERMAL SOUNDER		USSR
73-034A-04	05/29/73	METEOR 1	METEOR 1-15	ATMOSTHERMAL SOUNDER		USSR
66-082A-02	09/15/66	DMSP	DMSP 4A/F1	C-SYSTEM	AFGWC STAFF	US
67-010A-02	02/08/67	DMSP	DMSP 4A/F2	C-SYSTEM	AFGWC STAFF	US
67-080A-02	08/22/67	DMSP	DMSP 4A/F3	C-SYSTEM	AFGWC STAFF	US
67-096A-02	10/11/67	DMSP	DMSP 4A/F4	C-SYSTEM	AFGWC STAFF	US
68-042A-02	05/22/68	DMSP	DMSP 4B/F1	C-SYSTEM	AFGWC STAFF	US
68-092A-02	10/22/68	DMSP	DMSP 4B/F2	C-SYSTEM	AFGWC STAFF	US
69-062A-02	07/22/69	DMSP	DMSP 4B/F3	C-SYSTEM	AFGWC STAFF	US
65-068A-04	08/21/65	GEMINI	GEMINI 05	CLOUD TOP SPECTROMETER	SAIEDY	US
66-020A-04	03/16/66	GEMINI	GEMINI 08	CLOUD TOP SPECTROMETER	ALISHOUSE	US
67-066F-01	07/01/67	DODGE	DODGE	COLOR TV OF EARTH	THOMPSON	US
81-115A-01	11/20/81	BHASKARA	BHASKARA 2	DUAL TV CAMERA	CALLA	INDIA
66-057A-01	06/25/66	COSMOS	COSMOS 122	DUAL VIDECON CAMERAS		USSR
67-039A-01	04/27/67	COSMOS	COSMOS 156	DUAL VIDECON CAMERAS		USSR
69-029A-01	03/26/69	METEOR 1	METEOR 1-01	DUAL VIDICON CAMERAS		USSR
69-084A-01	10/06/69	METEOR 1	METEOR 1-02	DUAL VIDICON CAMERAS		USSR
70-019A-01	03/17/70	METEOR 1	METEOR 1-03	DUAL VIDICON CAMERAS		USSR
70-037A-01	04/28/70	METEOR 1	METEOR 1-04	DUAL VIDICON CAMERAS		USSR
70-047A-01	06/23/70	METEOR 1	METEOR 1-05	DUAL VIDICON CAMERAS		USSR
70-085A-01	10/15/70	METEOR 1	METEOR 1-06	DUAL VIDICON CAMERAS		USSR
71-003A-01	01/20/71	METEOR 1	METEOR 1-07	DUAL VIDICON CAMERAS		USSR
71-031A-01	04/17/71	METEOR 1	METEOR 1-08	DUAL VIDICON CAMERAS		USSR
71-059A-01	07/16/71	METEOR 1	METEOR 1-09	DUAL VIDICON CAMERAS		USSR
71-120A-01	12/29/71	METEOR 1	METEOR 1-10	DUAL VIDICON CAMERAS		USSR
72-022A-01	03/30/72	METEOR 1	METEOR 1-11	DUAL VIDICON CAMERAS		USSR
72-049A-01	06/30/72	METEOR 1	METEOR 1-12	DUAL VIDICON CAMERAS		USSR
72-085A-01	10/27/72	METEOR 1	METEOR 1-13	DUAL VIDICON CAMERAS		USSR
73-015A-01	03/20/73	METEOR 1	METEOR 1-14	DUAL VIDICON CAMERAS		USSR
73-034A-01	05/29/73	METEOR 1	METEOR 1-15	DUAL VIDICON CAMERAS		USSR
74-011A-01	03/05/74	METEOR 1	METEOR 1-16	DUAL VIDICON CAMERAS		USSR
74-025A-01	04/24/74	METEOR 1	METEOR 1-17	DUAL VIDICON CAMERAS		USSR
74-052A-01	07/09/74	METEOR 1	METEOR 1-18	DUAL VIDICON CAMERAS		USSR
73-083A-01	10/28/74	METEOR 1	METEOR 1-19	DUAL VIDICON CAMERAS		USSR
74-099A-01	12/17/74	METEOR 1	METEOR 1-20	DUAL VIDICON CAMERAS		USSR
75-023A-01	04/01/75	METEOR 1	METEOR 1-21	DUAL VIDICON CAMERAS		USSR
75-087A-01	09/18/75	METEOR 1	METEOR 1-22	DUAL VIDICON CAMERAS		USSR
75-124A-01	12/25/75	METEOR 1	METEOR 1-23	DUAL VIDICON CAMERAS		USSR
76-032A-01	04/07/76	METEOR 1	METEOR 1-24	DUAL VIDICON CAMERAS		USSR
76-043A-01	05/15/76	METEOR 1	METEOR 1-25	DUAL VIDICON CAMERAS		USSR
76-102A-01	10/16/76	METEOR 1	METEOR 1-26	DUAL VIDICON CAMERAS		USSR
77-024A-01	04/05/77	METEOR 1	METEOR 1-27	DUAL VIDICON CAMERAS		USSR
77-057A-01	06/29/77	METEOR 1	METEOR 1-28	DUAL VIDICON CAMERAS		USSR
79-005A-01	01/25/79	METEOR 1	METEOR 1-29	DUAL VIDICON CAMERAS		USSR
80-051A-01	06/18/80	METEOR 1	METEOR 1-30	DUAL VIDICON CAMERAS		USSR
81-065A-01	07/[illegible]/81	METEOR 1	METEOR 1-31	DUAL VIDICON CAMERAS		USSR
68-089A-01	10/11/68	APOLLO	APOLLO 07	EARTH CLOUD PHOTOGRAPHY	ALLENBY	US
75-066A-21	07/15/75	APOLLO	ASTP APOLLO	EARTH OBS & PHOTOS(MA-136)	EL BAZ	US
61-025A-01	09/13/61	MERCURY	MA-4	EARTH PHOTOGRAPHY	NASA	US
61-033A-01	11/29/61	MERCURY	MA-5	EARTH PHOTOGRAPHY	NASA	US
62-003A-01	02/20/62	MERCURY	MA-6	EARTH PHOTOGRAPHY	NASA	US
62-019A-01	05/24/62	MERCURY	MA-7	EARTH PHOTOGRAPHY	NASA	US
62-052A-01	10/03/62	MERCURY	MA-8	EARTH PHOTOGRAPHY	NASA	US

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63-015A-01	03/15/63	MERCURY	MA-9	EARTH PHOTOGRAPHY	NASA	US
70-025A-09	04/08/70	NIMBUS	NIMBUS 4	FILTER WEDGE SPECT	HOVIS	US
71-063A-01	07/26/71	APOLLO	APOLLO 15	HANDHELD PHOTOGRAPHY	DOYLE	US
72-031A-01	04/17/72	APOLLO	APOLLO 16	HANDHELD PHOTOGRAPHY	DOYLE	US
72-096A-05	12/07/72	APOLLO	APOLLO 17	HANDHELD PHOTOGRAPHY	DOYLE	US
68-068A-03	08/10/68	ATS	ATS 4	IMAGE ORTHICON CAMERA	HAZELTINE	US
77-108A-01	11/23/77	METEOSAT	METEOSAT 1	IMAGING RADIOMETER	SERENE	EUROPE
81-057A-01	06/19/81	METEOSAT	METEOSAT 2	IMAGING RADIOMETER	SERENE	EUROPE
MTSATP2-01	01/00/88	METEOSAT	METEOSAT P2	IMAGING RADIOMETER		EUROPE
70-105A-02	12/10/70	COSMOS	COSMOS 384	IR RADIOMETER		USSR
83-116A-38	11/28/83	SHUTTLE	SPACELAB 1	METRIC CAMERA FACILITY	REYNOLDS	EUROPE
71-063A-03	07/26/71	APOLLO	APOLLO 15	METRIC PHOTOGRAPHY	DOYLE	US
2-031A-03	04/17/72	APOLLO	APOLLO 16	METRIC PHOTOGRAPHY	DOYLE	US
72-096A-07	12/07/72	APOLLO	APOLLO 17	METRIC PHOTOGRAPHY	DOYLE	US
70-105A-01	12/10/70	COSMOS	COSMOS 384	MICROWAVE RADIOMETER		USSR
TOPEX-02	00/00/90	TOPEX	TOPEX	MICROWAVE RADIOMETER		US
72-097A-03	12/11/72	NIMBUS	NIMBUS 5	MICROWAVE SPECTROMETER	STAELIN	US
67-024A-02	03/21/67	COSMOS	COSMOS 149	NARROW ANGLE HRIR		USSR
60-006A-03	05/24/60	DOD(OTHER)	MIDAS 2	NON-SCANNING RADIOMETER	JURSA	US
61-017A-01	07/12/61	TIROS	TIROS 03	OMNI RADIOMETER	SUOMI	US
62-002A-01	02/08/62	TIROS	TIROS 04	OMNI RADIOMETER	SUOMI	US
63-024A-01	06/19/63	TIROS	TIROS 07	OMNI RADIOMETER	SUOMI	US
71-063A-02	07/26/71	APOLLO	APOLLO 15	PANORAMIC PHOTOGRAPHY	DOYLE	US
72-031A-02	04/17/72	APOLLO	APOLLO 16	PANORAMIC PHOTOGRAPHY	DOYLE	US
72-096A-06	12/07/72	APOLLO	APOLLO 17	PANORAMIC PHOTOGRAPHY	DOYLE	US
71-008A-01	01/31/71	APOLLO	APOLLO 14	PHOTOGRAPHY	EL BAZ	US
68-118A-01	12/21/68	APOLLO	APOLLO 08	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-043A-01	05/18/69	APOLLO	APOLLO 10	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-059A-01	07/16/69	APOLLO	APOLLO 11	PHOTOS, 70,16 & 35 MM	ALLENBY	US
69-099A-01	11/14/69	APOLLO	APOLLO 12	PHOTOS, 70,16 & 35 MM	ALLENBY	US
70-029A-01	04/11/70	APOLLO	APOLLO 13	PHOTOS, 70MM & 16 MM	ALLENBY	US
69-099A-09	11/14/69	APOLLO	APOLLO 12	PHOTOS,MULTISPECTRAL, 70 MM	GOETZ	US
66-057A-02	06/25/66	COSMOS	COSMOS 122	SCANNING HRIR RADIOMETER		USSR
67-039A-02	04/27/67	COSMOS	COSMOS 156	SCANNING HRIR RADIOMETER		USSR
69-029A-02	03/26/69	METEOR 1	METEOR 1-01	SCANNING HRIR RADIOMETER		USSR
69-084A-02	10/06/69	METEOR 1	METEOR 1-02	SCANNING HRIR RADIOMETER		USSR
70-019A-02	03/17/70	METEOR 1	METEOR 1-03	SCANNING HRIR RADIOMETER		USSR
70-037A-02	04/28/70	METEOR 1	METEOR 1-04	SCANNING HRIR RADIOMETER		USSR
70-047A-02	06/23/70	METEOR 1	METEOR 1-05	SCANNING HRIR RADIOMETER		USSR
70-085A-02	10/15/70	METEOR 1	METEOR 1-06	SCANNING HRIR RADIOMETER		USSR
71-003A-02	01/20/71	METEOR 1	METEOR 1-07	SCANNING HRIR RADIOMETER		USSR
71-031A-02	04/17/71	METEOR 1	METEOR 1-08	SCANNING HRIR RADIOMETER		USSR
71-059A-02	07/16/71	METEOR 1	METEOR 1-09	SCANNING HRIR RADIOMETER		USSR
71-120A-02	12/29/71	METEOR 1	METEOR 1-10	SCANNING HRIR RADIOMETER		USSR
72-022A-02	03/30/72	METEOR 1	METEOR 1-11	SCANNING HRIR RADIOMETER		USSR
72-049A-02	06/30/72	METEOR 1	METEOR 1-12	SCANNING HRIR RADIOMETER		USSR
72-085A-02	10/27/72	METEOR 1	METEOR 1-13	SCANNING HRIR RADIOMETER		USSR
73-015A-02	03/20/73	METEOR 1	METEOR 1-14	SCANNING HRIR RADIOMETER		USSR
73-034A-02	05/29/73	METEOR 1	METEOR 1-15	SCANNING HRIR RADIOMETER		USSR
74-011A-02	03/05/74	METEOR 1	METEOR 1-16	SCANNING HRIR RADIOMETER		USSR
74-025A-02	04/24/74	METEOR 1	METEOR 1-17	SCANNING HRIR RADIOMETER		USSR
74-052A-02	07/09/74	METEOR 1	METEOR 1-18	SCANNING HRIR RADIOMETER		USSR

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74-083A-02	10/28/74	METEOR 1	METEOR 1-19	SCANNING HRIR RADIOMETER		USSR
74-099A-02	12/17/74	METEOR 1	METEOR 1-20	SCANNING HRIR RADIOMETER		USSR
75-023A-02	04/01/75	METEOR 1	METEOR 1-21	SCANNING HRIR RADIOMETER		USSR
75-087A-02	09/18/75	METEOR 1	METEOR 1-22	SCANNING HRIR RADIOMETER		USSR
75-124A-02	12/25/75	METEOR 1	METEOR 1-23	SCANNING HRIR RADIOMETER		USSR
76-032A-02	04/07/76	METEOR 1	METEOR 1-24	SCANNING HRIR RADIOMETER		USSR
76-043A-02	05/15/76	METEOR 1	METEOR 1-25	SCANNING HRIR RADIOMETER		USSR
76-102A-02	10/16/76	METEOR 1	METEOR 1-26	SCANNING HRIR RADIOMETER		USSR
77-024A-02	04/05/77	METEOR 1	METEOR 1-27	SCANNING HRIR RADIOMETER		USSR
77-057A-02	06/29/77	METEOR 1	METEOR 1-28	SCANNING HRIR RADIOMETER		USSR
79-005A-02	01/25/79	METEOR 1	METEOR 1-29	SCANNING HRIR RADIOMETER		USSR
80-051A-02	06/18/80	METEOR 1	METEOR 1-30	SCANNING HRIR RADIOMETER		USSR
81-065A-02	07/10/81	METEOR 1	METEOR 1-31	SCANNING HRIR RADIOMETER		USSR
61-030A-02	11/15/61	DISCOVERER	DISCOVERER 35	SCANNING RADIOMETER	JURSA	US
70-012A-01	02/11/70	DMSP	DMSP 5A/F1	SCANNING RADIOMETER	AFGWC STAFF	US
70-070A-01	09/03/70	DMSP	DMSP 5A/F2	SCANNING RADIOMETER	AFGWC STAFF	US
71-012A-01	02/17/71	DMSP	DMSP 5A/F3	SCANNING RADIOMETER	AFGWC STAFF	US
71-087A-01	10/14/71	DMSP	DMSP 5B/F1	SCANNING RADIOMETER	AFGWC STAFF	US
72-018A-01	03/24/72	DMSP	DMSP 5B/F2	SCANNING RADIOMETER	AFGWC STAFF	US
72-089A-01	11/09/72	DMSP	DMSP 5B/F3	SCANNING RADIOMETER	AFGWC STAFF	US
73-054A-01	08/17/73	DMSP	DMSP 5B/F4	SCANNING RADIOMETER	AFGWC STAFF	US
74-015A-01	03/16/74	DMSP	DMSP 5B/F5	SCANNING RADIOMETER	AFGWC STAFF	US
74-063A-01	08/09/74	DMSP	DMSP 5C/F1	SCANNING RADIOMETER	AFGWC STAFF	US
75-043A-01	05/24/75	DMSP	DMSP 5C/F2	SCANNING RADIOMETER	AFGWC STAFF	US
61-018A-04	07/12/61	DOD(OTHER)	MIDAS 3	SCANNING RADIOMETER	JURSA	US
61-028A-02	10/21/61	DOD(OTHER)	MIDAS 4	SCANNING RADIOMETER	TODD	US
62-010A-04	04/09/62	DOD(OTHER)	MIDAS 5	SCANNING RADIOMETER	JURSA	US
63-014A-02	05/09/63	DOD(OTHER)	MIDAS 6	SCANNING RADIOMETER	TODD	US
70-008A-03	01/23/70	NOAA 1-5/ITOS	ITOS 1	SCANNING RADIOMETER SYSTEM	GEMUNDER	US
65-068A-06	08/21/65	GEMINI	GEMINI 05	SPACE OBJECT RADIOMETRY	BRENTNALL	US
65-100A-05	12/04/65	GEMINI	GEMINI 07	SPACE OBJECT RADIOMETRY	BRENTNALL	US
69-018A-01	03/03/69	APOLLO	APOLLO 09	SPECTRAL TERRAIN PHOTOS	ALLENBY	US
75-066A-19	07/15/75	APOLLO	ASTP APOLLO	STRAT AEROSOLS(MA-007)	PEPIN	US
65-024A-03	03/23/65	GEMINI	GEMIMI 03	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-043A-01	06/03/65	GEMINI	GEMINI 04	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-068A-02	08/21/65	GEMINI	GEMINI 05	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-104A-01	12/15/65	GEMINI	GEMINI 06	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-100A-01	12/04/65	GEMINI	GEMINI 07	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-020A-01	03/16/66	GEMINI	GEMINI 08	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-066A-02	07/18/66	GEMINI	GEMINI 10	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-081A-06	09/12/66	GEMINI	GEMINI 11	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-104A-02	11/11/66	GEMINI	GEMINI 12	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-047A-05	06/03/66	GEMINI	GEMINI 09	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-043A-02	06/03/65	GEMINI	GEMINI 04	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-068A-03	08/21/65	GEMINI	GEMINI 05	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-104A-02	12/15/65	GEMINI	GEMINI 06	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-100A-02	12/04/65	GEMINI	GEMINI 07	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-066A-03	07/18/66	GEMINI	GEMINI 10	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-081A-07	09/12/66	GEMINI	GEMINI 11	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-104A-03	11/11/66	GEMINI	GEMINI 12	SYNOPTIC WEATHER PHOTOS	NAGLER	US
59-004A-05	08/07/59	EXPLORER	EXPLORER 6	TELEVISION	BAKER	US
60-002B-01	04/01/60	TIROS	TIROS 01	TELEVISION	BUTLER	US
60-016A-03	11/23/60	TIROS	TIROS 02	TELEVISION	BUTLER	US
61-017A-04	07/12/61	TIROS	TIROS 03	TELEVISION	RADOS	US
62-002A-04	02/08/62	TIROS	TIROS 04	TELEVISION	RADOS	US
65-025A-01	06/19/62	TIROS	TIROS 05	TELEVISION	RADOS	US
62-047A-01	09/18/62	TIROS	TIROS 06	TELEVISION	NESS STAFF	US
63-024A-04	06/19/63	TIROS	TIROS 07	TELEVISION	NESS STAFF	US
63-054A-01	12/21/63	TIROS	TIROS 08	TELEVISION	O'SULLIVAN	US

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65-004A-01	01/22/65	TIROS	TIROS 09	TELEVISION	NESS STAFF	US
65-051A-01	07/02/65	TIROS	TIROS 10	TELEVISION	NESS STAFF	US
59-009A-01	10/13/59	EXPLORER	EXPLORER 7	THERMAL RADIATION	SUOMI	US
79-051A-02	06/07/79	BHASKARA	BHASKARA	TV CAMERA	JOSEPH	INDIA
67-024A-04	03/21/67	COSMOS	COSMOS 149	TV CAMERA SYSTEM		USSR
71-071A-01	08/16/71	EOLE/PEOLE	EOLE 1	UPPER ATMOS WEA RELAY SYS	MOREL/BANDEEN	FRANCE/US
66-082A-01	09/15/66	DMSP	DMSP 4A/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-010A-01	02/08/67	DMSP	DMSP 4A/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-080A-01	08/22/67	DMSP	DMSP 4A/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-096A-01	10/11/67	DMSP	DMSP 4A/F4	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-042A-01	05/22/68	DMSP	DMSP 4B/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-092A-01	10/22/68	DMSP	DMSP 4B/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
69-062A-01	07/22/69	DMSP	DMSP 4B/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
60-016A-01	11/23/60	TIROS	TIROS 02	WIDEFIELD RADIOMETER	HANEL	US
61-017A-02	07/12/61	TIROS	TIROS 03	WIDEFIELD RADIOMETER	HANEL	US
62-002A-02	02/08/62	TIROS	TIROS 04	WIDEFIELD RADIOMETER	HANEL	US

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78-041A	04/26/78	AEM	AEM-A	(SEE HCMM)		US
66-082A-02	09/15/66	DMSP	DMSP 4A/F1	C-SYSTEM	AFGWC STAFF	US
66-082A-01	09/15/66	DMSP	DMSP 4A/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-010A-02	02/08/67	DMSP	DMSP 4A/F2	C-SYSTEM	AFGWC STAFF	US
67-010A-01	02/08/67	DMSP	DMSP 4A/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-080A-02	08/22/67	DMSP	DMSP 4A/F3	C-SYSTEM	AFGWC STAFF	US
67-080A-01	08/22/67	DMSP	DMSP 4A/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
67-096A-02	10/11/67	DMSP	DMSP 4A/F4	C-SYSTEM	AFGWC STAFF	US
67-096A-01	10/11/67	DMSP	DMSP 4A/F4	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-042A-02	05/22/68	DMSP	DMSP 4B/F1	C-SYSTEM	AFGWC STAFF	US
68-042A-01	05/22/68	DMSP	DMSP 4B/F1	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
68-092A-02	10/22/68	DMSP	DMSP 4B/F2	C-SYSTEM	AFGWC STAFF	US
68-092A-01	10/22/68	DMSP	DMSP 4B/F2	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
69-062A-02	07/22/69	DMSP	DMSP 4B/F3	C-SYSTEM	AFGWC STAFF	US
69-062A-01	07/22/69	DMSP	DMSP 4B/F3	VIDICON CAMERA SYSTEM	AFGWC STAFF	US
70-012A-01	02/11/70	DMSP	DMSP 5A/F1	SCANNING RADIOMETER	AFGWC STAFF	US
70-070A-01	09/03/70	DMSP	DMSP 5A/F2	SCANNING RADIOMETER	AFGWC STAFF	US
71-012A-01	02/17/71	DMSP	DMSP 5A/F3	SCANNING RADIOMETER	AFGWC STAFF	US
71-087A-01	10/14/71	DMSP	DMSP 5B/F1	SCANNING RADIOMETER	AFGWC STAFF	US
72-018A-02	03/24/72	DMSP	DMSP 5B/F2	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
72-018A-01	03/24/72	DMSP	DMSP 5B/F2	SCANNING RADIOMETER	AFGWC STAFF	US
72-089A-02	11/09/72	DMSP	DMSP 5B/F3	(SSE) VERT TEMP PROFILE RAD	AFGWC STAFF	US
72-089A-01	11/09/72	DMSP	DMSP 5B/F3	SCANNING RADIOMETER	AFGWC STAFF	US
73-054A-01	08/17/73	DMSP	DMSP 5B/F4	SCANNING RADIOMETER	AFGWC STAFF	US
74-015A-02	03/16/74	DMSP	DMSP 5B/F5	(SSE)VERT TEMP PROFILE RAD	AFGWC STAFF	US
74-015A-01	03/16/74	DMSP	DMSP 5B/F5	SCANNING RADIOMETER	AFGWC STAFF	US
74-063A-01	08/09/74	DMSP	DMSP 5C/F1	SCANNING RADIOMETER	AFGWC STAFF	US
75-043A-01	05/24/75	DMSP	DMSP 5C/F2	SCANNING RADIOMETER	AFGWC STAFF	US
76-091A-01	09/11/76	DMSP	DMSP 5D-1/F1	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
76-091A-02	09/11/76	DMSP	DMSP 5D-1/F1	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
77-044A-01	06/05/77	DMSP	DMSP 5D-1/F2	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
77-044A-02	06/05/77	DMSP	DMSP 5D-1/F2	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
78-042A-01	05/01/78	DMSP	DMSP 5D-1/F3	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
78-042A-02	05/01/78	DMSP	DMSP 5D-1/F3	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
79-050A-01	06/06/79	DMSP	DMSP 5D-1/F4	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
79-050A-08	06/06/79	DMSP	DMSP 5D-1/F4	(SSC)SNOW/CLOUD DISCRIM	AFGWC STAFF	US
79-050A-02	06/06/79	DMSP	DMSP 5D-1/F4	(SSH)MULTICH FILTER RAD	AFGWC STAFF	US
79-050A-06	06/06/79	DMSP	DMSP 5D-1/F4	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
82-118A-01	12/21/82	DMSP	DMSP 5D-2/F6	(OLS)LINE SCAN SYSTEM	AFGWC STAFF	US
82-118A-02	12/21/82	DMSP	DMSP 5D-2/F6	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
83-113A-01	11/18/83	DMSP	DMSP 5D-2/F7	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
83-113A-03	11/18/83	DMSP	DMSP 5D-2/F7	(SSM/T)MW TEMP SOUNDER	AFGWC STAFF	US
87-053A-01	06/20/87	DMSP	DMSP 5D-2/F8	(OLS)OPERATIONAL LINESC SYS	AFGWC STAFF	US
87-053A-05	06/20/87	DMSP	DMSP 5D-2/F8	(SSH-2)IR TEMP PROF SOUNDER	AFGWC STAFF	US
87-053A-06	06/20/87	DMSP	DMSP 5D-2/F8	(SSM/I)MW IMAGER	AFGWC STAFF	US
66-020A-04	03/16/66	GEMINI	GEMINI 08	CLOUD TOP SPECTROMETER	ALISHOUSE	US
69-018A-01	03/03/69	APOLLO	APOLLO 09	SPECTRAL TERRAIN PHOTOS	ALLENBY	US
68-089A-01	10/11/68	APOLLO	APOLLO 07	EARTH CLOUD PHOTOGRAPHY	ALLENBY	US
68-118A-01	12/21/68	APOLLO	APOLLO 08	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-043A-01	05/18/69	APOLLO	APOLLO 10	PHOTOS, 70 MM & 16 MM	ALLENBY	US
69-059A-01	07/16/69	APOLLO	APOLLO 11	PHOTOS, 70,16 & 35 MM	ALLENBY	US
69-099A-01	11/14/69	APOLLO	APOLLO 12	PHOTOS, 70,16 & 35 MM	ALLENBY	US
70-029A-01	04/11/70	APOLLO	APOLLO 13	PHOTOS, 70MM & 16 MM	ALLENBY	US
72-058A-02	07/23/72	LANDSAT	LANDSAT 1	(MSS)MULTISPECT SCAN	ARLUSKAS	US
59-004A-05	08/07/59	EXPLORER	EXPLORER 6	TELEVISION	BAKER	US
70-025A-06	04/08/70	NIMBUS	NIMBUS 4	(IDC)IMAGE DISSECTOR CAMERA	BANCHFLOWER	US
60-016A-02	11/23/60	TIROS	TIROS 02	(SR)SCANNING RADIOMETER	BARKSDALE	US
62-002A-03	02/08/62	TIROS	TIROS 04	(SR)SCANNING RADIOMETER	BARKSDALE	US
84-108B-01	10/05/84	ERBE	ERBS	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US

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NSSDC ID	22222 L-DATE	PROJECT	S/C NAMES	EXP NAME	11111 PI/AGENCY	CO
84-123A-05	12/12/84	ERBE	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
84-123A-05	12/12/84	NOAA 8-J/ATN	NOAA 09	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
86-073A-05	09/17/86	ERBE	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
86-073A-05	09/17/86	NOAA 8-J/ATN	NOAA 10	(ERBE)EARTH RAD BUDGET EXP	BARKSTROM	US
78-041A-01	04/26/78	AEM	HCMM	(HCMM)HEAT CAPACITY MAP RAD	BARNES	US
73-027A-18	05/14/73	SKYLAB	SKYLAB	(EREP)IR SPECTROMETER(S-191)	BARNETT	US
69-037A-06	04/14/69	NIMBUS	NIMBUS 3	(IDC)IMAGE DISSECTOR CAMERA	BRACHFLOWER	US
67-111A-03	11/05/67	ATS	ATS 3	(IDC)IMAGE DISSECTOR CAMERA	BRANCHFLOWER	US
65-068A-06	08/21/65	GEMINI	GEMINI 05	SPACE OBJECT RADIOMETRY	BRENTNALL	US
65-100A-05	12/04/65	GEMINI	GEMINI 07	SPACE OBJECT RADIOMETRY	BRENTNALL	US
64-052A-01	08/28/64	NIMBUS	NIMBUS 1	(AVCS)ADV VIDICON CAMERA SYS	BURDETT	US
60-002B-01	04/01/60	TIROS	TIROS 01	TELEVISION	BUTLER	US
60-016A-03	11/23/60	TIROS	TIROS 02	TELEVISION	BUTLER	US
81-115A-02	11/20/81	BHASKARA	BHASKARA 2	(SAMIR)SATELLITE MW RAD	CALLA	INDIA
69-037A-02	04/14/69	NIMBUS	NIMBUS 3	(HRIR)HIGH RES IR RADIOMETER	CHERRIX	US
84-123A-07	12/12/84	NOAA 8-J/ATN	NOAA 09	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
NOAA-H-05	12/12/84	NOAA 8-J/ATN	NOAA-H	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
NOAA-J-05	12/12/84	NOAA 8-J/ATN	NOAA-J	(SBUV/2)SOLR BKSCTR UV RAD	CUNNINGHAM	US
73-027A-17	05/14/73	SKYLAB	SKYLAB	(EREP)M-SPECT. PHOTOG.(S-190)	DEMEL	US
83-116A-39	11/28/83	SHUTTLE	SPACELAB 1	(MRSE)MICROWAVE FACILITY	DIETERLE	EUROPE
67-066F-01	07/01/67	DODGE	DODGE	COLOR TV OF EARTH	DODGE	US
72-031A-01	04/17/72	APOLLO	APOLLO 16	HANDHELD PHOTOGRAPHY	DOYLE	US
72-031A-03	04/17/72	APOLLO	APOLLO 16	METRIC PHOTOGRAPHY	DOYLE	US
72-031A-02	04/17/72	APOLLO	APOLLO 16	PANORAMIC PHOTOGRAPHY	DOYLE	US
71-063A-01	07/26/71	APOLLO	APOLLO 15	HANDHELD PHOTOGRAPHY	DOYLE	US
71-063A-03	07/26/71	APOLLO	APOLLO 15	METRIC PHOTOGRAPHY	DOYLE	US
71-063A-02	07/26/71	APOLLO	APOLLO 15	PANORAMIC PHOTOGRAPHY	DOYLE	US
72-096A-05	12/07/72	APOLLO	APOLLO 17	HANDHELD PHOTOGRAPHY	DOYLE	US
72-096A-07	12/07/72	APOLLO	APOLLO 17	METRIC PHOTOGRAPHY	DOYLE	US
72-096A-06	12/07/72	APOLLO	APOLLO 17	PANORAMIC PHOTOGRAPHY	DOYLE	US
71-008A-01	01/31/71	APOLLO	APOLLO 14	PHOTOGRAPHY	EL BAZ	US
75-066A-21	07/15/75	APOLLO	ASTP APOLLO	EARTH OBS & PHOTOS(MA-136)	EL BAZ	US
81-111A-01	11/12/81	SHUTTLE	STS-02	(SIR-A)SHUTTLE IMAGING RADAR	ELACHI	US
84-108A-01	10/05/84	SHUTTLE	STS-41G	(SIR-B)SHUTTLE IMAGING RADAR	ELACHI	US
66-087A-01	10/02/66	ESSA	ESSA 3	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
67-006A-01	01/26/67	ESSA	ESSA 4	(APT)AUTOMATIC PIC TRANS	ESSA	US
67-036A-01	04/20/67	ESSA	ESSA 5	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
67-114A-01	11/10/67	ESSA	ESSA 6	(APT)AUTOMATIC PIC TRANS	ESSA	US
68-069A-01	08/16/68	ESSA	ESSA 7	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
68-114A-01	12/15/68	ESSA	ESSA 8	(APT)AUTOMATIC PIC TRANS	ESSA	US
69-016A-01	02/26/69	ESSA	ESSA 9	(AVCS)ADV VIDICON CAMERA SYS	ESSA	US
73-027A-21	05/14/73	SKYLAB	SKYLAB	(EREP)L-BAND RADIOMTR(S-194)	EVANS	US
73-027A-20	05/14/73	SKYLAB	SKYLAB	(EREP)MICROWAVE SCATT(S-193)	EVANS	US
78-064A-04	06/27/78	SEASAT	SEASAT 1	(VIRR)SCAN VIS/IR RADIOMETER	FELLERMAN	US
64-052A-03	08/28/64	NIMBUS	NIMBUS 1	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
66-040A-03	05/15/66	NIMBUS	NIMBUS 2	(HRIR)HIGH RES IR RADIOMETER	FOSHEE	US
75-004A-02	01/22/75	LANDSAT	LANDSAT 2	(MSS)MULTISPECT SCAN	FREDEN	US
78-026A-02	03/05/78	LANDSAT	LANDSAT 3	(MSS)MULTISPECT SCAN	FREDEN	US
70-008A-03	01/23/70	NOAA 1-5/ITOS	ITOS 1	SCANNING RADIOMETER SYSTEM	GEMUNDER	US
70-106A-03	12/11/70	NOAA 1-5/ITOS	NOAA 01	(SR)SCANNING RADIOMETER	GEMUNDER	US
75-052A-04	06/12/75	NIMBUS	NIMBUS 6	(LRIR)LIMB RAD INVER RAD	GILLE	US
78-098A-08	10/24/78	NIMBUS	NIMBUS 7	(SMMR)SCAN MICROWAVE RAD	GLOERSEN	US
69-099A-09	11/14/69	APOLLO	APOLLO 12	PHOTOS,MULTISPECTRAL, 70 MM	GOETZ	US
60-016A-01	11/23/60	TIROS	TIROS 02	WIDEFIELD RADIOMETER	HANEL	US

NCSDC ID	22222 L-DATE	PROJECT	S/C NAMES	EXP NAME	11111 PI/AGENCY	CO
61-017A-02	07/12/61	TIROS	TIROS 03	WIDEFIELD RADIOMETER	HANEL	US
62-002A-02	02/08/62	TIROS	TIROS 04	WIDEFIELD RADIOMETER	HANEL	US
69-037A-03	04/14/69	NIMBUS	NIMBUS 3	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
70-025A-03	04/08/70	NIMBUS	NIMBUS 4	(IRIS)IR INTERFEROMETER SPECT	HANEL	US
68-068A-03	08/10/68	ATS	ATS 4	IMAGE ORTHICON CAMERA	HAZELTINE	US
70-025A-05	04/08/70	NIMBUS	NIMBUS 4	(BUV)BACKSCATTER UV SPEC	HEATH	US
78-098A-09	10/24/78	NIMBUS	NIMBUS 7	(SBUV/TOMS)-BACKSC UV/OZONE	HEATH	US
70-025A-10	04/08/70	NIMBUS	NIMBUS 4	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
72-097A-02	12/11/72	NIMBUS	NIMBUS 5	(SCR)SELECTIVE CHOPPER RAD	HOUGHTON	UK
75-052A-09	06/12/75	NIMBUS	NIMBUS 6	(PMR)PRESS MODULATED RAD	HOUGHTON	US
78-098A-02	10/24/78	NIMBUS	NIMBUS 7	(SAMS)STRAT + MESO SOUNDER	HOUGHTON	UK
70-025A-09	04/08/70	NIMBUS	NIMBUS 4	FILTER WEDGE SPECT	HOVIS	US
72-097A-05	12/11/72	NIMBUS	NIMBUS 5	(SCMR)SFC COMP MAPPING RAD	HOVIS	US
78-098A-03	10/24/78	NIMBUS	NIMBUS 7	(CZCS)COAST ZONE COLOR SCAN	HOVIS	US
63-054A-02	12/21/63	TIROS	TIROS 08	(APT)AUTO PIC TRANSMISSION	HUNTER	US
64-052A-02	08/28/64	NIMBUS	NIMBUS 1	(APT)AUTO PIC TRANSMISSION	HUNTER	US
82-031A-01	04/10/82	INSAT	INSAT 1A	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
83-089B-01	08/31/83	INSAT	INSAT 1B	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
INSAT1C-01	06/00/88	INSAT	INSAT 1C	(VHRR)VERY HIGH RES RAD	ISRO	INDIA
IRS-1A-01	10/00/87	IRS	IRS 1A	(LISS)LIN IMG SELF-SCN SENS	ISRO	INDIA
78-098A-07	10/24/78	NIMBUS	NIMBUS 7	(ERB)EARTH RADIATION BUDGET	JACOBOWITZ	US
77-065A-01	07/14/77	GMS	GMS	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
81-076A-01	08/10/81	GMS	GMS 2	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
84-080A-01	08/02/84	GMS	GMS 3	(VISSR)VIS & IR RADIOMETER	JMA STAFF	JAPAN
66-016A-01	02/28/66	ESSA	ESSA 2	(APT)AUTOMATIC PIC TRANS	JONES	US
79-051A-01	06/07/79	BHASKARA	BHASKARA	(SAMIR)SATELLITE MW RAD	JOSEPH	INDIA
79-051A-02	06/07/79	BHASKARA	BHASKARA	TV CAMERA	JOSEPH	INDIA
81-115A-01	11/20/81	BHASKARA	BHASKARA 2	DUAL TV CAMERA	CALLA	INDIA
75-052A-01	06/12/75	NIMBUS	NIMBUS 6	(TWERLE)TRP WND ENG CONV	JULIAN	US
60-006A-03	05/24/60	DOD(OTHER)	MIDAS 2	NON-SCANNING RADIOMETER	JURSA	US
61-018A-04	07/12/61	DOD(OTHER)	MIDAS 3	SCANNING RADIOMETER	JURSA	US
61-030A-02	11/15/61	DISCOVERER	DISCOVERER 35	SCANNING RADIOMETER	JURSA	US
62-010A-04	04/09/62	DOD(OTHER)	MIDAS 5	SCANNING RADIOMETER	JURSA	US
73-027A-19	05/14/73	SKYLAB	SKYLAB	(EREP)BAND SCANNER(S-192)	KORB	US
65-024A-03	03/23/65	GEMINI	GEMIMI 03	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-043A-01	06/03/65	GEMINI	GEMINI 04	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-068A-02	08/21/65	GEMINI	GEMINI 05	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-100A-01	12/04/65	GEMINI	GEMINI 07	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
65-104A-01	12/15/65	GEMINI	GEMINI 06	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66 020A-01	03/16/66	GEMINI	GEMINI 08	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-047A-05	06/03/66	GEMINI	GEMINI 09	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-066A-02	07/18/66	GEMINI	GEMINI 10	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-081A-06	09/12/66	GEMINI	GEMINI 11	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
66-104A-02	11/11/66	GEMINI	GEMINI 12	SYNOPTIC TERRAIN PHOTOS	LOWMAN	US
83-059A-06	06/18/83	SHUTTLE	STS-07	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
84-011A-01	02/03/84	SHUTTLE	STS-11	(MOMS)MODLR OPTOELEC MSP SC	MBB	GERMANY
78-098A-06	10/24/78	NIMBUS	NIMBUS 7	(SAM-II)STRAT AEROSOL MEA	MCCORMICK	US
79-013A-01	02/18/79	AEM	SAGE	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
84-108B-02	10/05/84	ERBE	ERBS	(SAGE)STRAT AEROSL & GAS EXP	MCCORMICK	US
66-040A-04	05/15/66	NIMBUS	NIMBUS 2	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
69-037A-05	04/14/69	NIMBUS	NIMBUS 3	(MRIR)MED RES IR RADIOMETER	MCCULLOCH	US
70-025A-02	04/08/70	NIMBUS	NIMBUS 4	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
72-097A-08	12/11/72	NIMBUS	NIMBUS 5	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
75-052A-12	06/12/75	NIMBUS	NIMBUS 6	(THIR)TEMP-HUMIDITY IR RAD	MCCULLOCH	US
84-108A-02	10/05/84	SHUTTLE	STS-41G	(LFC)LARGE FORMAT CAMERA	MOLLBERG	US

NSSDC ID	22222 L-DATE	PROJECT	S/C NAMES	EXP NAME	11111 PI/AGENCY	CO
71-071A-01	08/16/71	EOLE/PEOLE	EOLE 1	UPPER ATMOS WEA RELAY SYS	MOREL/BANDEEN	FRANCE/US
65-043A-02	06/03/65	GEMINI	GEMINI 04	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-068A-03	08/21/65	GEMINI	GEMINI 05	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-100A-02	12/04/65	GEMINI	GEMINI 07	SYNOPTIC WEATHER PHOTOS	NAGLER	US
65-104A-02	12/15/65	GEMINI	GEMINI 06	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-020A-07	03/16/66	GEMINI	GEMINI 08	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US
66-047A-06	06/03/66	GEMINI	GEMINI 09	(SIDS)CLOUD PHOTOGRAPHY	NAGLER	US
66-066A-03	07/18/66	GEMINI	GEMINI 10	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-081A-07	09/12/66	GEMINI	GEMINI 11	SYNOPTIC WEATHER PHOTOS	NAGLER	US
66-104A-03	11/11/66	GEMINI	GEMINI 12	SYNOPTIC WEATHER PHOTOS	NAGLER	US
61-025A-01	09/13/61	MERCURY	MA-4	EARTH PHOTOGRAPHY	NASA	US
61-033A-01	11/29/61	MERCURY	MA-5	EARTH PHOTOGRAPHY	NASA	US
62-003A-01	02/20/62	MERCURY	MA-6	EARTH PHOTOGRAPHY	NASA	US
62-019A-01	05/24/62	MERCURY	MA-7	EARTH PHOTOGRAPHY	NASA	US
62-052A-01	10/03/62	MERCURY	MA-8	EARTH PHOTOGRAPHY	NASA	US
63-015A-01	03/15/63	MERCURY	MA-9	EARTH PHOTOGRAPHY	NASA	US
67-113A-	11/09/67	APOLLO	APOLLO 04	(EARTH PHOTOGRAPHY)	NASA	US
68-025A-	04/04/68	APOLLO	APOLLO 06	(EARTH PHOTOGRAPHY)	NASA	US
87-018A-04	02/19/87	MOS	MOS 1	(DCS)DATA COLL SYS TRANSPNDR	NASDA	JAPAN
87-018A-01	02/19/87	MOS	MOS 1	(MESSR)MSP ELE SELF-SCAN RAD.	NASDA	JAPAN
87-018A-03	02/19/87	MOS	MOS 1	(MSR)MICROWAVE SCAN RAD	NASDA	JAPAN
87-018A-02	02/19/87	MOS	MOS 1	(VTIR)VIS & THERMAL IR RAD	NASDA	JAPAN
70-106A-05	12/11/70	NOAA 1-5/ITOS	NOAA 01	(APT)AUTO PIC TRANSM	NESDIS	US
70-106A-04	12/11/70	NOAA 1-5/ITOS	NOAA 01	(AVCS)ADV VIDICON CAMERA SYS	NESDIS	US
72-082A-02	10/15/72	NOAA 1-5/ITOS	NOAA 02	(SR)SCANNING RADIOMETER	NESDIS	US
72-082A-03	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VHRR)VERY HIGH RES RAD	NESDIS	US
72-082A-04	10/15/72	NOAA 1-5/ITOS	NOAA 02	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
73-086A-02	11/06/73	NOAA 1-5/ITOS	NOAA 03	(SR)SCANNING RADIOMETER	NESDIS	US
73-086A-03	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VHRR)VERY HIGH RES RAD	NESDIS	US
73-086A-04	11/06/73	NOAA 1-5/ITOS	NOAA 03	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
74-089A-02	11/15/74	NOAA 1-5/ITOS	NOAA 04	(SR)SCANNING RADIOMETER	NESDIS	US
74-089A-03	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VHRR)VERY HIGH RES RAD	NESDIS	US
74-089A-04	11/15/74	NOAA 1-5/ITOS	NOAA 04	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
78-096A-01	10/13/78	NOAA 6-D/T-N	TIROS N	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
78-096A-02	10/13/78	NOAA 6-D/T-N	TIROS N	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
79-057A-01	06/27/79	NOAA 6-D/T-N	NOAA 06	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
76-077A-03	06/27/79	NOAA 1-5/ITOS	NOAA 05	(SR)SCANNING RADIOMETER	NESDIS	US
79-057A-02	06/27/79	NOAA 6-D/T-N	NOAA 06	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
76-077A-01	07/29/76	NOAA 1-5/ITOS	NOAA 05	(VHRR)VERY HIGH RES RAD	NESDIS	US
76-077A-02	06/27/79	NOAA 1-5/ITOS	NOAA 05	(VTPR)VERT TEMP PRFL RAD	NESDIS	US
80-074A-01	09/09/80	GOES/SMS	GOES 4	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
81-049A-01	05/22/81	GOES/SMS	GOES 5	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
81-059A-01	06/23/81	NOAA 6-D/T-N	NOAA 07	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
81-059A-02	06/23/81	NOAA 6-D/T-N	NOAA 07	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
83-022A-01	03/28/83	NOAA 8-J/ATN	NOAA 08	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
83-022A-02	03/28/83	NOAA 8-J/ATN	NOAA 08	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
83-041A-01	04/28/83	GOES/SMS	GOES 6	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
84-123A-01	12/12/84	NOAA 8-J/ATN	NOAA 09	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
84-123A-02	12/12/84	NOAA 8-J/ATN	NOAA 09	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
86-073A-01	09/17/86	NOAA 8-J/ATN	NOAA 10	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
86-073A-02	09/17/86	NOAA 8-J/ATN	NOAA 10	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
87-022A-01	02/26/87	GOES/SMS	GOES 7	(VAS)VISSR ATMOS SOUNDER	NESDIS	US
NOAA-D-01		NOAA 6-D/T-N	NOAA-D	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-H-01		NOAA 8-J/ATN	NOAA H	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-I-01		NOAA 8-J/ATN	NOAA I	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-J-01		NOAA 8-J/ATN	NOAA J	(AVHRR)ADV VERY HI RES RAD	NESDIS	US
NOAA-D-02		NOAA 6-D/T-N	NOAA-D	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-H-02		NOAA 8-J/ATN	NOAA H	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
NOAA-I-02		NOAA 8-J/ATN	NOAA I	(TOVS)OPERNL VERT SOUNDER	NESDIS	US

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NOAA-J-02		NOAA 8-J/ATN	NOAA J	(TOVS)OPERNL VERT SOUNDER	NESDIS	US
62-047A-01	09/18/62	TIROS	TIROS 06	TELEVISION	NESS STAFF	US
63-024A-04	06/19/63	TIROS	TIROS 07	TELEVISION	NESS STAFF	US
65-004A-01	01/22/65	TIROS	TIROS 09	TELEVISION	NESS STAFF	US
65-051A-01	07/02/65	TIROS	TIROS 10	TELEVISION	NESS STAFF	US
66-008A-01	02/03/66	ESSA	ESSA 1	(VCS)VIDICON CAMERA SYS.	NESS STAFF	US
70-008A-05	01/23/70	NOAA 1-5/ITOS	ITOS 1	(APT)AUTO PIC TRANSMISSION	NESS STAFF	US
70-008A-04	01/23/70	NOAA 1-5/ITOS	ITOS 1	(AVCS)ADV VIDICON CAMERA SYS	NESS STAFF	US
74-033A-01	05/17/74	GOES/SMS	SMS 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-011A-04	02/06/75	GOES/SMS	SMS 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
75-100A-01	10/16/75	GOES/SMS	GOES 1	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
77-048A-01	06/16/77	GOES/SMS	GOES 2	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
78-062A-01	06/16/78	GOES/SMS	GOES 3	(VISSR)VIS & IR RADIOMETER	NESS STAFF	US
63-054A-01	12/21/63	TIROS	TIROS 08	TELEVISION	O'SULLIVAN	US
67-036A-02	04/20/67	ESSA	ESSA 5	(FPR)FLAT PLATE RADIOMETER	PARENT	US
68-069A-02	08/16/68	ESSA	ESSA 7	(FPR)FLAT PLATE RADIOMETER	PARENT	US
75-066A-19	07/15/75	APOLLO	ASTP APOLLO	STRAT AEROSOLS(MA-007)	PEPIN	US
77-108A-02	11/23/77	METEOSAT	METEOSAT 1	(DCP)DATA COLL PLAT	PERA	EUROPE
77-108A-01	11/23/77	METEOSAT	METEOSAT 1	IMAGING RADIOMETER	SERENE	EUROPE
81-057A-02	06/19/81	METEOSAT	METEOSAT 2	(DCP)DATA COLL PLAT	PERA	EUROPE
81-057A-01	06/19/81	METEOSAT	METEOSAT 2	IMAGING RADIOMETER	SERENE	EUROPE
78-064A-03	06/27/78	SEASAT	SEASAT 1	(SASS)SEASAT-A-SAT SCATMTR	PIERSON	US
61-017A-03	07/12/61	TIROS	TIROS 03	(SR)SCANNING RADIOMETER	RADOS	US
61-017A-04	07/12/61	TIROS	TIROS 03	TELEVISION	RADOS	US
62-002A-04	02/08/62	TIROS	TIROS 04	TELEVISION	RADOS	US
65-025A-01	06/19/62	TIROS	TIROS 05	TELEVISION	RADOS	US
63-024A-02	06/19/63	TIROS	TIROS 07	(SR)SCANNING RADIOMETER	RADOS	US
67-031A-10	04/06/67	ATS	ATS 2	(AVCS)VIDICON CAMERA SYSTEM	RCA	US
81-111A-04	11/12/81	SHUTTLE	STS-02	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
84-108A-03	10/05/84	SHUTTLE	STS-41G	(MAPS)MEAS AIR POLL FROM SAT	REICHLE	US
83-116A-38	11/28/83	SHUTTLE	SPACELAB 1	METRIC CAMERA FACILITY	REYNOLDS	EUROPE
78-098A-01	10/24/78	NIMBUS	NIMBUS 7	(LIMS)LIMB IR MON STRATO	RUSSELL	US
65-068A-04	08/21/65	GEMINI	GEMINI 05	CLOUD TOP SPECTROMETER	SAIEDY	US
82-072A-02	07/16/82	LANDSAT	LANDSAT 4	(MSS)MULTISPECT SCAN	SALMONSEN	US
84-021A-02	03/01/84	LANDSAT	LANDSAT 5	(MSS)MULTISPECT SCAN	SALMONSEN	US
66-040A-02	05/15/66	NIMBUS	NIMBUS 2	(APT)AUTO PIC TRANSMISSION	SCHULMAN	US
66-040A-01	05/15/66	NIMBUS	NIMBUS 2	(AVCS)ADV VIDICON CAMERA SYS	SCHULMAN	US
74-039A-08	05/30/74	ATS	ATS 6	(VHRR)VERY HIGH RES RAD	SHENK	US
72-097A-01	12/11/72	NIMBUS	NIMBUS 5	(ITPR)IR TEMP PROFILE RAD	SMITH	US
75-052A-05	06/12/75	NIMBUS	NIMBUS 6	(ERB)EARTH RADIATION BUDGET	SMITH	US
75-052A-02	06/12/75	NIMBUS	NIMBUS 6	(HIRS)HIGH RES IR SOUNDER	SMITH	US
78-064A-01	06/27/78	SEASAT	SEASAT 1	(ALT)RADAR ALT	SMITH	US
72-097A-03	12/11/72	NIMBUS	NIMBUS 5	MICROWAVE SPECTROMETER	STAELIN	US
75-052A-10	06/12/75	NIMBUS	NIMBUS 6	(SCAMS)SCAN MICROWAVE RAD	STAELIN	US
78-064A-05	06/27/87	SEASAT	SEASAT 1	(SMMR)SCAN MICROWAVE RAD	STEPHANIDES	US
78-098A-10	10/24/78	NIMBUS	NIMBUS 7	(THIR)TEMP-HUMIDITY IR RAD	STOWE	US
59-001A-01	02/17/59	VANGUARD	VANGUARD 2	(OPTICAL SCANNER)	STROUD	US
59-009A-01	10/13/59	EXPLORER	EXPLORER 7	THERMAL RADIATION	SUOMI	US
61-017A-01	07/12/61	TIROS	TIROS 03	OMNI RADIOMETER	SUOMI	US
62-002A-01	02/08/62	TIROS	TIROS 04	OMNI RADIOMETER	SUOMI	US
63-024A-01	06/19/63	TIROS	TIROS 07	OMNI RADIOMETER	SUOMI	US
66-087A-02	10/02/66	ESSA	ESSA 3	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
66-110A-09	12/07/66	ATS	ATS 1	(SSCC)SPIN SCAN CLOUD CAMERA	SUOMI	US
67-111A-01	11/05/67	ATS	ATS 3	(MSSCC)MULTI COLOR SSCC	SUOMI	US
69-016A-02	02/26/69	ESSA	ESSA 9	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
70-008A-02	01/23/70	NOAA 1-5/ITOS	ITOS 1	(FPR)FLAT PLATE RADIOMETER	SUOMI	US

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70-106A-02	12/11/70	NOAA 1-5/ITOS	NOAA 01	(FPR)FLAT PLATE RADIOMETER	SUOMI	US
78-064A-02	06/27/78	SEASAT	SEASAT 1	(SAR)SYNTHETIC AP RADAR	TELEKI	US
61-028A-02	10/21/61	DOD(OTHER)	MIDAS 4	SCANNING RADIOMETER	TODD	US
63-014A-02	05/09/63	DOD(OTHER)	MIDAS 6	SCANNING RADIOMETER	TODD	US
81-111A-06	11/12/81	SHUTTLE	STS-02	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
82-065A-01	06/27/82	SHUTTLE	STS-04	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
83-026A-01	04/04/83	SHUTTLE	STS-06	(NOSL)NIGHT/DAY SURV OF LGTG	VONNEGUT	US
69-037A-04	04/14/69	NIMBUS	NIMBUS 3	(SIRS)SAT IR SPECT	WARK	US
70-025A-04	04/08/70	NIMBUS	NIMBUS 4	(SIRS)SAT IR SPECT	WARK	US
72-097A-04	12/11/72	NIMBUS	NIMBUS 5	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US
75-052A-03	06/12/75	NIMBUS	NIMBUS 6	(ESMR)ELEC SCAN MICRO RAD	WILHEIT	US