SPACE SCIENCE & APPLICATIONS PROGRAMS

Presented to the Space Science Board

by

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PAST ACCOMPLISHMENTS

The following is a list of the successful major satellite and space probe firings that have been carried out in connection with the NASA program since the creation of NASA in 1958:

1958

PIONEER I	Magnetic field, radiation belts
PIONEER II	Magnetic field, radiation belts, cosmic rays
PIONEER III	Radiation belts, cosmic rays

1959

VANGUARD II	Cloud cover
PIONEER IV	Radiation belts, cosmic rays
EXPLORER VI	Magnetic field, radiation belts
VANGUARD III	Magnetic field
EXPLORER VII	Radiation belts, cosmic rays, thermal radiation, micrometeors

1960

PIONEER V	Magnetic field, cosmic rays
TIROS I	Cloud cover
ECHO I	Air density, passive communications
EXPLORER VIII	Ionosphere, micrometeors
TIROS II	Cloud cover, thermal radiation

1961

EXPLORER IX	Air density
EXPLORER X	Magnetic field, plasma
EXPLORER XI	Gamma radiation

(1961 - Continued)

TIROS III	Cloud cover, thermal radiation
EXPLORER XII	Magnetic field, radiation belts, cosmic rays
EXPLORER XIII	Micrometeoroids

1962

TIROS IV	Cloud cover, thermal radiation
OSO I	Electromagnetic radiation from sun
ARIEL I	Ionosphere, radiation
TIROS V	Cloud cover
TELSTAR I	Active communications
MARINER II	Energetic particles and magnetic fields, cosmic dust, Venus IR and microwave radiation
TIROS VI	Cloud cover
ALOUETTE	Ionosphere topside sounding, radio noise, cosmic rays
EXPLORER XIV	Energetic particles, magnetic field, cosmic rays
EXPLORER XV	Radiation Belts
ANNA 1-B	Geodesy
RELAY I	Active communications, radiation
EXPLORER XVI	Micrometeoroids, radiation

1963

EXPLORER XVII	Atmosphere structure
TELSTAR II	Active communications

(1963 - Continued)

TIROS VII	Cloud cover
SYNCOM II	Active communications, synchronous orbit
EXPLORER XVIII	Interplanetary Explorer, particles and fields, solar wind shock wave
CENTAUR 2	First successful development flight, instrumented with sensors and telemetry
EXPLORER XIX	Air density
TIROS VIII	Cloud cover, Automatic Picture Transmission (APT) system for real-time readout of local cloud pictures

<u>1964</u>

RELAY II	Active communications, low altitude orbit
ECHO II	Passive communications
ARIEL II	International (US-UK) satellite, ozone distribution sampling, galactic radio noise
RANGER VII	Lunar photography
SYNCOM III	Active communications, synchronous orbit
EXPLORER XX	Ionospheric measurement by topside sounding
NIMBUS I	Global cloud cover, APT for local read-out, HRIR for nighttime cloud pictures
EXPLORER XXII	Ionospheric measurement, laser tracking

(1964 - Continued)

EXPLORER XXIII	Meteoroid penetration
EXPLORER XXIV	Upper air density and temperature measurements
EXPLORER XXV	Corpuscular radiation and charged particle measurements
MARINER IV	Fly-by Mars in mid-1965; provide data on Martian atmosphere and surface, magnetic fields, cosmic dust.
CENTAUR 4	Carried mass model of Surveyor spacecraft
SAN MARCO I	Atmospheric physics, Italian payload, Italian launch
EXPLORER XXVI	Radiation belts

1965

TIROS IX	First Tiros cartwheel configuration for increased cloud cover
OSO II	Solar physics
RANGER VIII	Lunar photography
RANGER IX	Lunar photography
EARLY BIRD I	Communications (for Comsat Corporation)
EXPLORER XXVII	Geodesy, laser tracking, ionospheric measurements
EXPLORER XXVIII	Interplanetary explorer, particles and fields
TIROS X	Meteorology, cloud cover photography, first Weather Bureau funded spacecraft
SCOUT EVALUATION	Vehicle development, evaluation of Castor II second stage, orbited US Army SECOR geodetic satellite

(1965 - Continued)

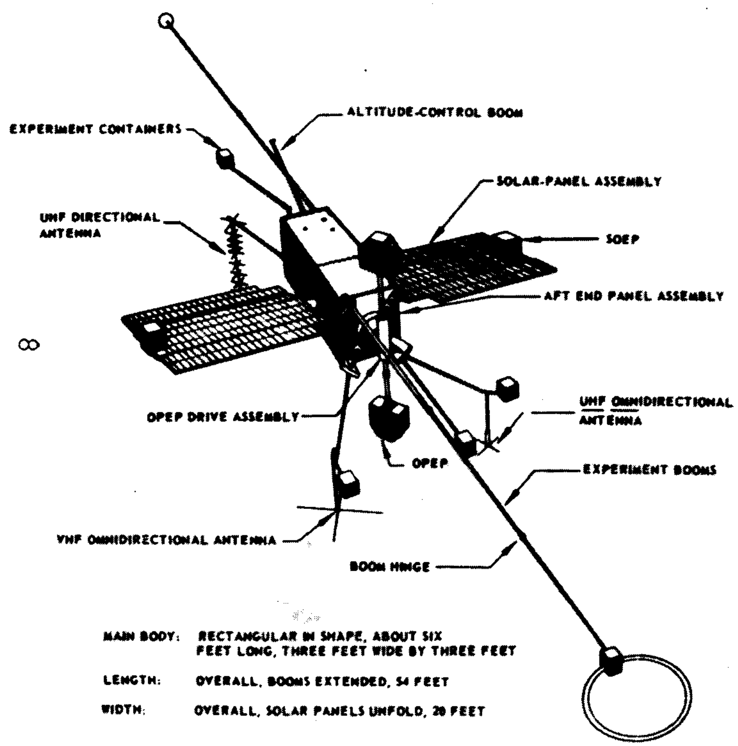
CENTAUR 6	Carried Surveyor dynamic model into simulated lunar transfer trajectory
OGO II	Orbiting Geophysical Observatory, inter-disciplinary experiments
EXPLORER XXX	Solar explorer, Navy payload
ALOUETTE II	Topside sounder
EXPLORER XXXI	Ionospheric measurements
GEOS I	Geodetic explorer, define earth's gravity field
FRENCH I	Ion distribution in magnetosphere, French payload

OSS&A PLANNED FLIGHT SCHEDULE

PROGRAM/PROJECT	LAUNCH VEHICLE	CY 1965 4 QTR	CY 1966 1	2	3	4	CY 1967 1	2	3	4
GEOPHYSICS & ASTRONOMY										
OSO	D			X		X				X
OAO	AAG		X			X			X	
OGO	AAG, TAT			X		X			X	
EXPLORERS	SC, D, TAD, TAT	1	X	2X	2X	2X	X	5X	3X	3X
LUNAR & PLANETARY										
LUNAR ORBITER	AAG			X	X	X	X	X		
SURVEYOR	AC			X	X	X	X		2X	
PIONEER	TAD	X	X			X		X		
BIOSCIENCES										
BIOSATELLITE	D, TAD				X	X		X	X	X
METEOROLOGY										
TIROS	D, TAD									X
NIMBUS	TAT			X						X
APPLICATIONS TECHNICAL SATELLITE										
ATS	AAG					X		X		X
LAUNCH VEHICLES										
CENTAUR DEVELOPMENT	AC		X			X				

ORBITING GEOPHYSICAL OBSERVATORY (OGO)

OGO FULLY DEPLOYED IN ORBIT



GROSS WEIGHT	1100 LBS.
INSTRUMENT WEIGHT	200 LBS.
INVESTIGATIONS	20/SPACECRAFT
POWER	250 WATTS (AVERAGE)
STABILIZATION	ACTIVE 3-AXIS
DESIGN LIFE	ONE YEAR
LAUNCH VEHICLES	ATLAS-AGENA TAT-AGENA
ORBITS	HIGHLY ELLIPTICAL INCLINED ORBIT; NEAR CIRCULAR POLAR ORBIT
STATUS	NEXT FLIGHT-1966

NASA SP65-16317
12/8/65

INSTRUMENTS AND INVESTIGATORS FOR FORTHCOMING MISSIONS

ORBITING GEOPHYSICAL OBSERVATORIES

The Orbiting Geophysical Observatories (OGO) are a series of standardized spacecraft incorporating active three-axis stabilization and accommodating up to thirty scientific investigations to make correlative studies.

The first two observatories have been launched: OGO-I into a highly eccentric orbit with an apogee of 93,000 miles and OGO-II into a polar orbit with an apogee of somewhat over 900 miles. Nine additional missions are planned at approximately nine month intervals.

Two general types of orbits are planned for future OGO's:

(1) A highly eccentric orbit reaching to an apogee of 92,000 miles, with a perigee of 170 miles. This orbit is used for studies of terrestrial and interplanetary magnetic fields, energetic particles, trapped radiation, thermal particles, ionic composition, and very low frequency (VLF) noise.

(2) A polar orbit with apogee of about 500 miles and perigee of about 200 miles. This orbit is used for investigations of the phenomena of the polar regions such as the "horns" of the radiation belt, auroral activity, solar and galactic cosmic rays, the geomagnetic field, airglow, the neutral and ionic composition of the upper atmosphere, the ionosphere, and solar radiation.

The OGO spacecraft weigh about 1100 pounds, of which approximately 200 pounds are available for investigations. The first OGO was launched on September 5, 1964, with an Atlas Agena from the Eastern Test Range. It did not stabilize as planned, but it is spin stabilized at 5 RPM and is returning useable data over a considerable portion of its orbit. The second OGO was launched on October 14, 1965, with a Thrust-Augmented Thor-Agena from the Western Test Range. The orbit achieved was higher than planned. An anomalous operation of the earth sensors resulted in an early depletion of the attitude control gas. It is anticipated that limited operation of OGO-II will still be possible.

Spacecraft design, development, and fabrication through test and evaluation are carried out under contract by TRW Systems, Los Angeles, California.

The design for the OGO spacecraft calls for a body of about 31 inches x 33 inches x 67 inches containing portions of the stabilization control; power supply; communications, data handling, and thermal control systems; and space for scientific instrumentation. The power supply system consists of solar cell panels, chemical batteries, and a charge control system. A maximum power of 500 watts and an average power of 250 watts will be available.

Maximum power allocated to scientific investigations is 80 watts and the average power is 50 watts. Angular orientation of the spacecraft is accomplished through torques developed by motor-driven inertial flywheels and by gas jets. Deviations of the spacecraft from the sun axis are sensed by solar cells; deviations from the earth's local vertical are determined by horizon scanners. Thermal control is accomplished by use of radiation shields and louvers. The data processing and communications system accepts ground commands to program investigations, to vary transmission rates, and to apportion information bits to the data generated by the investigations and by vehicle performance parameters. Storage of 84 million bits of data is possible by use of two magnetic tape recorders. Two redundant wideband telemetry transmitters in the spacecraft are capable of sending scientific and spacecraft engineering data back to earth, either in real time on command, or from storage.

The following are the final lists of scientific investigations and investigators for OGO's B, D, and E. Fifty-four proposals for investigations on OGO-F have been received and a payload will be selected in January 1966.

OGO-B

Investigations and Investigators

1. Solar cosmic rays (2 -90 Mev) using a scintillation detector to measure fluxes.

    K. A. Anderson
    University of California (Berkeley)

2. Positron and gamma ray detection, using double gamma ray spectrometer to measure positrons (0 to 3 Mev) and to monitor solar photon bursts (30 Kev to 1.2 Mev).

    T. L. Cline, Goddard Space Flight Center
    E. W. Hones, Jr., Institute for Defense Analysis

3. Trapped radiation studies, with ion-electron scintillation detectors; electrons with directional energy flux, 10 Kev $<$ E $<$ 100 Kev and protons with directional intensity, 120 Kev $<$ E $<$ 4.5 Mev.

    A. Konradi, L. R. Davis, R. A. Hoffman and J. M. Williamson
    Goddard Space Flight Center

4. Galactic cosmic rays and isotope abundance with cosmic ray telescope.

    F. B. McDonald and G. H. Ludwig
    Goddard Space Flight Center

5. Low energy galactic cosmic ray flux, using charged particle telescope to study protons above 0.2 Mev and other nuclei at higher energies.

   J. A. Simpson, C. Y. Fan and P. Meyer
   University of Chicago

6. Cylindrical electrostatic analyzer to study the distribution of low energy electrons and protons (0.10 to 50 Kev).

   J. A. Van Allen and L. A. Frank
   State University of Iowa

7. Trapped radiation and cosmic radiation, using magnetic electron spectrometer to measure electron energy up to 4 Mev; ionization chamber and geiger counters to monitor trapped radiation and galactic cosmic radiation.

   J. R. Winckler and R. L. Arnoldy
   University of Minnesota

8. Fluctuations in vector magnetic field (0.01 to 1000 cps) using triaxial search coil magnetometer.

   E. J. Smith
   Jet Propulsion Laboratory

   R. E. Holzer
   University of California (Los Angeles)

9. Measurement of magnitude and direction of magnetic fields (1 to 14,000 gammas) using rubidium vapor and triaxial fluxgate magnetometers.

   J. P. Heppner
   Goddard Space Flight Center

10. Measurement of proton concentrations (10^{-2} to 10^{-4} particles per cm^3) as a function of proton energy (0.2 to 20 Kev) with electrostatic analyzer.

    J. H. Wolfe
    Ames Research Center

11. Study of solar plasma flux using Faraday cup plasma probes to measure plasma flux and energy spectrum, and their variations (10 ev to 10 Kev).

    H. Bridge, A. Bonetti, B. Rossi, A. J. Lazarus, F. Scherb
    Massachusetts Institute of Technology

12. Density and energy distribution of positively and negatively charged particles (0 to 1.0 Kev) using spherical three electrode probe.

    R. C. Sagalyn and M. Smiddy
    Air Force Cambridge Research Laboratories

13. Densities and energy distributions of charged particles of both polarities in the low energy or thermal range and information on ion masses and fluxes using a planar ion and electron trap.

E. C. Whipple, Jr.
Goddard Space Flight Center

14. Continuous synoptic survey of VLF noise and propagation characteristics (0.2 to 100 Kc/s).

R. A. Helliwell and L. H. Rorden
Stanford University and Stanford Research Institute

15. Brightness distribution of cosmic radio noise over the sky with sweep frequency receiver (2 to 4 Mc/s).

F. T. Haddock
University of Michigan

16. Atmospheric electron content using radio beacon to radiate linearly polarized signals (between 40 and 360 Mc) toward the earth.

R. S. Lawrence and H. J. A. Chivers
National Bureau of Standards (CRPL)

17. Direct measurements of the density of positive ions (1-50 AMU from 10 to 10^5 ions per cm^3) with RF ion mass spectrometer.

H. Taylor and N. W. Spencer
Goddard Space Flight Center

18. Micrometeoroids; vector velocity distribution, cumulative mass distribution, effect of geocentric distance, using piezoelectric detectors, plasma detector, and velocity discriminator.

W. M. Alexander and C. W. McCracken
Goddard Space Flight Center

19. Lyman-alpha scattering in the geocorona to determine the distribution of neutral hydrogen, measured with ion chambers.

P. W. Mange
Naval Research Laboratory

20. Gegenschein photometry in ultraviolet, green and infrared regions with photomultiplier and filter.

C. L. Wolff and K. Hallam — Goddard Space Flight Center
S. P. Wyatt — University of Illinois

21. Electrostatic and magnetic analyzers for the detection of low energy protons (5-100 Kev).

D. S. Evans and Leo R. Davis
Goddard Space Flight Center

OGO D

Investigations and Investigators

1. Brightness distribution of cosmic radio noise over the sky with sweep frequency receiver (2.5 and 2.0 Mc/s).

F. T. Haddock
University of Michigan

2. Continuous synoptic survey of VLF noise and propagation characteristics (0.2 to 100 Kc/s).

R. A. Helliwell
Stanford University

L. H. Rorden
Stanford Research Institute

3. Determination of diurnal and latitude variations of VLF spectra in the range 0.5 to 18 Kc/s.

M. G. Morgan and T. L. Laaspere
Dartmouth College

4. Magnetic field fluctuations in the low and sub-audio frequency range from 0.01 to 1000 cps using coil magnetometers.

H. J. Smith
Jet Propulsion Laboratory

R. E. Holzer
University of California (Los Angeles)

5. World magnetic survey with rubidium-vapor magnetometer (10,000 to 65,000 gammas).

J. P. Heppner and J. C. Cain
Goddard Space Flight Center

6. Monitoring of cosmic radiation and trapped radiation with ionization chamber (above 0.5 Mev for electrons, 10 Mev for protons, and 40 Mev for alpha particles).

H. R. Anderson
Rice University

H. V. Neher
California Institute of Technology

7. Study of low energy protons and nucleons in cosmic radiation and trapped radiation (from 0.3 to 30 Mev) with scintillation telescope.

J. A. Simpson, E. C. Stone, and C. Y. Fan
University of Chicago

8. Energy spectrum and charged particle composition of galactic and solar cosmic rays as observed with a modified Cerenkov detector.

W. R. Webber
University of Minnesota

9. Net downflux of corpuscular radiation in the auroral zones and over the polar caps, using Geiger tubes as detectors.

J. A. Van Allen and L. A. Frank
State University of Iowa

10. Study of fluctuations in the trapped radiation by measuring low energy trapped radiation (electrons, 10-100 Kev; protons, 100 Kev to 10 Mev) as observed with scintillation detector.

R. A. Hoffman, A. Konradi, L. R. Davis, and J. M. Williamson
Goddard Space Flight Center

11. Photometric airglow measurements at 6300A, 6200A, 5890A, 5577A, 3914A, and 2600A using photomultipliers and filters.

J. Blamont
University of Paris

E. I. Reed
Goddard Space Flight Center

12. Airglow measurements in the Lyman-alpha and the far ultraviolet between 1230A and 1350A, with ion chambers.

P. W. Mange, T. A. Chubb and H. Friedman
Naval Research Laboratory

13. Airglow measurements with ultraviolet spectrometer between 1100A and 3400A.

C. A. Barth
Colorado University

L.Wallace
Kitt Peak National Observatory

14. Neutral particle and ion composition of the atmosphere (0-6 AMU and 0-40 AMU), with Paul massenfilter mass spectrometer.

L. M. Jones and E. J. Schaefer
University of Michigan

15. Atmospheric positive ion composition and density (1-6 AMU and 7-45 AMU), with Bennett RF ion mass spectrometer.

H. A. Taylor, Jr., and H. C. Brinton
Goddard Space Flight Center

16. Density of neutral atmospheric particles with Bayard-Alpert ionization gage in pressure range from 10^{-5} to 10^{-10} mm Hg.

G. P. Newton
Goddard Space Flight Center

17. Micrometeorities; spatial density, mass distribution, velocity, and charge in 10^{-13} to 10^{-9} gm range using a combined electrostatic piezoelectric microphone detector.

W. M. Alexander, C. W. McCracken, O. E. Berg, L. Secretan
Goddard Space Flight Center

18. Measurements of electron temperature (800° to 3000°K), of ion or neutral gas temperature (800° to 3000°K) and charged particle density (10^3 to 5×10^6) with a retarding-potential analyzer.

R. E. Bourdeau
Goddard Space Flight Center

19. Time variations in solar X-ray emissions in the 0.5-3A, 2-8A, 8-16A, and 44-60A bands using an ionization chamber.

R. W. Kreplin, T. A. Chubb, H. Friedman
Naval Research Laboratory

20. Monitoring of solar energy (170-1700A) in six ranges using six grating and photocathode combinations.

H. E. Hinteregger
Air Force Cambridge Research Laboratories

OGO-E

Investigations and Investigators

1. Study of distribution of thermal electrons in the magnetosphere with spherical retarding potential analyzers; electron densities, 10 to 10^4 per cm^3; temperatures 500-10,000°K.

R. L. F. Boyd and A. P. Willmore
University College, London

2. Detailed description of x-ray and high energy particle features of large solar flares with scintillation detectors and proportional counters; x-rays 1-90 Kev; protons 8-300 Mev; alpha particles 30-1200 Mev.

K. A. Anderson and H. Mark
University of California, Berkeley

3. Magnetic electron spectrometer and proton telescope for energetic particle measurements: electrons 50 Kev to 3 Mev; protons 100 Kev to 50 Mev.

R. D'Arcy, L. Mann, and H. West
Lawrence Radiation Laboratories

4. Cylindrical electrostatic analyzer to study the distribution of low energy electrons and protons, 0.10 to 50 Kev, GM tube for electron flux above 40 Kev.

L. A. Frank, J. A. Van Allen, and W. A. Whelpley
State University of Iowa

5. Measurements with a spark chamber to determine possible existence of any preferred directions in the gamma ray component of primary cosmic rays and to detect charged primaries.

G. W. Hutchinson, D. Ramsden, and R. D. Wills
University of Southampton, England

6. Monitoring the lower energy galactic cosmic rays and solar proton events with good energy resolution using three counter telescopes.

F. B. McDonald, G. H. Ludwig, D. E. Hagge, and V. K. Balasubrahmanyan
Goddard Space Flight Center

7. Triaxial fluxgate magnetometer and six solid state particle detectors for correlation of trapped particle characteristics with hydromagnetic waves.

P. J. Coleman, Jr., T. A. Farley
University of California (Los Angeles)

D. L. Judge
University of Southern California and TRW Systems

8. Vector and scalar magnetic field measurements, to 30,000 gammas, using rubidium vapor and triaxial fluxgate magnetometers.

J. P. Heppner, T. L. Skillman, B. G. Ledley, M. Campbell and M. Sugiura
Goddard Space Flight Center

9. Study of magnetic field fluctuations (0.01 to 1000 cps) with triaxial search coil magnetometers.

H. J. Smith
Jet Propulsion Laboratory

R. E. Holzer
University of California (Los Angeles)

10. High resolution measurements of energetic plasma with electrostatic analyzers and Faraday cups (3 ev to 16 Kev).

C. W. Snyder, M. Neugebauer, and J. L. Lawrence, Jr.
Jet Propulsion Laboratory

11. Observations of low frequency radio bursts from the sun and Jupiter, and cosmic noise (50Kc/s to 2 Mc/s) with step frequency radiometer.

F. T. Haddock
University of Michigan

12. Distribution of the density of neutral atomic hydrogen and atomic oxygen using UV photometers and 1304A and 1216A wavelengths.

C. A. Barth
University of Colorado

J. B. Pearce
Packer-Bell Electronics

13. Measurement of the spatial and temporal variations in the flux and energy distributions of charged particles of thermal energies (from 0 to 2 Kev) with spherical retarding potential analyzers.

R. C. Sagalyn and M. Smiddy
Air Force Cambridge Research Laboratories

14. Density and temperature of ions and electrons (below 100 ev) with planar retarding potential analyzer.

G. P. Serbu and E. J. Maier
Goddard Space Flight Center

15. Studies of low rigidity interplanetary electrons (0.1-8 Mev), positrons (0.5-8 Mev), and protons (2-70 Mev) using scintillation counter telescope; gamma rays (50 to 700 Mev).

T. L. Cline
Goddard Space Flight Center

16. Measurement of the flux and energy spectrum of cosmic ray electrons (20 to 100 Mev) with a particle telescope.

P. Meyer and C. Y. Fan
University of Chicago

17. Study of the distribution of electrons (0 to 15 Kev) with triaxial electrostatic analyzers.

K. W. Ogilvie
Goddard Space Flight Center

T. D. Wilkerson
University of Maryland

18. Measurement of the absolute flux and energy spectrum of energetic galactic cosmic ray electrons with a particle counter telescope: electrons, 0.5 to 10 Bev; protons, 20-100 Bev, gamma rays above 500 Mev.

A. H. Wapstra
Institute of Nuclear Physics Research, Netherlands

Y. Tanaka, M. N. Lund, Ir. A. Scheepmaker and B. M. Swanenberg
Working Group, Cosmic Radiation, Netherlands

19. Determination of the distribution of light ions (H^+, H_2^+ and He^+) with magnetic mass spectrometer.

G. W. Sharp and T. J. Crowther
Lockheed Missiles and Space Company

20. Determination of spatial density, mass distribution, velocity, and charge of interplanetary dust particles, using four particle detectors. in the weight range 10^{-13} to 10^{-19} gms.

W. M. Alexander, O. E. Berg, C. W. McCracken and L. Secretan
Goddard Space Flight Center

21. Determination of the number density and temperature of hydrogen in the geocorona with hydrogen cell.

J. E. Blamont
University of Paris

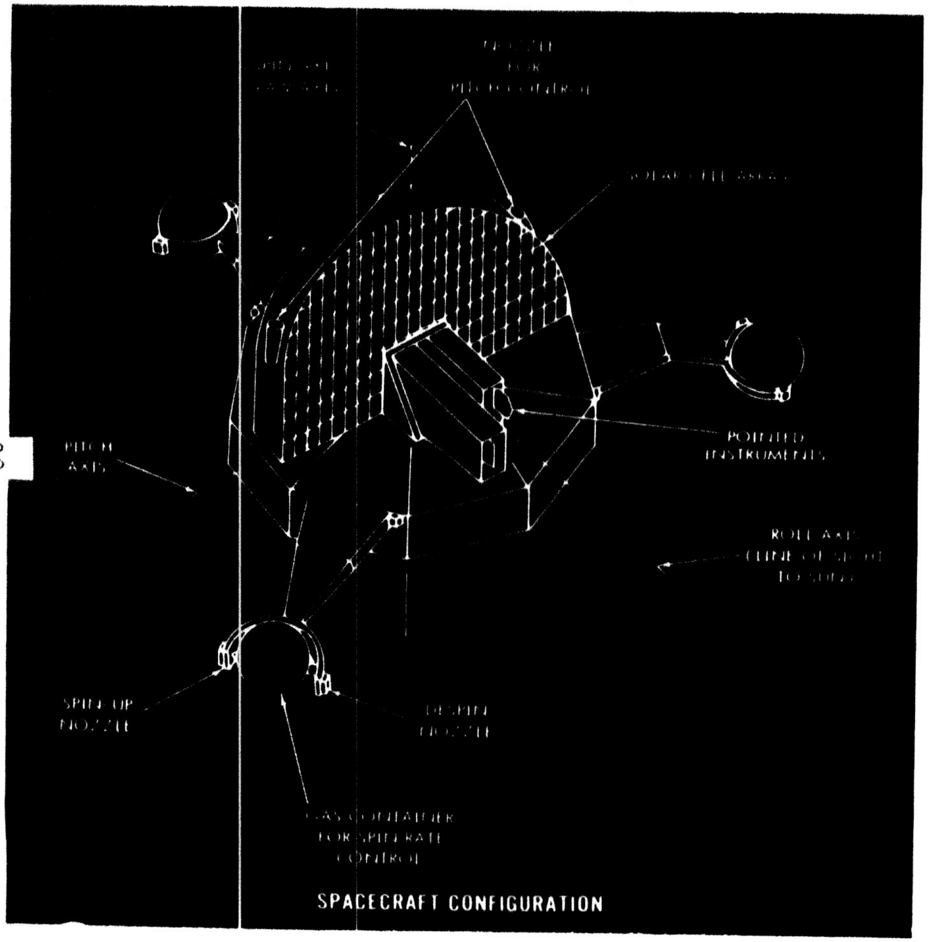
22. Proportional counter spectrometer to measure solar x-ray emissions in the region of 2-8A.

R. W. Kreplin, T. A. Chubb, H. Friedman
Naval Research Laboratory

23. Measurement of electric plasma oscillations and electromagnetic waves using orthogonal systems of electric and magnetic field antenna, 300 cps to 20 Kc/s.

G. M Crook, F. L. Scarf, R. W. Fredricks
TRW Systems, Inc.

ORBITING SOLAR OBSERVATORY



SPACECRAFT CONFIGURATION

GROSS WEIGHT	540 LBS.
INSTRUMENT WEIGHT	220 LBS.
EXPERIMENTS	13
POWER	26 WATTS (aver.)
STABILIZATION	SPIN
DESIGN LIFE	6 MONTHS
LAUNCH VEHICLE	DELTA
ORBIT	NEAR-EARTH CIRCULAR ORBIT
STATUS	NEXT FLIGHT 1966

NASA SG64-192
REV. 12/8/65

ORBITING SOLAR OBSERVATORIES

The Orbiting Solar Observatories (OSO) are a series of stabilized space platforms designed to investigate solar phenomena from above the obscuring and distorting effects of the atmosphere. The spacecraft consists of a fan-shaped stabilized section connected by a shaft to a lower rotating wheel-like structure. The wheel contains nine wedge-shaped compartments, five of which are available for scientific instrumentation with the remaining four carrying housekeeping equipment such as the telemetry system and batteries. The oriented portion of the spacecraft, which carries two compartments for scientific instrumentation, points continuously at the center of the sun with an accuracy of somewhat less than one minute of arc. Provision for scanning the sun with a resolution of 1 arc minute can be made available to the experimenters. The wheel investigations are, in general, sky mapping in character, comparing radiation from the sun to that in other portions of the sky. The OSO's will be launched from the Eastern Test Range by Thor-Delta vehicles and are intended to orbit the earth in a circular orbit at an altitude of 350 miles inclined 33 degrees to the equator.

The first Orbiting Solar Observatory (OSO-I) was launched successfully on March 7, 1962, and returned unique data concerning the sun during approximately 10 weeks of tape recorder operation. Real time data were transmitted subsequently until August of 1963, at which time the spacecraft was commanded off. Early in January 1964, the spacecraft was commanded on and returned information on the trapped radiation belt.

The second OSO (OSO-B) was being readied for launch in April 1964 when it was damaged by an unfortunate accident during the mating of the spacecraft to the third stage motor at Cape Kennedy. It was decided to fly this mission with the refurbished prototype as OSO-B2. It was launched on February 3 to become OSO-II. After varying periods of operation, all experiments on the pointing section failed to transmit data. The wheel experiments are functioning well. The third OSO (OSO-C) was launched unsuccessfully on August 25. Because of an unusual malfunction of the Delta launch vehicle it failed to go into orbit. A re-flight of the OSO-C mission using the experiment spares has been designated OSO-E and will be launched in 1966.

Experiments and experimenters for three additional OSO's (D, F and G) have been selected and proposals are being received for OSO-H. Following is a list of the experiments and experimenters which have been selected as of 30 October 1965.

OSO-D

Pointing Section

1. Measurements of solar flare x-rays with crystal spectrometer to distinguish between emissions from a thermally excited corona and from a relatively low temperature corona.

   H. Friedman, T. A. Chubb
   Naval Research Laboratory

2. Solar UV spectrum (300-1300A) using normal incidence scanning spectrometer.

   L. Goldberg, E. M. Reeves, W. H. Parkinson
   Harvard College Observatory

3. Study of solar x-rays, 8-20A, above 20A, and below 8A, using totally reflecting parabolic mirror and detector.

   R. Giacconi
   American Science and Engineering, Inc.

Wheel Section

4. Survey of non-solar x-ray radiation (0.1-10A) using CsI and SrF_2 detectors.

   R. Giacconi
   American Science and Engineering, Inc.

5. Distribution of total solar x-ray emission over a wide band, 1.2-3.6A, 3-9A, 6-18A, 44-55A and 44-70A using proportional counters and geiger counters.

   E. A. Stewardson, R. L. F Boyd
   Leicester University and University College, London

6. Measurements of charged particles (electrons > 60 Kev and protons > 2 Mev) using a crystal scintillator.

   J. A. Waggoner, S. D. Bloom, C. D. Schrader, R. Kaifer
   University of California, Livermore

7. Solar HeII resonance emission (303.8A) using grating spectrometer and photomultipliers.

   R. L. F. Boyd
   University College, London

8. Measurements of a solar x-ray radiation (8-16A, 2-8A, 0.5-3A, 0.1-1.6A) with four ion chambers.

   T. A. Chubb, R. W. Kreplin, H. Friedman
   Naval Research Laboratory

9. Lyman-alpha night sky glow observed with two ion chamber detectors.

   P. W. Mange, T. A. Chubb, H. Friedman
   Naval Research Laboratory

OSO-E

Pointing Section

1. Solar extreme ultraviolet flux using a monochromator (250-1300A).

   H. E. Hinteregger
   Air Force Cambridge Research Laboratories

2. X-ray and UV solar spectrum, using spectrometer (1-400A) and x-ray ion chambers (1-8A and 10-20A).

   J. C. Lindsay*, W. M. Neupert, W. E. Behring, W. A. White
   Goddard Space Flight Center

   *Deceased

Wheel Section

3. Solar and galactic cosmic rays of energies > 3.3 Mev per nucleon with counter telescopes with scintillators and Cerenkov detectors.

   M. F. Kaplon, E. M. Hafner
   University of Rochester

4. Solar x-ray flux (8-20A) using gas-filled ionization chambers, and comparison with optical and radio aspects of sun.

   R. G. Teske
   University of Michigan

5. Earth albedo (1000A-4 microns) using photomultiplier tubes to measure reflected solar radiation.

   C. B. Neel, G. G. Robinson
   Ames Research Center

6. Emissivity stability of low temperature coatings.

   C. B. Neel, G. G. Robinson
   Ames Research Center

7. Celestial x-ray and gamma ray astronomy (15-600 Kev) and study of solar bursts in these frequencies, using Na I scintillation counter.

   L. E. Peterson
   University of California, La Jolla

8. Gamma ray astronomy and search for non-solar gamma ray sources with energies above 100 Mev.

   W. L. Kraushaar, G. W. Clark, G. Garmire, R. Baker
   Massachusetts Institute of Technology

OSO-F

Pointing Section

1. Solar x-ray (3-9A, 8-18A) using spectroheliograph with proportional counters.

   E. A. Stewardson, R. L. F. Boyd
   University College, London and Leicester University

2. Solar monitoring with extreme ultraviolet spectroheliograph, 1216A, 584A, 304A and probably 335A and 284A.

   J. D. Purcell, R. Tousey, H. Friedman
   Naval Research Laboratory

3. Solar x-ray and UV spectrum using spectrometers (1-400A) and x-ray ion chambers (1-8A and 10-20A).

   J. C. Lindsay*, W. M. Neupert, W. E. Behring, W. A. White
   Goddard Space Flight Center

   *Deceased

Wheel Section

4. Solar x-radiation 8-16A, 2-8A, 0.5-3A, 0.1-1.6A with ion chamber photometers.

T. A. Chubb, R. W. Kreplin, H. Friedman
Naval Research Laboratory

5. Low energy solar gamma rays (5-150 Kev) using scintillation detector.

K. Frost, H. Horstman, E. Rothe
Goddard Space Flight Center

6. Monitoring of self-reversal of the solar Lyman-alpha line using photometer with atomic hydrogen absorption cell.

J. Blamont
University of Paris

7. Intensity and polarization of the zodiacal light in visible and IR regions with photomultipliers and polaroid filters.

E. P. Ney
University of Minnesota

8. Monitoring of solar far-ultraviolet radiation, 280-370A, 465-630A, 760-1030A with concave grating and photomultiplier.

W. A. Rense, R. Parker
University of Colorado

OSO-G

1. Normal incidence spectrometer - spectroheliometer (300 - 1300A) to scan the total spectral range at a point on the solar disk and to scan the sun at a fixed wavelength in the range.

L. Goldberg, E. M. Reeves, W. H. Parkinson
Harvard College Observatory

2. Bragg crystal spectrometer with three Geiger counters to measure solar x-rays in the range 0.6 to 25A; a scintillation spectrometer to measure x-rays in the range 0.6 to 6A; three filtered Geiger counters functioning as x-ray burst detectors to monitor the radiation from the solar disk in the ranges 1-8A, 8-16A, and 44-60A.

R. W. Kreplin, J. F. Meekins, T. A. Chubb, H. Friedman
Naval Research Laboratory

Wheel Section:

1. Study of the zodiacal light; brightness and polarization

   A. L. Rouy, B. Carroll. L. H. Aller
   Rutgers University

2. Solar x-ray monitoring in the 16-40A region

   H. V. Argo, J. A. Bergey, W. D. Evans, D. L. Henke, M. D. Montgomery
   Los Alamos Scientific Laboratories

3. Solar x-ray monitoring in the energy range 20-200 Kev and albedo flux of photons.

   D. Brini, M. Galli, U. Ciriego, F. Fuligni, A. Gandolfi, D. Moretti
   University of Bologna

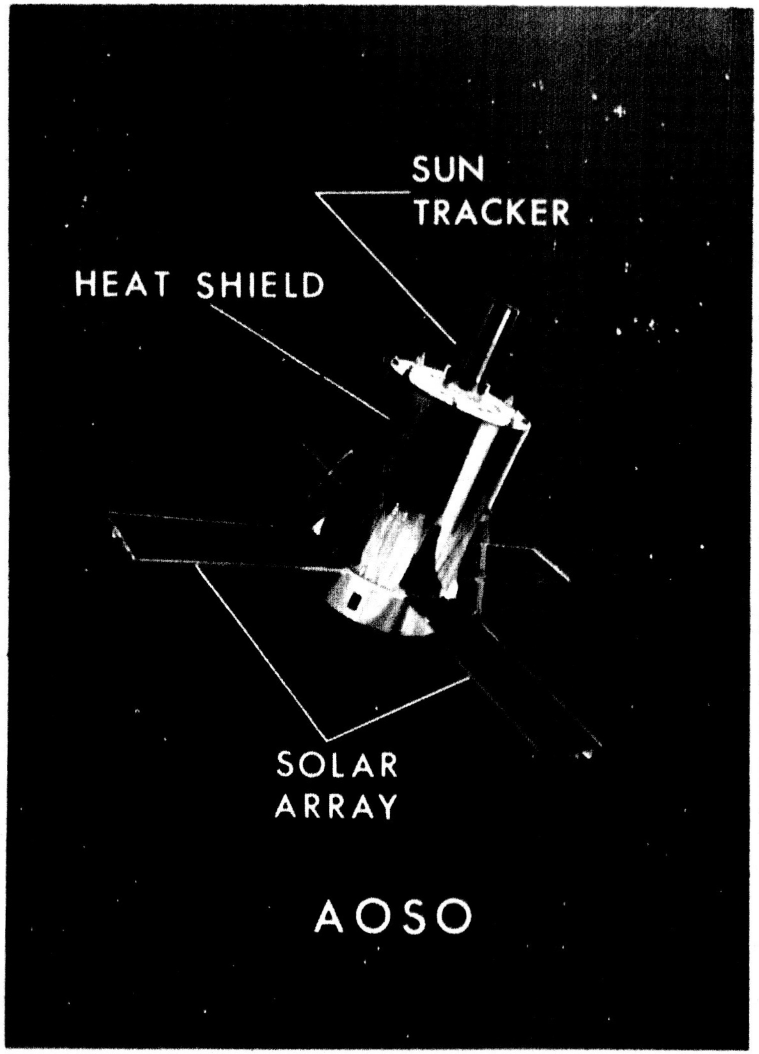
4. Study of the HeI (584A) and HeII (304A) resonance radiation and correlation with ground-based observations.

   R. L. F. Boyd
   University College, London

5. High energy neutron flux in space

   C. P. Leavitt
   University of New Mexico

ADVANCED ORBITING SOLAR OBSERVATORY



GROSS WEIGHT	1250 LBS.
INSTRUMENT WEIGHT	250 LBS.
INVESTIGATIONS	4 TO 6 POINTED
POWER	400 WATTS
STABILIZATION	ACTIVE 3 AXIS
DESIGN LIFE	ONE YEAR
LAUNCH VEHICLE	TAT-AGENA
ORBIT	CIRCULAR, 380 MI. POLAR RETROGRADE
PLAN	FIRST FLIGHT DURING SOLAR MAXIMUM

NASA SG64-194
REV. 12/8/65

ADVANCED ORBITING SOLAR OBSERVATORY

The Advanced Orbiting Solar Observatory (AOSO) is being developed as a space vehicle capable of making continuous detailed, high resolution studies of solar phenomena from beyond the earth's atmosphere. These phenomena include: (a) the transient events with bursts of ionizing radiation and ejections of energetic charged particles; (b) the generation and dissipation of the sun's magnetic fields and the flare process; (c) the temperature inversions in which the photosphere is cooler than the chromosphere and corona; and (d) the spicules, the granulation and the chromosphere mottles.

The AOSO will provide a stable platform in a 380 mile circular sun-synchronous orbit. Its length will accommodate large optics with accurate pointing for high spatial resolution. A three-axis stabilization and control system will accurately maintain spacecraft orientation. A coarse and a fine sun sensor provide pointing and scanning of locations as commanded in a 40 x 40 arc minute field of view on the solar surface. Pointing error is less than 5 arc seconds. A coarse 40 arc minute raster scan and a fine 5 arc minute raster scan are available. A data handling system provides a high transmission rate and a storage capacity for data acquired during two orbits.

The spacecraft consists of a cylindrically shaped housing, 120 inches (3.048M) long and 55 inches (1.4M) in diameter, housing the experiments and spacecraft support equipment. A center mounted rigid experiment support structure is provided as an optical bench for the experiments. Eight solar paddles are attached to the end of the cylinder, and face the sun to provide power to the spacecraft. The total observatory weight of 1250 pounds (544.3 kg), includes 250 pounds (113.4 kg) of experiment instrumentation.

The planned 380 mile (612 Km) orbit will be polar retrograde, with a period of 95 minutes to provide a maximum operational time in full sunlight. The observatory operational life goal is one year. Launch will be from the Western Test Range (WTR), by a Thrust Augmented Thor Agena D vehicle.

The AOSO is being designed to be able to make precise observations of specialized areas of interest on the sun, for example;

(a) high resolution spectra and spectroheliograms in the extreme ultraviolet and x-ray regions of the chromospheric structure;

(b) plage activity with higher spatial and spectral resolution than obtainable from rockets or present satellites;

(c) flare mechanisms with more detailed spectroheliograms in the ultraviolet and x-ray spectra allowing electron density and temperature to be determined;

(d) temperature inversion in the solar atmosphere;

(e) coronal structure, solar streamers, and emission lines and continua of highly ionized atoms in localized regions.

Instruments currently under development for AOSO include:

1. 300 - 1300A normal incidence scanning spectrometer - spectroheliometer for studies of the fine structure and spectra of active regions on the solar disk.

   L. Goldberg, E. M. Reeves, W. H. Parkinson
   Harvard College Observatory

2. High resolution (5 arc seconds) x-ray telescope to measure the intensity, distribution, and temporal variations of solar x-rays (3-60A).

   J. C. Lindsay*, R. Giacconi
   GSFC and American Science and Engineering, Inc.

   *Deceased

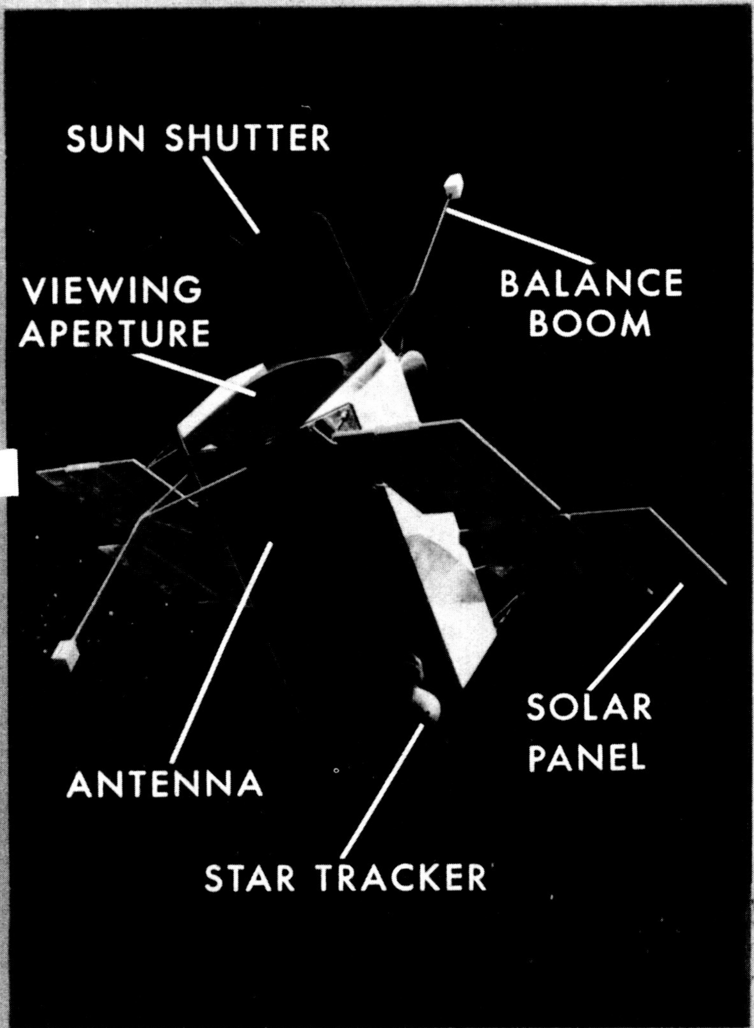
3. White light coronagraph for the continuous recording of the form, intensity, and polarization of the outer white light corona at distances of 2-6 solar radii.

   G. Newkirk, J. A. Eddy
   High Altitude Observatory

4. Ultraviolet spectroheliograph with 5 seconds resolution using several parts of the Lyman-alpha line rather than the entire line and HeII (304A), Fe XV (284A), and Fe XVI (335A).

   J. D. Purcell, R. Tousey, H. Friedman
   Naval Research Laboratory

ORBITING ASTRONOMICAL OBSERVATORY



GROSS WEIGHT	- 4000 LBS.
INSTRUMENT WEIGHT	- 1000 LBS.
INVESTIGATIONS	- SEVERAL/SPACECRAFT
STABILIZATION	- ACTIVE 3-AXIS
DESIGN LIFE	- ONE YEAR
LAUNCH VEHICLE	- ATLAS-AGENA
ORBIT	- CIRCULAR 500 MI. INCLINATION 32°
PLAN	- FIRST FLIGHT - 1966

NASA SD63-1450
REV. 12/8/65

ORBITING ASTRONOMICAL OBSERVATORIES

The Orbiting Astronomical Observatories (OAO) are designed to provide an opportunity to explore those regions of the spectrum that are inaccessible to ground-based instrumentation because of atmospheric absorption. The OAO is a precisely-stabilized satellite designed to accommodate various types of astronomical observing equipment. The primary experiments for the first four observatories are concerned with stellar astronomy in the ultraviolet range (800-4000A). The observatories will be placed in nearly circular orbits at an altitude of 500 miles with an inclination of 32 degrees.

The basic OAO structure is tubular with an octagonal cross-section. The total weight of the spacecraft is about 4000 pounds, of which 1000 pounds is allocated to the experimental equipment. An average power of 400 watts is available, supplied by silicon solar cells and nickel-cadmium storage batteries. About 30 watts average and 60 watts peak is available for each investigation. Provision is made for data storage and for commands to the spacecraft.

The stabilization and control system consists of star trackers, sun trackers, inertial wheels, and gas jets. The spacecraft is designed to point in any direction with an accuracy of 0.1 second of arc during the observation of an individual star. The attitude control system performs three functions:

1. To stabilize the OAO following booster separation and establish the required attitude.

2. To slew the satellite to the attitudes needed by the scientific objectives of the mission.

3. To maintain a given attitude for long periods of time.

It is expected that all observatories will have a limited amount of payload capacity for secondary investigations in addition to the primary investigations. Good progress has been made in 1965 in preparing the first OAO for launching in 1966.

Investigations and Investigators

OAO-A1

1. Stellar broad-band photometry between 900A and 3000A; measurements of emission characteristics of diffuse nebulae; extension of opacity measurements of the interstellar medium into the ultraviolet. Multicolor filter photometers using 8 and 16 inch telescopes and two auxiliary spectrometers.

   A. D. Code
   University of Wisconsin

2. Survey of extraterrestrial high energy gamma rays above 100 Mev using crystal scintillator and Cerenkev counter detectors.

W. L. Kraushaar
University of Wisconsin

3. Survey of the celestial sphere for protons from 2 to 150 Kev and measurement of the spectrum of the fluxes, using a thallium-activated sodium iodide crystal viewed by three photomultiplier tubes.

K. A. Frost
Goddard Space Flight Center

4. Survey of the night sky to detect photons between 0.4 and 6A, using a multiple wire array of high-gain gas proportional counters.

P. Fisher
Lockheed Missiles and Space Company

OAO-B

1. Absolute spectrophotometry measurements of stars and nebulae (1000 to 4000A).

J. Milligan
Goddard Space Flight Center

OAO-A2

1. Four high resolution telescopes (Schwarzschild cameras) with UV sensitive Unicon image forming devices to survey the sky in the UV ranges, 1200-1550A, 1375-1625A, 1800-2800A, and 2350-2850A; to record the brightness of hot stars, primarily spectral type A and earlier; and to map the form and brightness characteristics of faint nebulae.

F. Whipple and R. Davis
Smithsonian Astrophysical Observatory

2. Same as his experiment on OAO A1.

A. D. Code
University of Wisconsin

OAO-C

1. Quantitative absorption spectra of interstellar gas in the far UV (800-3000A) with 0.1A resolution; composition and physical condition of the clouds of interstellar gas and dust. Cassegrain reflecting

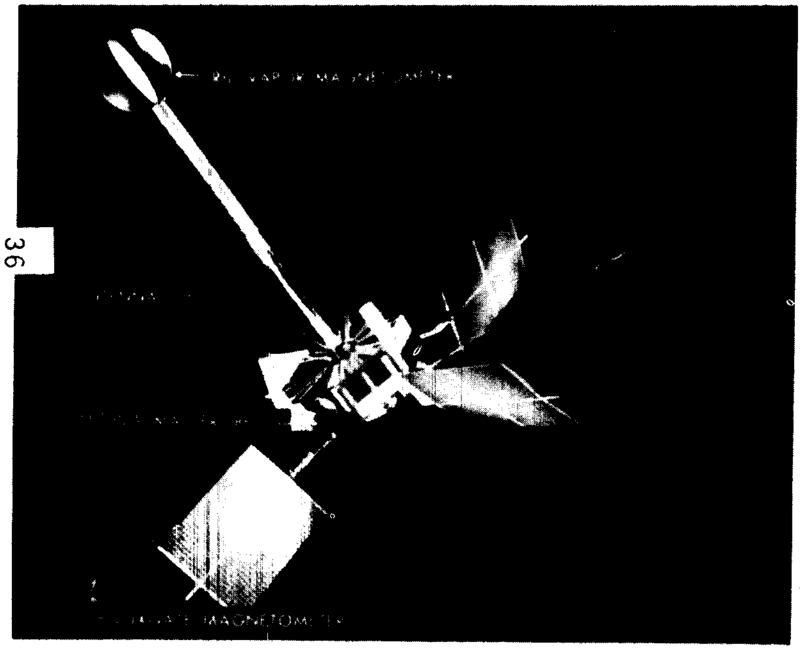
telescope, concave grating spectrometer, and photocells.

L. Spitzer
Princeton University

2. X-ray emissions of stars and nebulae in the ranges 3-12A, 8-18A, and 44-60A; three paraboloidal reflectors, three photon detectors, and three gas counters. Search for interstellar absorption in the range 44-60A.

R. L. F. Boyd
University College London

INTERPLANETARY EXPLORER
(IMP)



GROSS WEIGHT	135/181 LBS.
EXPERIMENTS	8 TO 11
POWER	16 WATTS
STABILIZATION	SPIN
DESIGN LIFE	1 YEAR
LAUNCH VEHICLE	DELTA
ORBIT	HIGHLY ELLIPTICAL EARTH ORBIT, OR ELLIPTICAL LUNAR ORBIT
PLAN	NEXT LAUNCH - 1966

NASA SP65-16316
12-8-65

INTERPLANETARY EXPLORERS

The interplanetary explorer project has the primary objective of studying the radiation environment of cislunar space throughout a solar cycle. The interplanetary explorers belong to the general group of small satellites, and will be placed in highly elliptical earth orbits or lunar orbits by means of the Delta launch vehicle.

The first three of the seven missions which have been approved are already in earth orbits, and are Explorer XVIII launched November 27, 1963; Explorer XXI launched October 3, 1964; and Explorer XXVIII launched May 29, 1965.

IMP-D and IMP-E

The fourth and sixth interplanetary explorers (IMP's D and E) are planned for measurements near the moon and will be placed into loose elliptical lunar orbits with altitudes ranging between 200 and 26,000 miles. The first launch is scheduled for 1966. The experiments selected for these flights are listed below.

1. Measurement of vector magnetic field from 0 to 200 gammas with closed loop, saturable core fluxgate magnetometers.

   C. P. Sonett, J. H. Wolfe, W. J. Kerwin, R. W. Silva
   Ames Research Center

2. Vector magnetic field from 0 to 64 gammas with a triaxial fluxgate magnetometer.

   N. F. Ness
   Goddard Space Flight Center

3. Energetic particle flux, protons >0.5, 17 and 50 Mev, electrons >45 Mev, using ion chamber and Geiger tubes.

   K. A. Anderson
   University of California, Berkeley

4. Low energy interplanetary electrons and protons, electrons >40 and >60 Kev and protons, 0.5 to 8 Mev and 0.9 to 3.5 Mev, and alpha particles, 2 to 20 Mev, using GM tubes and solid state detectors.

   J. A. Van Allen
   State University of Iowa

5. Measurement of the ionization, momentum, speed and direction of micrometeorites using thin film charge detectors, induction devices, and microphones.

   J. L. Bohn, Temple University — W. M. Alexander and O. E. Berg, Goddard Space Flight Center

6. Flux of positive and negative charged particles (100 ev to 10 Kev), using retarding potential analyzer.

   H. S. Bridge, A. J. Lazarus, and E. F. Lyon
   Massachusetts Institute of Technology

7. Passive observation of unmodified telemetry signal

   A. M. Peterson, V. R. Eshleman, O. K. Garriott, R. L. Leadabrand, and B. B. Lusignan
   Stanford University

8. Selenodesy using analysis of orbits

   W. M. Kaula
   University of California, Los Angeles

IMP-F AND IMP-G

The fifth and seventh interplanetary explorers (IMP's F and G) are scheduled for launch in 1966 and 1967 in eccentric earth orbits with an apogee of about 122,000 miles, a perigee of about 125 miles and an inclination of 66°. The investigations selected are as follows:

1. Integrated ionization from protons of E > 17 Mev and electrons of E > 1 Mev and X-rays, E > 100 Kev with a Neher-type ionization chamber and measurement of absolute flux of electrons about 45 Kev and 120 Kev by use of two thin-window Geiger tubes.

   K. A. Anderson
   University of California, Berkeley

2. Vector magnetic field from 0 to 64 gammas using a triaxial fluxgate magnetometer.

   N. F. Ness
   Goddard Space Flight Center

3. Cosmic ray anisotropy, protons and alpha particles 10 to 100 Mev, alpha particles 200 to 400 Mev, with particle telescope.

K. G. McCracken, W. C. Bartley, and U. R. Rao
Graduate Research Center of the Southwest

4. Composition of cosmic rays, protons 0.5 to 85 Mev, Z 2 above 6 Mev per nucleon.

J. A. Simpson and C. Y. Fan
University of Chicago

5. The quiet time galactic proton and alpha particle energy spectra (12-80 Mev per nucleon interval) and the modulation of the ratio of these two particles by solar activity; also the intensity and modulation processes involving 1-20 Mev electrons; using a telescope with three scintillators, two in a dE/dx-E configuration and one as an anti-coincidence detector.

F. B. McDonald and G. H. Ludwig
Goddard Space Flight Center

6. Particle flux with low energy cosmic ray detector for protons 0.4 to 8 Mev, alpha particles 2 to 8 Mev per nucleon.

F. B. McDonald and G. H. Ludwig
Goddard Space Flight Center

7. Proton and electron spectra in the energy interval from .10 to 50 Kev by means of a cylindrical electrostatic analyzer.

J. A. Van Allen, L. A. Frank, W. A. Whelpley
State University of Iowa

8. Low energy particle telescope; electrons 0.3 to 3.0 Mev; protons 0.5 to 18 Mev.

W. L. Brown, C. S. Roberts, G. L. Miller
Bell Telephone Laboratories

9. Azimuthal direction of arrival and intensity of protons and electrons with spherical electrostatic analyzer, protons 100 ev - 10 Kev and electrons 5 Kev - 100 Kev.

F. B. Harrison and J. L. Vogl
TRW Systems

10. Positive ions up to 10 Kev per unit charge using cylindrical electrostatic analyzer, for $m/z = 1$ and 2.

K. W. Ogilvie
Goddard Space Flight Center

T. D. Wilkerson
University of Maryland

11. Energetic protons, by use of three solid state radiation detectors, in the following four energy ranges:

(a) $E_p > 60$ Mev, 3×10^3 protons/cm^{2}sec.
(b) $E_p > 30$ Mev, 2×10^4 protons/cm^{2}sec.
(c) $E_p > 10$ Mev, 2×10^5 protons/cm^{2}sec.
(d) $1 < E_p < 10$ Mev, 3.3×10^4 protons/cm^{2}sec.

C. Bostrom
Applied Physics Laboratory

D. E. Hagge, F. B. McDonald and D. Williams
Goddard Space Flight Center

INTERNATIONAL EXPLORERS

This section deals with the satellites that call for international cooperation with national units of scientists, such as the second U.S./U.K. cooperative satellite launched on March 27, 1964, as Ariel II and the Beacon Explorer B launched on October 9, 1964, as Explorer XXII.

UK-E

The UK-E is the third in the series of joint NASA/UK undertakings. Ariel I and Ariel II were both successful. UK-E is to be launched by a Scout vehicle into a near-circular orbit of approximately 370 miles altitude, and inclination of 57°. The scientific objectives are to continue the examination of the ionosphere and to continue radio experimentation.

The experiments and investigators are:

1. Continuous measurement of ionization density and temperature.

   J. Sayers
   University of Birmingham

2. Measurement of the vertical distribution of molecular oxygen.

   R. Frith
   Meteorological Office, England

3. Mapping large scale noise sources in the galaxy.

   F. G. Smith
   University of Cambridge

4. Radio signals below 20 Kc/s.

   T. R. Kaiser
   University of Sheffield

5. Terrestrial radio noise

   J. A. Ratcliffe
   Radio Research Station

ISIS

The ISIS (International Satellites for Ionospheric Studies) program is a joint NASA/Canadian Defense Research Board undertaking. ISIS is to continue the joint NASA/Canadian program begun with Alouette I by means of a series of ionospheric research satellites for performing studies of the ionospher from sunspot minimum through sunspot maximum. ISIS-X was launched November 27, 1965.

ISIS-A

ISIS-A is to be launched by an improved Delta into a low altitude, near-polar orbit with a perigee of approximately 500 km., (300 miles), apogee of 3500 km., (2200 miles), and inclination of 80°.

The experiments and investigators are:

1. Electron density using sweep frequency sounder (0.1 to 16 Mc/s).

   J. H. Chapman
   DRTE, Canada

2. Small irregularities in ionosphere with fixed frequency sounder.

J. H. Chapman DRTE, Canada	W. Calvert, T. E. Van Zandt CRPL	G. L. Nelms, L. E Petrie, DRTE

3. Integrated electron content with radio beacon operating at 136 Mc/s.

J. H. Chapman DRTE, Canada	P. A. Forsyth, G. L. Lyon E. H. Tull University of Western Ontario

4. Monitoring of background cosmic radio noise using sweep frequency receiver.

   T. R. Hartz
   DRTE, Canada

5. ELV/VLF emissions from upper atmosphere, using receiver sensitive to 0.05 to 30 Kc/s.

   J. S. Belrose
   DRTE, Canada

6. Study of positive and negative particles in three overlapping ranges, 10 ev to 10 Kev, using electrostatic detector.

W. J. Heikkila
Graduate Research Center of the Southwest

7. Electron temperature and density with two cylindrical Langmuir probes.

L. H. Brace, J. A. Findlay
Goddard Space Flight Center

8. Energetic charged particles in lower part of outer radiation belt using geiger counters for electrons, 40-780 Kev, and silicon junction detectors for protons, 100 Kev to 63 Mev.

I. B. McDiarmid, D. C. Rose, J. R. Burrows, E. E. Budzinski
National Research Council of Canada

9. Positive ion density and temperature using spherical ion retarding potential analyzer in altitude range, 1000 to 3500 Km.

R. C. Sagalyn, M. Smiddy
Air Force Cambridge Research Laboratories

10. Positive ion measurements with ion mass spectrometer with mass range of 1 to 20 A.M.U. and density range from 5 to 5 x 10^5 ions/cm^3.

R. S. Narcisi, A. D. Bailey
Air Force Cambridge Research Laboratories

ISIS-B and ISIS-C

ISIS-B and ISIS-C have been approved, but experiments have not been selected.

SAN MARCO

The San Marco program is a cooperative effort of Italy and the United States. The primary purpose is a direct, continuous measurement of atmospheric density inthe equatorial region in the altitude range between 120 and 240 miles by means of atmospheric drag on the satellite. A secondary purpose is determination of the electron content between the satellite and earth. The spacecraft consists of two spherical shells, one within the other. Motion of one relative to the other will be measured with displacement transducers arranged on three orthogonal axes to secure the atmospheric drag on the outer sphere. The experiments and experimenters are as follows:

1. Atmospheric parameters by means of strain gage drag balance between two concentric spheres.

   L. Broglio
   University of Rome, Italy

2. Integrated electron content with radio beacon at 20 Mc/s.

   N. Carrara
   Microwave Center, Florence, Italy

The first was launched on December 15, 1964, from Wallops Island, but primary mission launchings will be from a platform in the Indian Ocean.

ESRO

There are two ESRO (European Space Research Organization) projects planned. These are cooperative international projects whereby ESRO will provide the spacecraft and experiments and NASA will provide the launch vehicle and launch support.

ESRO I

ESRO I is to be launched by a Scout into a polar eccentric orbit with perigee of about 175 miles, apogee about 950 miles, and inclination of 90°. The scientific objective is an integrated study of high latitude energetic particles and their effects on the polar ionosphere. The payload will include a beacon experiment for measurements of the total electron content between the satellite and ground observers.

The experiments and investigators are:

1. Corpuscular radiation

   O. E. Peterson
   Technical University, Denmark

   W. Riedler
   Kiruna Geophysics Observatory, Sweden

   R. Dalziel
   Radio Research Station, England

2. Electron temperature and density

   A. P. Willmore
   University College, London, England

3. Ion Composition

   A. P. Willmore
   University College, London, England

4. Auroral Photometry

   A. Omholt
   University of Oslo

   D. R. Bates
   Queen's University, Belfast

ESRO II

ESRO II is to be launched by a Scout into a polar eccentric orbit with perigee of about 200 miles, apogee of about 750 miles, and inclination of 98°.

The scientific areas of ESRO II are solar radiation and cosmic rays.

The experiments and investigators are:

1. Solar X-Rays

    E. A. Stewardson and K. A. Pounds
    Leicester University

    R. L. F Boyd and J. L. Culham
    University College, London

    C. de Jager and W. de Graaff
    Sterrenwacht, Utrecht, Holland

2. Trapped radiation

    H. Elliot and J. J. Quenby
    Imperial College, London

3. Solar and Van Allen Belt Protons (1-100 Mev)

    H. Elliot and J. J. Quenby
    Imperial College, London

4. Cosmic ray protons and alpha particles (85-350 Mev)

    H. Elliot and J. J. Quenby
    Imperial College, London

5. High energy electrons (500 Mev and 5 Gev)

    P. L. Marsden
    University of Leeds

6. Solar and cosmic ray protons (35-1000 Mev)

    J. Labeyrie and L. Koch
    Saclay, France

OTHER EXPLORERS, BALLOONS, RESEARCH AIRCRAFT

AIR DENSITY/INJUN-C

The Air Density/Injun-C payload consists of two independent spacecraft to be launched simultaneously by a Scout into a nearly polar, eccentric orbit with perigee of about 300 miles and apogee of 2700 miles. The Air Density spacecraft is a 12-foot inflatable sphere of the same basic design as Explorers IX, XIX, and XXIV, and will continue the measurements of the density of the upper atmosphere through changes in drag as shown by orbital changes. The Injun spacecraft is designed to measure the downflux of corpuscular radiation into the earth's atmosphere and to determine the effects of the radiation upon the upper atmosphere. Measurements also will be made of very low frequency radio emissions in the ionosphere. The flux data will be correlated with atmospheric density data.

The investigators and investigations are:

AIR DENSITY EXPLORER

1. Systematic changes in atmospheric drag:

   W. J. O'Sullivan, C. Coffee, G. Keating
   Langley Research Center

2. Non-systematic changes in atmospheric density:

   L. Jacchia
   Smithsonian Astrophysical Observatory

INJUN

1. Study of precipitated and trapped electrons and protons (75 ev - 75 kev), and their correlation with air density, particle temperature, and VLF emissions by use of a curved plate electrostatic analyzer, a retarding potential analyzer, and a Geiger Mueller tube.

   J. A. Van Allen, L. A. Frank
   State University of Iowa

2. Measurements of frequency, amplitude, and polarization of natural and artificial VLF emissions using two balanced dipoles and corresponding receivers.

   J. A. Van Allen, D. A. Gurnett, S. D. Shawhan
   State University of Iowa

3. Measurements of energy spectra, angular distribution and time dependence of absolute intensities of protons, alpha particles,

and electrons (protons 200 kev - 21 Mev, alpha particles 1.5 - 10 Mev, electrons 200 Kev - 1.2 Mev) with three solid state detectors.

J. A. Van Allen, T. P. Armstrong, S. M. Krimigis
State University of Iowa

4. Spatial and temporal variations in the concentration and energy distribution of low energy charged particles (0-2 Kev) with two four-grid spherical retarding potential analyzers.

R. C. Sagalyn, M. Smiddy
Air Force Cambridge Research Laboratories

ATMOSPHERE EXPLORER AE-B

A second Atmosphere Explorer, similar to Explorer XVII which was launched on April 2, 1963, is planned for launch in 1966 to study the neutral atmosphere. It is a stainless steel, vacuum tight 35-inch sphere, designed to avoid atmospheric contamination. The experimentation is as follows:

1. Electron densities between 10^3 per cm^3 and 4×10^6 per cm^3 with swept voltage electron probe.

   L. Brace
   Goddard Space Flight Center

2. Partial densities of neutral gases using double focusing neutral mass spectrometer (1,4,14,16,18,28, and 32 AMU)

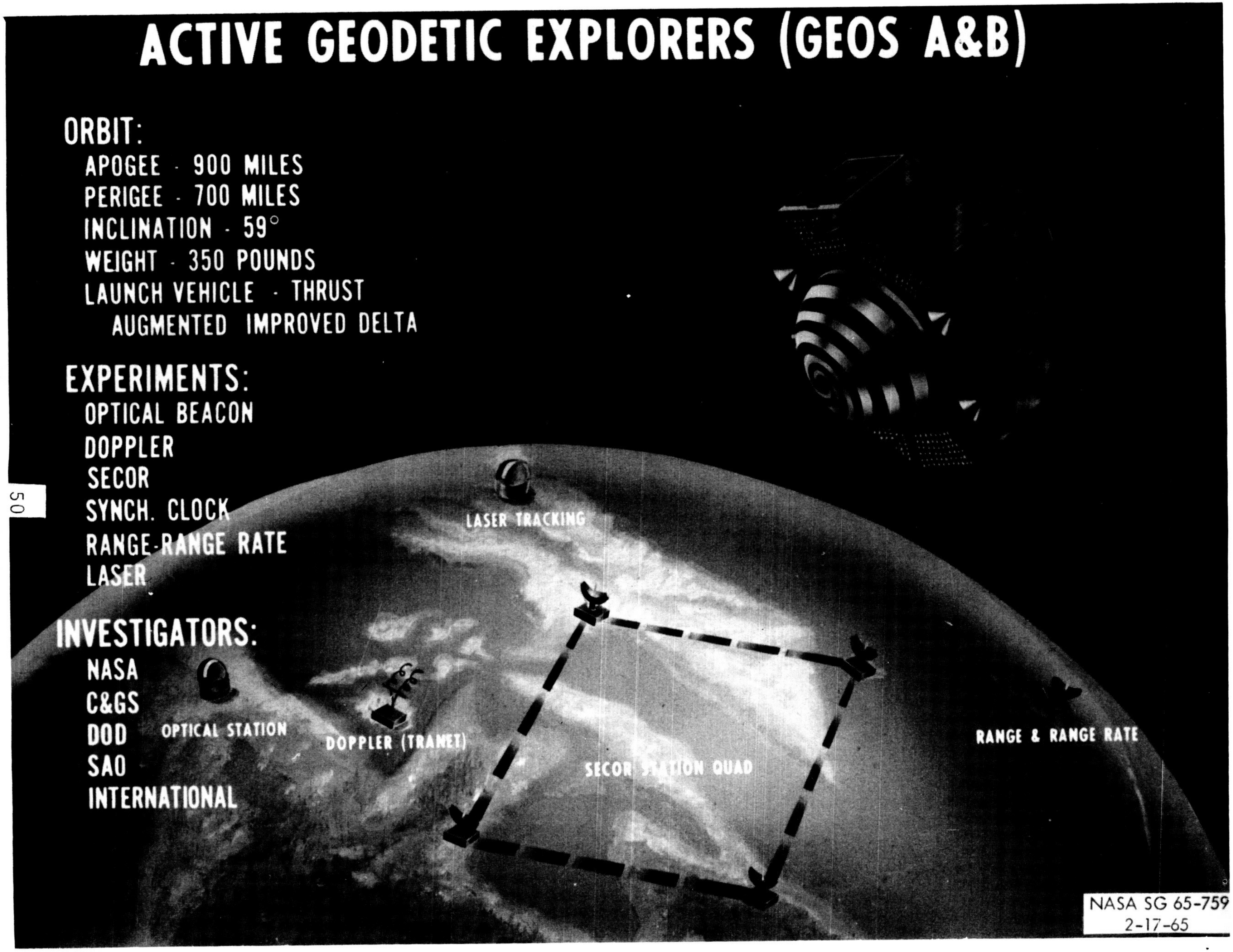
   C. Reber and J. E. Cooley
   Goddard Space Flight Center

3. Direct measurement of atmospheric pressures, 10^{-6} to 10^{-10} mm. Hg, densities, and temperatures, with three Redhead gages

   G. P. Newton
   Goddard Space Flight Center

4. Distribution of ions in the upper atmosphere with radio frequency 3-stage ion mass spectrometer (0.5 - 2.5, 3.5 - 4.5, and 13 - 19 AMU)

   H. A. Taylor, H. C. Brinton, R. A. Pickett
   Goddard Space Flight Center


ACTIVE GEODETIC EXPLORERS (GEOS A&B)
ORBIT:
APOGEE - 900 MILES
PERIGEE - 700 MILES
INCLINATION - 59°
WEIGHT - 350 POUNDS
LAUNCH VEHICLE - THRUST AUGMENTED IMPROVED DELTA
EXPERIMENTS:
OPTICAL BEACON
DOPPLER
SECOR
SYNCH. CLOCK
RANGE-RANGE RATE
LASER
INVESTIGATORS:
NASA
C&GS
DOD
SAO
INTERNATIONAL
LASER TRACKING
OPTICAL STATION
DOPPLER (TRANET)
SECOR STATION QUAD
RANGE & RANGE RATE
NASA SG 65-759
2-17-65

PAGEOS AND GEOS

In the National Geodetic Satellite Program both active and passive Explorer satellites are being developed. The program objectives are to improve the accuracy of geocentric positions of geodetic datum points. The passive satellite, PAGEOS, will be flown in a near circular, polar orbit at an altitude of about 2300 miles. The active satellites, GEOS-A and B, are planned for orbits with a perigee of about 690 miles, apogee of 690 to 920 miles, and inclinations of 59° and 80°, respectively. Three government agencies will be the main participants in the program -- the Department of Commerce, the Department of Defense, and NASA. The international geodetic community will be invited to participate in the planning and establishment of a cooperative observing network. The first was launched on November 6, 1965, to become Explorer XXIX.

Six satellite geodesy systems are utilized. The systems are as follows:

1. S-band range and range rate

2. Optical beacon

3. Passive satellite triangulation

4. SECOR

5. Laser reflector tracking

6. Doppler

The following individuals have primary responsibility for use of the data from particular observational techniques.

1. O. W. Williams
   Air Force Cambridge Research Laboratories

   Photographic observations by PC 1000 Air Force camera teams of flashing optical beacons on GEOS in the simultaneous long and short arc modes to accomplish geodetic ties.

2. Captain L. W. Swanson
   U. S. Coast and Geodetic Survey

   Passive satellite triangulation by means of simultaneous observations of PAGEOS to derive a figure of the Earth with a minimum of hypothesis about gravity or the loca vertical.

3. J. S. McCall
Army Corps of Engineers

Use of basic observational techniques to accomplish intercontinental, interdatum, and interisland geodetic ties and to provide a scale for the optical triangulation networks.

4. Cdr. C. L. Limerick
Bureau of Naval Weapons

Use of Doppler system to refine the description of the earth's gravity field (dynamic geodesy).

5. W. M. Kaula, M. Caputo, B. Douglas, D. Lewis
University of California, Los Angeles

Analysis of data to determine the gravitational field of the Earth.

6. C. Lundquist
Smithsonian Astrophysical Observatory

Analysis of geodetic satellite data to obtain a representation of the gravitational potential of the earth by a series of spherical harmonics; determination of positions of the 12 Baker-Nunn stations on a common coordinate system; determination of the relationships of the major geodetic datums.

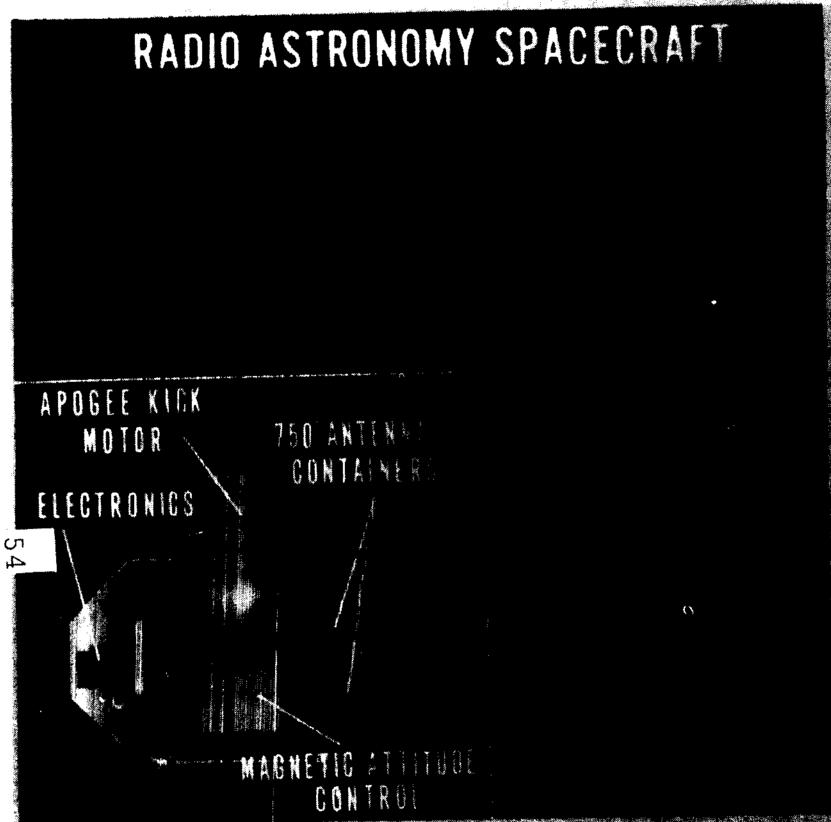
7. I. I. Mueller, S. Cushman, H. D. Preuss
Ohio State University

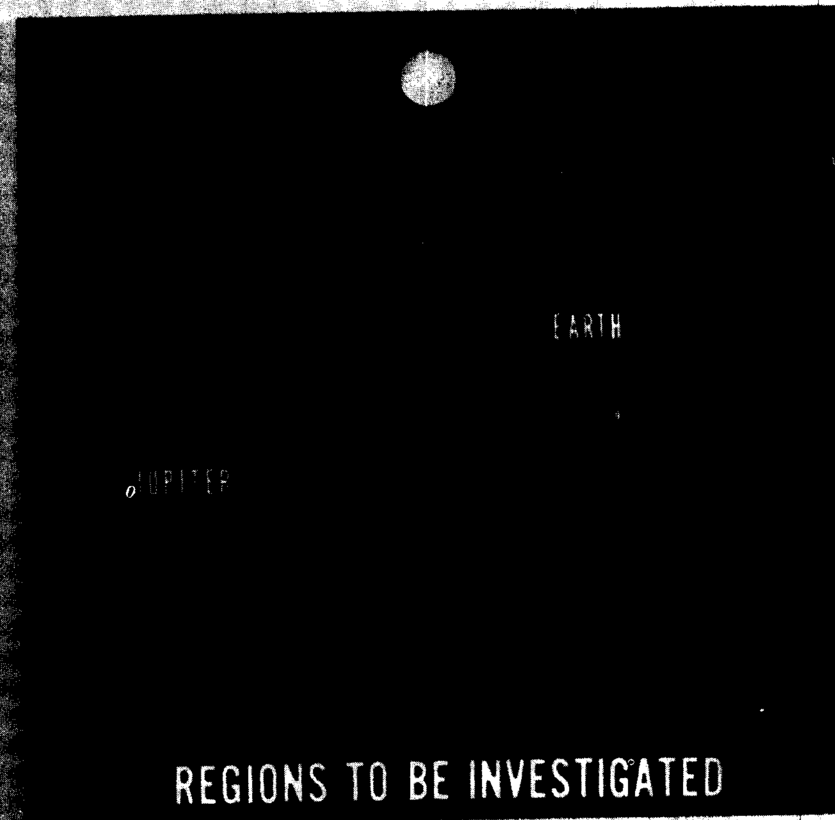
Geometric-geodetic analysis of observation results using both simultaneous and orbital methods.

8. J. H. Berbert
GSFC

Analysis of the accuracy of radio and optical geodetic tracking systems.

RADIO ASTRONOMY EXPLORER





GROSS WEIGHT 285 LBS
ANTENNA WEIGHT 70 LBS
EXPERIMENTS - 5
POWER - 22 WATTS

STABILIZATION - GRAVITY
LAUNCH VEHICLE -
THRUST AUGMENTED
IMPROVED DELTA

ORBIT
3700 MILES
CIRCULAR
INCLINATION - 50°
STATUS - LAUNCH IN 1967

NASA SG 65-779
2-17-65

RADIO ASTRONOMY EXPLORERS

The Radio Astronomy Explorer is designed to measure the intensity and direction of radio signals from celestial sources in the frequency range from 0.3 Mc to 20 Mc. The first RAE will be launched into a circular orbit of 3700 mile diameter with an inclination of 58° by means of a Delta launch vehicle and apogee kick motor. Two missions have been approved, and the first flight is scheduled for 1967. The experiments which have been selected are as follows:

RAE - A & B

1. Measurements of the impedance behavior of the antenna and of the local plasma parameters by use of a capacity probe, an analogue impedance probe, and an electron trap (200 kc - 5 mc).

   R. G. Stone, R. Bourdeau, J. Donley,
   R. Somerlock, J. Guthrie, and J. Kane
   Goddard Space Flight Center

2. Long wavelength solar and planetary emissions by means of a long antenna and a "fast burst" radiometer.

   R. G. Stone, J. Alexander, and H. Malitson
   Goddard Space Flight Center

3. Intensity distribution of cosmic radio emissions at frequencies below the ionospheric cutoff (0.3 - 10 Mc) by means of two long directive antennas and a radiometric system.

   R. G. Stone, R. Weber, and L. Brown
   Goddard Space Flight Center

OWL EXPLORERS

The OWL Explorer is a satellite designed to study near-earth atmospheric phenomena, particularly the characteristics of aurora and of the airglow, as they correlate with the trapped radiation belts and precipitated radiation. Diurnal and conjugate effects are to be investigated.

Two identically designed and equipped satellites will be launched one month apart in 1967. Each will be placed in a circular orbit at altitudes of approximately 500 miles (800 km) and 450 miles (700 km) respectively with an inclination of 80°. The two orbits will have coincident lines of nodes.

Rice University is responsible for the design, development, fabrication, integration, and testing of the satellite, including pre-launch checkout and preparation. Facilities of NASA may be used for any required testing beyond the capability of Rice University. Each OWL is planned to weigh 140 pounds, and will have passive magnetic orientation. The two OWL's will differ in the directions of their magnetic axes. While one OWL views the northern hemisphere, the other will view the southern.

The experiments to be flown on the two OWL's are the following:

1. Coordinated measurement of the light of aurorae and of the energetic particles causing them.

   B. J. O'Brien

2. Intensity of the auroral light at the wavelengths 5577A (oxygen), 3914A (nitrogen), and 4861A (hydrogen).

   B. J. O'Brien, H. Goldwire

3. Flux of electrons and protons bombarding the atmosphere and becoming trapped; their energy spectra and pitch angles.

   B. J. O'Brien, J. Freeman, D. C. Laughlin,
   R. La Quey, H. Goldwire, T. Winiecki

4. Temporal and spatial variations in the pitch-angle distribution of electrons with $E > 40$ Kev.

   B. J. O'Brien, L. Westerlund, D. Criswell

5. Number flux and total energy of fast neutral hydrogen atoms.

   B. J. O'Brien, R. Allum, A. J. Dessler

6. Measurement of the local-time and conjugate-area variations of aurorae, of the boundary of trapping precipitated fluxes, and of solar proton fluxes.

   B. J. O'Brien

7. Intensity of light at 5577A, 3914A, and 4816A.

   B. J. O'Brien

8. Spatial distribution of the light emitted in aurorae

   B. J. O'Brien, M. Trichel

9. Monitoring of the flux of solar cosmic rays and their energy deposition in the atmosphere in both hemispheres.

   B. J. O'Brien, R. Haymes, L. Westerlund
   H. Goldwire, C. Laughlin

10. Monitoring of the flux of cosmic rays and of the albedo.

   B J. O'Brien, L. Westerlund, C. Laughlin

OSSA SCIENTIFIC BALLOON PROGRAM

The Office of Space Science and Applications (OSSA) supports a program of balloon flights to carry scientific instruments into space to the altitudes available to balloons.

Balloon launch sites are available to NASA investigators at:

Fort Churchill, Canada, for launches from

June to September

Flin Flon, Canada, for launches from

June to September

Palestine, Texas

Page, Arizona

Equipment needed for determining balloon altitude and orientation will be provided. Telemetry equipment can be provided if desired. An FM/FM telemetry system is most commonly used.

Experiments supported have investigated cosmic rays, auroral activity, the solar corona, and interplanetary dust.

X-15A-2 AND CONVAIR 990A RESEARCH AIRPLANES

X-15A-2

The X-15A-2 research airplane is a modified version of the standard X-15, and reaches an altitude of more than 200,000 feet for about two minutes.

The X-15A-2 provides a unique vehicle for scientific payloads. Recovery and immediate availability of the payload is provided. The flights must be made in the immediate vicinity of the NASA Flight Research Center, Edwards Air Force Base, California. For safety all flights are restricted to the daylight hours. Flights take place on a regular basis and proposals are acceptable at any time. The pilot is available to aid the experimenter.

The following experiments are scheduled for flight.

1. Ultraviolet stellar photographic photometry at 2100A, 2600A, and 4200A. Stellar spectra in range 1800 - 3000A.

   A. D. Code, T. E Houck, T. Bless, L. Doherty,
   J. McNall, and D. Schroeder
   University of Wisconsin

2. Background brightness of sky and earth

   A. D. Code
   University of Wisconsin

Convair 990A

In addition to the X-15A-2 airplane, a modified Convair 990 plane has been acquired by NASA for use in research. It can carry bulky and heavy observational instruments to altitudes of 40,000 feet. It is based at the NASA Ames Research Center, Moffett Field, California, but may be operated from almost any advanced field.

SOUNDING ROCKETS

The NASA is supporting research with sounding rockets in the following disciplines:

Meteorology
Ionospheres and Radio Physics
Aeronomy
Solar Physics
Astronomy
Energetic Particles and Magnetic Fields
Micrometeorites and Cosmic Dust
Planetary Observations
Biology

Investigations are carried out with the use of sounding rockets because this is often the best way in which to carry out investigations in the upper atmosphere or to make observations from above the atmosphere. Instrumentation intended for use on satellites and space probes are tested with flights on sounding rockets. Some two hundred launches with scientific payloads will be made in the current year. Telemetry, recovery and pointing control are available.

The available rockets are the Arcas, the Nike-Cajun, the Nike Apache, the Aerobee 150/150A, the Argo D-4, the Argo D-8, the Astrobee 1500, the Aerobee 300, the Aerobee 350 and the Nike-Tomahawk.

The following investigators have experiments scheduled on October 15 for launch on sounding rockets. The listing is in the order of the scheduled flights.

Investigator	Institution	Experiment	Launch Site*
C. A. Barth	U. of Colorado	Cometary studies	WI
W. G. Fastie	Johns Hopkins U.	Cometary studies	WI
L. H. Brace	GSFC	Thermosphere	FC
N. H. Farlow	Ames Res. Center	Micrometeorites	WS
C. L. Hemenway	Dudley Observ.	Interplanetary matter	WS
C. A. Barth	U. of Colorado	Airglow	WS
W. G. Fastie	Johns Hopkins U.	Auroral spectra	FC
L. H. Brace	GSFC	Thermosphere	WI
J. H. Hoffman	NRL	Atmospheric structure	WI
T. M. Donahue	U. of Pittsburgh	Aeronomy	FC
C. L. Hemenway	Dudley Observ.	Interplanetary matter	WS
W. H. Hansen	U. of Michigan	Air density	WI

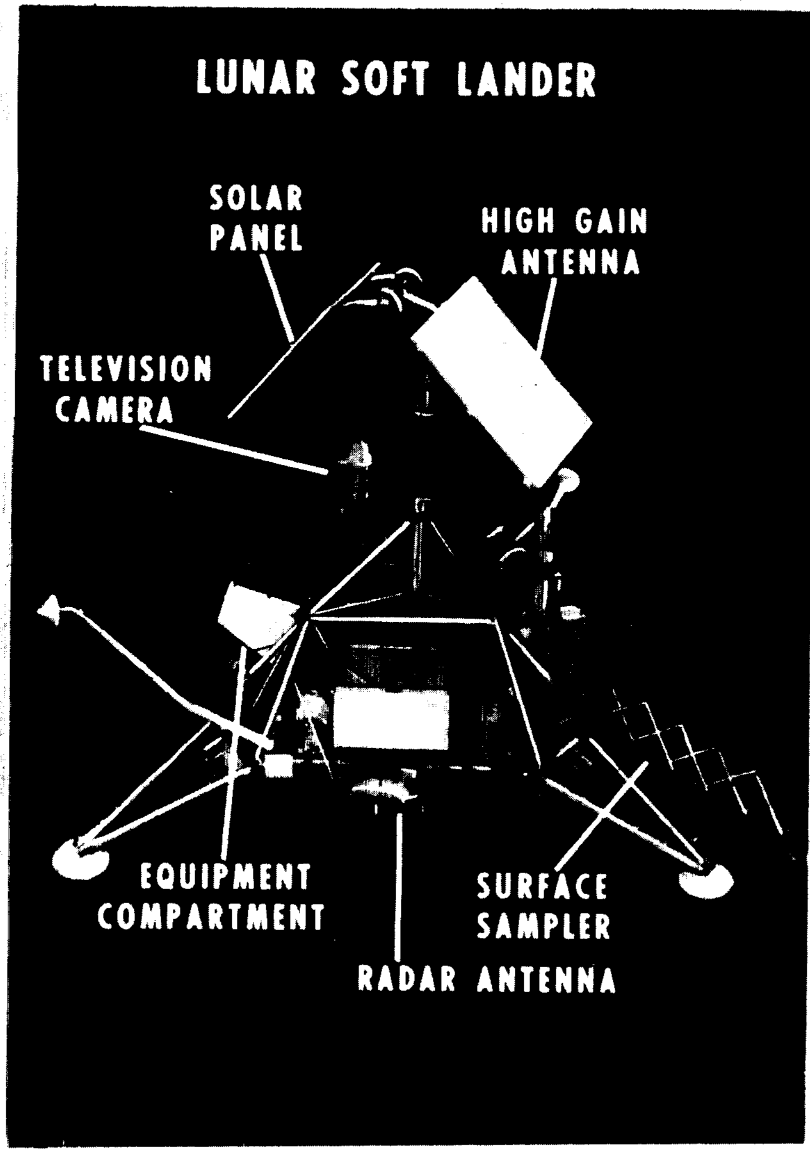
*WI refers to Wallops Island; WS to White Sands; FC to Fort Churchill; and PB to Point Barrow.

Investigator	Institution	Experiment	Launch Site*
E. J. Schaefer	U. of Michigan	Atmospheric structure	FC
L. H. Brace	GSFC	Thermosphere	WI
E. A. Martell	NCAR	Atmospheric structure	WS
J. F Bedinger	Geophysics Corp. of America	Luminescent cloud	FC
W. G. Fastie	Johns Hopkins U.	Auroral spectra	FC
W. G. Fastie	Johns Hopkins U.	Day airglow	WI
J. A. Lockwood	Univ. of New Hamp.	Energetic particles	FC
R. C. Haymes	Rice Univ.	Magnetic fields	WI
W. B. Murcray	U. of Alaska	Aurorae	FC
T. L. Aggson	GSFC	Fields and plasmas	WI
R. C. Haymes	Rice U.	Magnetic fields	WI
D. S. Evans	GSFC	Aurorae	FC
B. J. O'Brien	Rice U.	Aurorae	FC
J. P. Heppner	GSFC	Fields and plasmas	FC
C. E. Fichtel	GSFC	Energetic particles	FC
B. J. O'Brien	Rice U.	Aurorae	FC
C. E. Fichtel	GSFC	Energetic particles	FC
J. A. Lockwood	U. of New Hamp.	Cosmic ray intensities	WI, FC
S. A. Bowhill	U. of Illinois	Ionosphere during IQSY	WI
S. J. Bauer & N. W. Spencer	GSFC	Geoprobe	WI
R. T. Bettinger	U. of Maryland	Ionospheric physics	WI
S. A. Bowhill	U. of Illinois	Ionosphere during IQSY	WI
S. J. Bauer	GSFC	Ionosphere	WI
W. Calvert	Bureau of Standards	Ionospheric physics	WI
R. T. Bettinger	U. of Maryland	Ionospheres	WI
W. J. Heikkila	Southwest Center for Advanced Stud.	Ionospheres	WI
K. Fredga	GSFC	Solar physics	WS
W. A. Rense	U. of Colorado	Solar spectroscopy	WS
W. S. Muney	GSFC	Solar studies	WS
H. E. Hinteregger	AFCRL	Monochromatic UV	WI
W. S. Muney	GSFC	Solar studies	WS
H. C. McAllister	U. of Hawaii	Solar physics	WS
L. W. Acton	Lockheed	Solar x-radiation	WS
W. S. Muney	GSFC	X-ray spectrometry of sun	WS
L. W. Acton	Lockheed	Solar x-radiation	WS
R. Scolnik	GSFC	Cometary studies	WS
R. Scolnik	GSFC	Stellar spectra	WS
J. E. Kupperian	GSFC	Stellar spectroscopy	WI
D. C. Morton	Princeton U.	Stellar spectra	WS
R. Giacconi	American Science & Engineering		WS
A. Boggess	GSFC	Stellar spectra	WS

Investigator	Institution	Experiment	Launch Site*
A. Boggess	GSFC	Planetary spectra	WS
D. C. Morton	Princeton U.	Stellar spectra	WS
J. K. Alexander	GSFC	Radio astronomy	WI
F. T. Barath	JPL	High altitude radar	WS
E. F. Sorgnit & A. A. Rudman	GSFC	Aero instrumentation test	WI
F. A. Volpe	GSFC	FACS test	WS
W. S. Smith	GSFC	Synoptic rocket grenades	FC, WI, PB
J. J. Horvath	U. of Michigan	Atmospheric structure	FC
E. Hilsenrath	GSFC	Ozone	WS
D. F. Heath	GSFC	Meteorology	WS

In addition to the above investigations, a number are scheduled for launching from foreign launch sites.

SURVEYOR



GROSS WEIGHT	- 2470 LBS
INSTRUMENT WEIGHT	- 125 LBS
EXPERIMENTS	- 6
POWER	- 88 WATTS
STABILIZATION	- ACTIVE 3 AXIS
PROPULSION	
RETROROCKET	- SOLID
VERNIER ROCKETS	- LIQUID
DESIGN LIFE	- 1 LUNAR DAY
LAUNCH VEHICLE	- ATLAS-CENTAUR
TRAJECTORY	- DIRECT ASCENT OR PARKING ORBIT
STATUS	- FIRST FLIGHT 1966

NASA SD63-1456
REV. 12/8/65

SURVEYOR

Surveyor is the NASA lunar exploration program concerned with the soft landing of unmanned instrumented spacecraft on the Moon. The first seven Surveyors will be engineering test models. These spacecraft will carry a single survey TV camera. The remaining three approved Surveyors will be operational missions with the following experimental payload:

1. Television - two survey cameras to obtain stereo ranging and to make visual observations of lunar surface topographic and terrain features.

E. M. Shoemaker - U.S. Geological Survey

G. P. Kuiper - University of Arizona

E. Whitaker - University of Arizona

J. J. Rennilson - Jet Propulsion Laboratory

E. C. Morris - U.S. Geological Survey

R. Altenhofer - U.S. Geological Survey

2. Micrometeorite Ejecta Detection - to determine flux, velocity, and mass of primary particles and secondary ejecta on the lunar surface.

W. M. Alexander - Goddard Space Flight Center

O. E. Berg - Goddard Space Flight Center

L. Secretan - Goddard Space Flight Center

C. W. McCracken - Goddard Space Flight Center

3. Seismometer - to investigate seismic activity on the Moon using a single-axis short-period seismometer.

G. H. Sutton - Lamont Geological Observatory

M. Ewing - Lamont Geological Observatory

F. Press - California Institute of Technology

4. Alpha Scattering - to perform elemental analysis of lunar surface material.

A. Turkevich - University of Chicago

J. Patterson - Argonne National Laboratory

E. Franzgrote - Jet Propulsion Laboratory

5. Surface Sampler/Soil Mechanics - to determine surface structure and mechanical properties of lunar surface material.

R. F. Scott - California Institute of Technology

R. M. Haythornwaite - University of Michigan

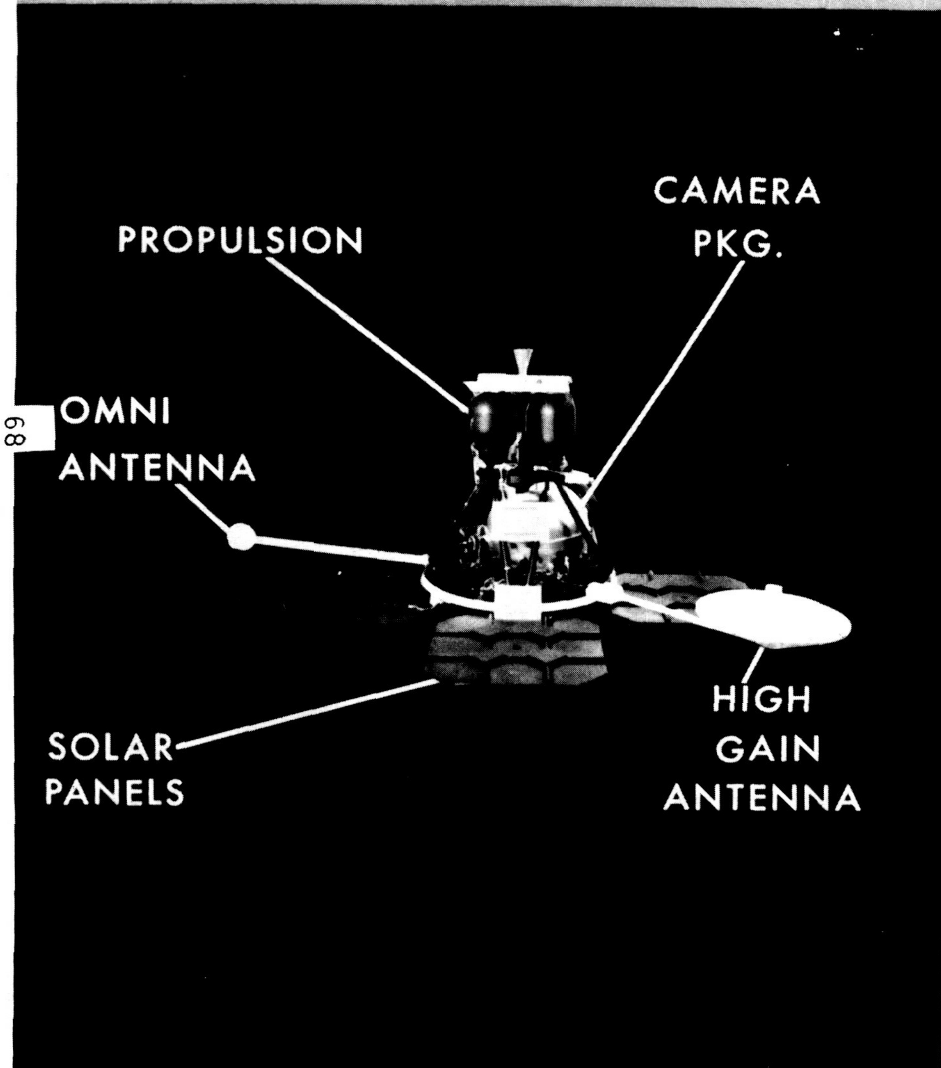
R. A. Liston - U. S. Army Ordnance Land Locomotion Laboratory

6. Touchdown Dynamics - to determine mechanical properties of lunar surface material.

S. A. Batterson - Langley Research Center

The Surveyor Program will assist the Apollo Program by providing topographic and lunar surface bearing strength information needed to certify suitable landing sites.

LUNAR ORBITER



GROSS WEIGHT	845 LBS
INSTRUMENT WEIGHT	150 LBS
INVESTIGATIONS	TELEMETERED FILM PHOTOGRAPHY SELENODESY ENVIRONMENTAL MEASUREMENTS
POWER	235 WATTS (MAX)
STABILIZATION	3 AXIS
DESIGN LIFE	1 YEAR [1 MONTH PHOTOG.]
LAUNCH VEHICLE	ATLAS-AGENA
TRAJECTORY	ECCENTRIC LUNAR ORBIT
STATUS	TEST PHASE

NASA SL64-201
REV. 12/8/65

LUNAR ORBITER

The Lunar Orbiter Program is concerned with the placement of unmanned instrumented spacecraft into close-in elliptical orbits about the Moon to support investigations of the lunar surface and the near-lunar environment. A series of five Lunar Orbiter spacecraft missions have been approved. The first spacecraft is scheduled to be launched in mid-1966. Subsequent launches are planned at three-month intervals.

The primary objective for the mission is to obtain detailed topographic, geologic, and small scale feature information about the lunar surface for use in selecting suitable landing sites for unmanned Surveyor and manned Apollo spacecraft. Each spacecraft will carry a photographic system capable of taking both medium and high resolution pictures on film, processing the exposed film, and scanning the images for transmission to earth.

The Lunar Orbiter missions will have two additional objectives which take advantage of the extended orbital lifetime. One of these objectives is to provide precise trajectory information which will lead to an improvement in the definition of the lunar gravitational field. The responsibility for analyzing this information has been given to a team of Langley Research Center and Jet Propulsion Laboratory investigators for the selenodesy experiment approved for these missions. The other objective is to provide measurements of the micrometeoroid flux and radiation flux in the lunar environment for spacecraft performance analysis and for a preliminary assessment of their potential hazards to future manned lunar missions. Langley Research Center will be responsible for the analysis of these measurements.

Ten areas on the lunar surface providing a representative sampling of major terrain types--mare, highlands, craters--have been selected by NASA for the planning of the first mission. These areas are located in a narrow belt along the Moon's equator between 43 degrees east longitude and 56 degrees west longitude. The locations of the centers of these areas are as follows:

Area No.	Longitude	Latitude
1	$42^{\circ}20'$E	$0^{\circ}50'$S
2	$36^{\circ}00'$E	$0^{\circ}10'$S
3	$24^{\circ}50'$E	$0^{\circ}20'$N

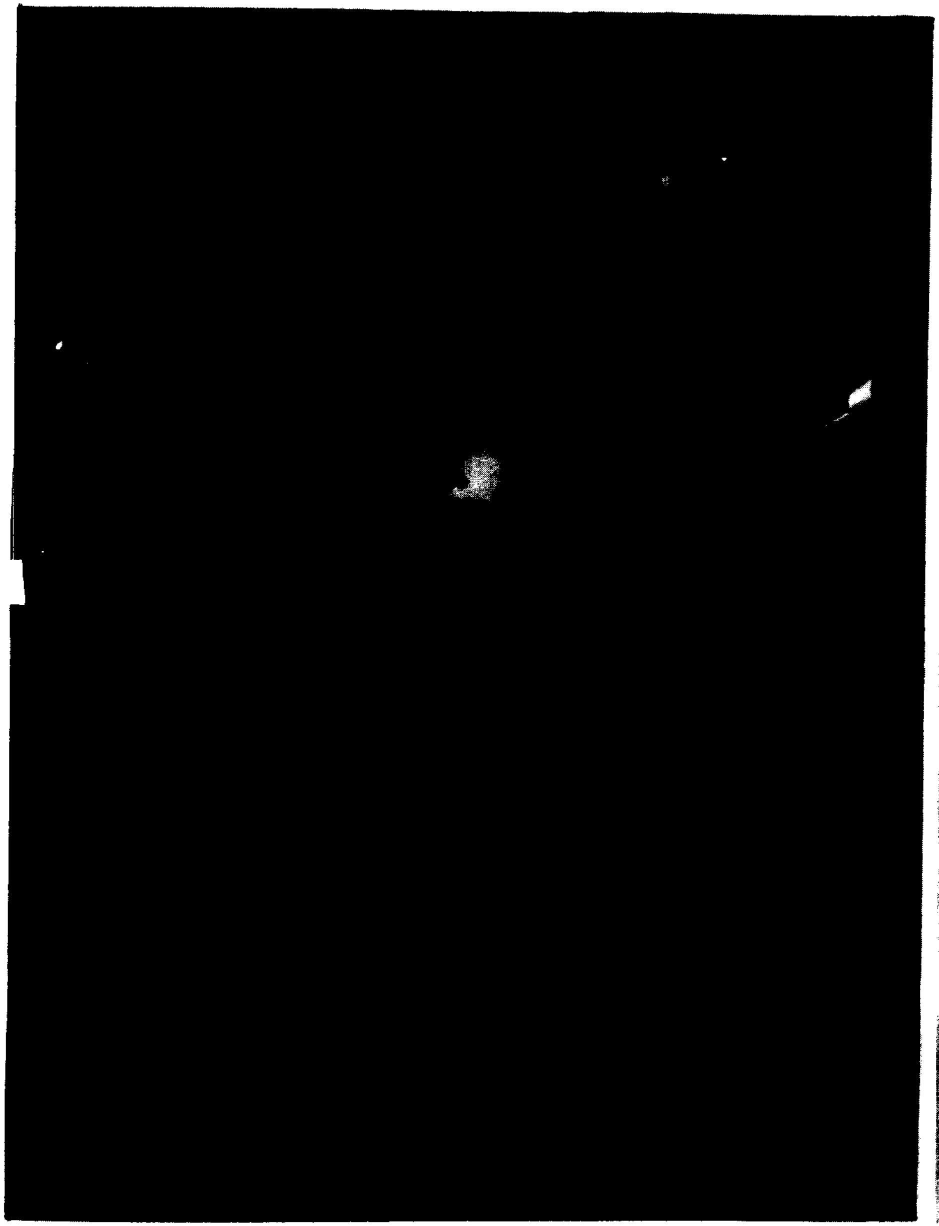
Area No.	Longitude	Latitude
4	$12^{\circ}50'$E	$0^{\circ}00'$
5	$1^{\circ}20'$W	$0^{\circ}25'$S
6	$2^{\circ}50'$W	$4^{\circ}00'$S
7	$22^{\circ}45'$W	$3^{\circ}45'$S
8	$36^{\circ}30'$W	$3^{\circ}30'$S
9	$43^{\circ}50'$W	$3^{\circ}15'$S
10	$56^{\circ}05'$W	$3^{\circ}40'$S

A series of one meter, high-resolution, contiguous pictures covering an area of 16 by 64 km and eight meter, medium-resolution stereo pictures covering an area of 37 by 94 km will be taken as the spacecraft overflies each of the ten areas. About thirty days will be required for the acquisition and transmission of all the pictures to earth. The analysis of the information contained in the pictures will be carried out under a NASA coordinated program by the Langley Research Center, the Manned Spacecraft Center, the Astrogeologic Branch of the U.S. Geological Survey, the Air Force Aeronautical Chart and Information Center, and the Army Map Service.

Upon completion of the photographic phase of the mission, range and range-rate radio tracking data from the spacecraft will be obtained continuously for a period of 30 days and then intermittently for a period of about 10 months in order to satisfy the requirements of the selenodesy experiment.

When successful Surveyor landings have been made on the lunar surface, subsequent Lunar Orbiter missions will be planned to photograph the surrounding area at high resolution in order to certify the site for manned landings. The Surveyor surface information at one position will then hopefully be extrapolated with some confidence over a much larger area.

PIONEER



GROSS WEIGHT	- 140 LBS
INSTRUMENT WEIGHT	- 34 LBS
INVESTIGATIONS	- 6
POWER	- 50 WATTS
STABILIZATION	- SPIN
DESIGN LIFE	- 6 MONTHS
LAUNCH VEHICLE	- THRUST AUGMENTED IMPROVED DELTA
TRAJECTORY	- INTERPLANETARY
STATUS	FIRST FLIGHT LATE 1965

NASA SD63-1453
REV. 12/8/65

PIONEER

NASA, beginning in late 1965, will launch a series of spacecraft, designated Pioneer, to monitor interplanetary space during and following the International Quiet Sun Year. The scientific payload for Pioneers A & B is as follows:

1. Fluxgate Magnetometer - measures the interplanetary magnetic field.

N. F. Ness (GSFC)

2. Plasma Probe - Faraday cup with split collector measures the characteristics of the interplanetary plasma including the flux, energy spectrum, direction, and angular distribution of positive ions and electrons.

H. S. Bridge (MIT)

A. J. Lazarus (MIT)

F. Scherb (MIT)

3. Cosmic Ray Telescope - measures proton and alpha particle fluxes and energy spectra.

J.A. Simpson (Chicago)

J. Lamport (Chicago)

C.Y. Fan (Chicago)

4. Radio Propagation Investigation - measures the interplanetary electron density and its variation.

V. R. Eshleman (Stanford)

O. K. Garriott (MSC)

R. L. Leadabrand (SRI)

A. M. Peterson (SRI & Stanford)

5. Cosmic Ray Detector - studies the lower energy portion of cosmic ray spectrum to determine degree and variations of anisotropy.

K. G. McCracken (Graduate Res. Center of the Southwest)

W. C. Bartley (Graduate Res. Center of the Southwest)

U. R. Rao (Graduate Res. Center of the Southwest)

6. Plasma Probe - curved plate electrostatic particle detector measures characteristics of the interplanetary plasma including the flux, energy spectrum, direction, and angular distribution of positive ions and electrons.

J. H. Wolfe (Ames)

R. W. Silva (Ames)

PIONEER C AND D PAYLOAD

1. Magnetometer - a three-orthogonal component fluxgate magnetometer, each sensor having a dynamic range of ±200 gamma and a sensitivity of 0.2 gamma to monitor the interplanetary magnetic field and its fluctuations.

C. P. Sonett (Ames Research Center)

W. J. Kerwin (Ames Research Center)

2. Plasma Probe - a quadrispherical electrostatic analyzer, employing eight separate current collectors, will provide angular distribution in the polar meridian plane. Energy coverage is from 200 ev to 16 kev in two sets of ranges for protons and 3 ev to 1 kev for electrons.

J. H. Wolfe (Ames Research Center)

R. W. Silva (Ames Research Center)

3. Cosmic Ray Telescope - a time-multiplexed triple-purpose telescope will measure the intensity and energy spectrum of protons, alpha particles and heavier nuclei in the range 1 Mev to greater than 1 Bev.

W. R. Webber (University of Minnesota)

G. Bingham (University of Minnesota)

4. Cosmic Ray Detector - high and low counting rate detectors capable of resolving the anisotropy in the galactic and solar cosmic radiation.

K. G. McCracken (Graduate Res. Ctr. of the Southwest)

W. C. Bartley (Graduate Res. Ctr. of the Southwest)

U. R. Rao (Graduate Res. Ctr. of the Southwest)

5. Radio Receivers - two receivers, one at 50 Mc/s and the other at 425 Mc/s for receiving signals transmitted by two transmitters (30 and 300 kw) emitted from the Stanford 150 foot steerable parabolic dish; for measuring average interplanetary electron density between the Earth and the probe, and its time variations.

V. R. Eshleman (Stanford University)

O. K. Garriott (Stanford University)

A. M. Peterson (Stanford University)

R. L. Leadabrand (Stanford University)

B. B. Lusignan (Stanford University)

6. Cosmic Dust Detector - four sensors mechanically and electrically integrated to measure the particle time of flight, approximate radiant, impact impulse and cross section of impact crater to determine mass, density, and orbits of dust particles.

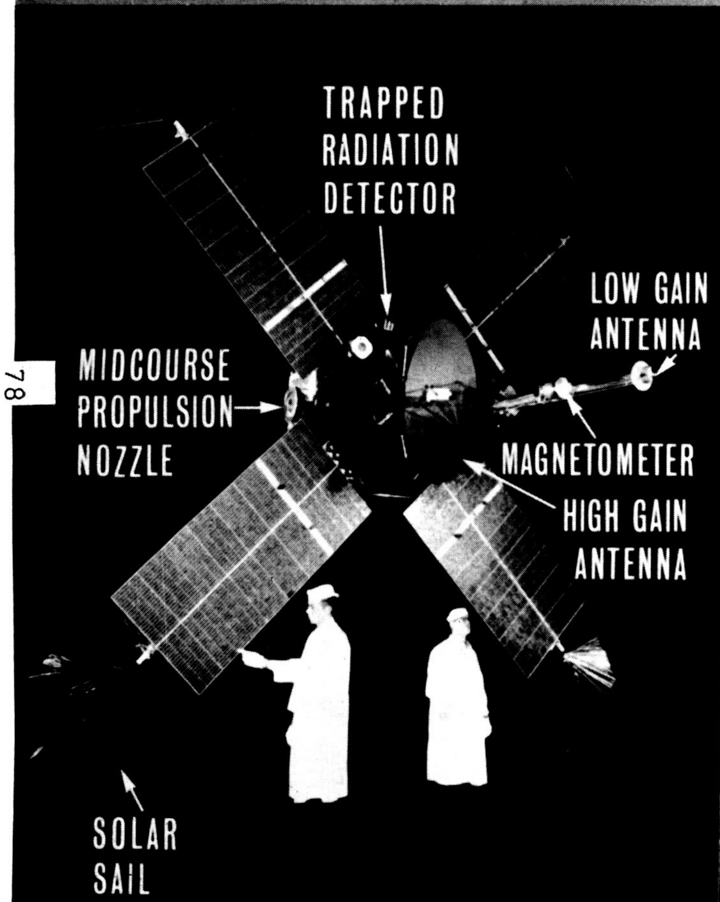
W. M. Alexander (GSFC)

O. E. Berg (GSFC)

C. S. Nilsson (GSFC)

L. Secretan (GSFC)

MARINER MARS–1964



GROSS WEIGHT	575 lbs.
INSTRUMENT WEIGHT	60 lbs.
INVESTIGATIONS	
TELEVISION	RADIATION DETECTOR
MAGNETOMETER	COSMIC RAY TELESCOPE
PLASMA PROBE	DUST DETECTOR
ION CHAMBER	OCCULTATION
POWER ≅	310 WATTS @ MARS
STABILIZATION	3 AXIS
DESIGN LIFE	250 DAYS
LAUNCH VEHICLE	ATLAS AGENA
MISSION	MARS FLY-BY
ENCOUNTER	MID-JULY 1965

NASA SL65-6
1-4-65

MARINER

Although the primary objectives of the Mariner IV mission were accomplished successfully with the July 14 fly-by of Mars, this spacecraft continued transmitting good interplanetary data until about October 1, 1965. At that time its transmitter was switched to the omnidirectional antenna because the geometry was such that the Earth would soon pass outside the beam of the fixed directional antenna on board the spacecraft.

About April 1, 1966, the spacecraft will be at superior conjunction, and it may be possible to study the solar corona using the 210-foot radio telescope now being constructed at the Mars site at Goldstone, California.

On August 15, 1967, the spacecraft will be at opposition. The distance to the spacecraft at closest approach will be 29 million miles. If the spacecraft and its scientific instruments are still operating at that time, it should be possible to obtain approximately six months of interplanetary data. The following investigations may be conducted:

(1) Magnetometer - measures the interplanetary magnetic field using a sensitive 3-axis helium magnetometer.

E. J. Smith	(JPL)
P. J. Coleman, Jr.	(UCLA)
L. Davis, Jr.	(CIT)
D. E. Jones	(Brigham Young & JPL)

(2) Plasma Probe - measures the character of the interplanetary plasma including flux, energy, and direction of protons.

H. S. Bridge	(MIT)
A. J. Lazarus	(MIT)
C. W. Snyder	(JPL)

(3) Cosmic Ray Telescope - determines flux and energy spectrum of low, medium and high energy protons and alpha particles using silicon solid-state detectors.

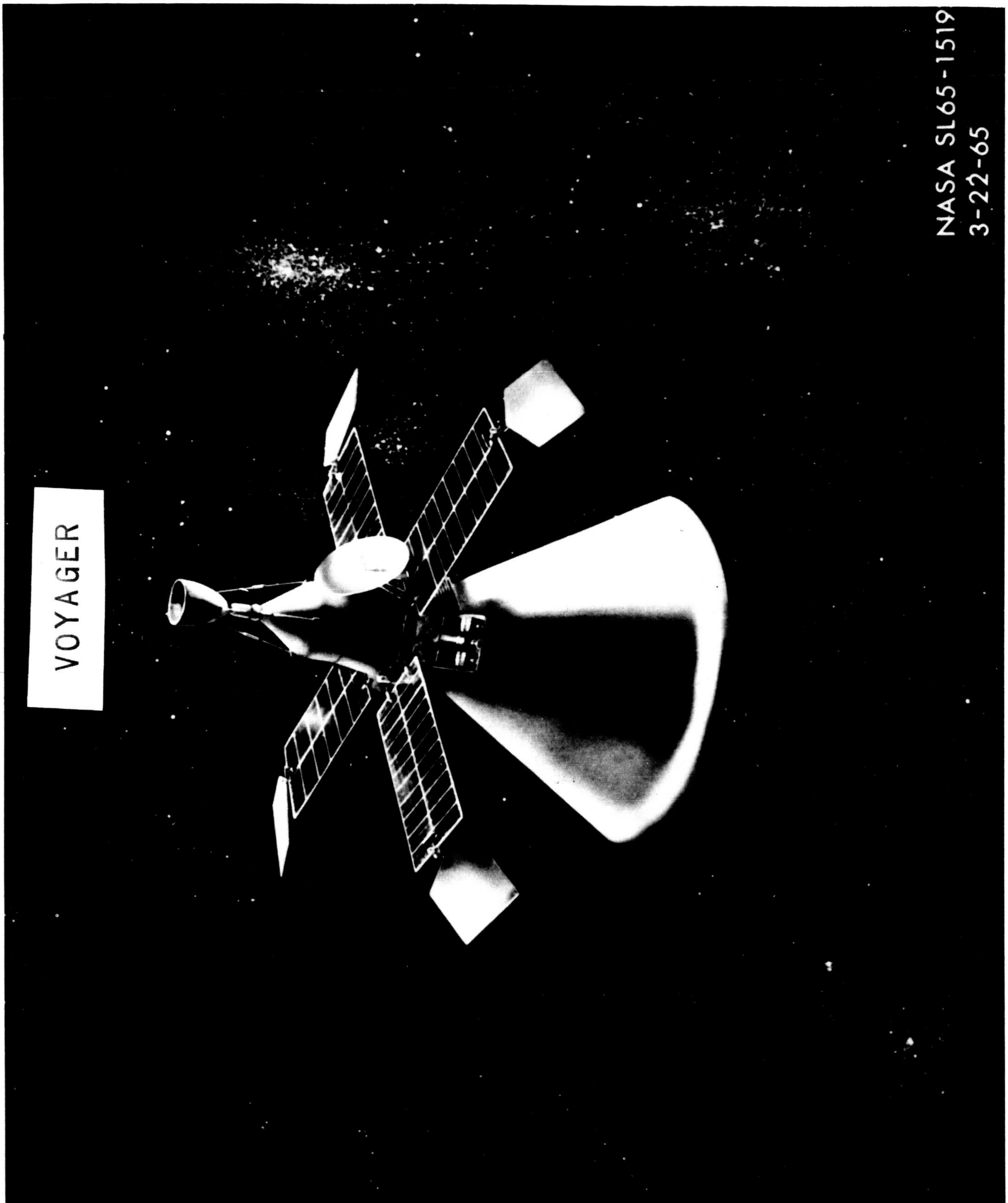
J. A. Simpson	(Chicago)
J. O'Gallagher	(Chicago)

(4) Low Energy Cosmic Ray - studies the angular distributions, energy spectra and time histories of solar cosmic rays and energetic electrons in interplanetary space.

J. A. Van Allen	(SUI)
L. A. Frank	(SUI)
S. M. Krimigis	(SUI)

(5) Cosmic Dust - measures flux, direction, mass and velocity distribution of micrometeorites in interplanetary space.

W. M. Alexander	(GSFC)
O. E. Berg	(GSFC)
C. W. McCracken	(GSFC)
L. Secretan	(GSFC)
J. L. Bohn	(Temple)


VOYAGER
NASA SL65-1519
3-22-65

VOYAGER

The primary objective of the Voyager Program is to carry out scientific investigations of the Solar System by instrumented, unmanned spacecraft which will fly-by, orbit, and/or land on the planets. Emphasis will be placed on acquisition of scientific information relevant to the origin and evolution of the Solar System; the origin, evolution and nature of life; and the application of this information to an understanding of terrestrial life.

The first scheduled phase of the program is the exploration of Mars. The primary objective of the Voyager missions to Mars beginning in 1971, is to obtain information relevant to the existence and nature of extraterrestrial life, the atmospheric, surface and body characteristics of the planet, and the planetary environment by performing unmanned experiments on the surface of and in orbit about the planet. For the 1971 missions, primary emphasis will be placed on the orbiter with engineering capsule tests or probes to be included, if possible.

A secondary objective is to further our knowledge of the interplanetary medium between the planets Earth and Mars by obtaining scientific and engineering measurements while the spacecraft is in transit.

It is presently planned to launch two orbiting spacecraft on a single Saturn V during both the 1971 and 1973 Mars opportunities. The first scientific landed capsule missions are being planned for 1973. Orbiter and capsule missions to Mars at subsequent opportunities are also envisioned. Emphasis would be placed on larger landed scientific payloads.

Preliminary Design of the Spacecraft System will be completed in the Spring of 1966. This will be followed by detailed System Design which will be completed about the first of 1967. It is currently planned to select the 1971 orbiter experiments about July, 1966. In-house studies of possible 1971 capsule tests and probe are continuing. A decision on the 1971 capsule/probe concept is scheduled for May, 1966. A detailed schedule for the Voyager Capsule effort will be established at that time.

General areas of experimentation for the early missions are as follows:

I. Interplanetary Space Experiments

(cosmic radiation, solar plasma, magnetic fields, micrometeoroid flux)

II. Martian Orbiter Experiments

a. Atmosphere studies (chemical composition, temperature, and pressure and their diurnal variations, scale height, circulation patterns)

b. Planetary studies (gravitational and magnetic fields, mapping in the visible and infrared, topography, high resolution pictorial coverage of selected areas)

c. Planetary environment (radiant energy spectrum, charged particle energy and density, micrometeoroid flux)

III. Martian Lander Experiments

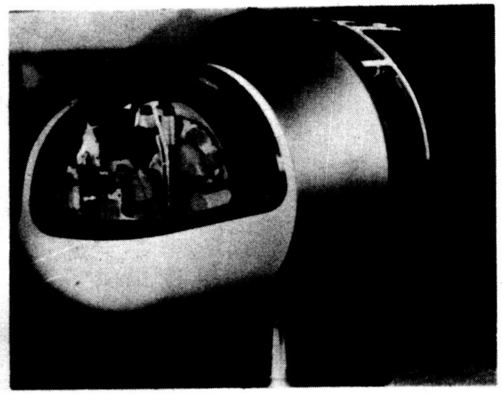
a. Atmosphere studies (complete chemical analysis, vertical temperature and pressure profiles, wind velocities)

b. Planetary studies (touchdown dynamics, chemical composition of crust, mineralogy, seismology, radioactivity)

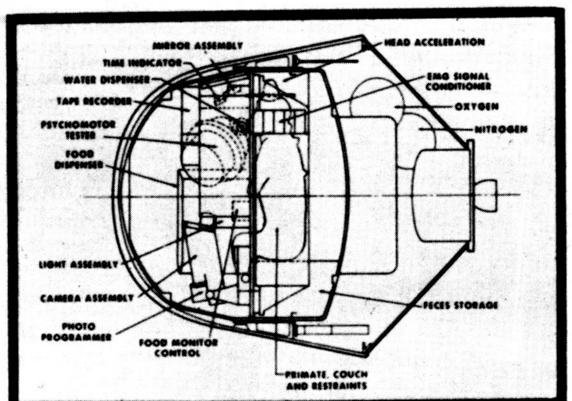
c. Actinic radiation (flux and energy spectrum) and energetic particle penetration to the surface.

d. Life detection (deviations from inorganic equilibrium, detection of organic compounds, optical activity)

BIOSATELLITE



MOCK-UP; 30-DAY PAYLOAD



COMPONENT INSTALLATION;
30-DAY PAYLOAD

GROSS WEIGHT

IN ORBIT	1175 LBS.
ON PARACHUTE	295 LBS.

INVESTIGATIONS

WEIGHTLESSNESS, RADIATION
CIRCADIAN RHYTHMS

TIME IN ORBIT

3, 21 AND 30 DAYS

POWER

3-DAY BATTERIES
21-DAY AND 30-DAY
FUEL CELL PLUS BATTERIES

RECOVERY

AERIAL OR FROM WATER

LAUNCH VEHICLE

TWO-STAGE,
THRUST-AUGMENTED DELTA

ORBIT

CIRCULAR 150 TO 180 MILES
INCLINATION 33.5°

PLAN

SIX FLIGHTS, FIRST FLIGHT
LATE 1966

SP65-16321
12-8-65

BIOLOGICAL SATELLITES

The Biosatellite Program is designed to study the effects on biological systems of the unique factors of the space environment. Among these are the effects of weightlessness, the effects of weightlessness combined with a known source of gamma radiation, and the removal of living systems from the direct influence of the Earth's periodicity. Living systems, exposed to simultaneous weightlessness and radiation, will be studied to determine if these environmental factors are synergistic (working together) or antagonistic or produce no significant effect compared to Earth laboratory controls.

Proposals for 187 Biosatellite experiments were submitted by scientists from universities, government, and industry. These were reviewed by panels of experts and nineteen experiments were selected for flight. The primary consideration during the review of the experiment proposals was whether each consisted of a valid scientific investigation and a specific biologic hypothesis to be tested. The selected Biosatellite investigations involve mainly the effects of greatly decreased gravity on cells and higher organisms which have known gravity-sensing mechanisms, specifically those governing growth, polarization, and behavioral responses to gravity.

The experiments to be conducted in the Biosatellite deal with biologic functions at the cellular, tissue, organ, and organism levels in a wide variety of plants and animals. The phenomena to be studied at the cellular and tissue levels include biochemical reactions, genetic changes, embryologic development, growth and integrated function. Physiologic function, behavior, and performance will be monitored in more highly developed organisms such as primates.

The radiation-weightlessness experiments consist of plants, cells, and insects that will be exposed to precise doses of gamma radiation provided by an 85-strontium source. The radioactive source, enclosed in a tungsten-nickel-copper sphere, can be rotated to provide from 200 to 5000 Rads over a period of three days in orbit. Duplicate control experiments will be in the spacecraft, but shielded from the radiation by a tungsten backscatter shield.

Investigations will be made of circadian (24-hour) rhythms indigenous to the organism. These rhythms, primarily changes in body temperature, body activity and food consumption, will be studied in rats.

The hypothesis to be tested is whether the normal 24-hour behavior of these animals is affected by removing them from the Earth environment and periodicity.

In the primate, Macaca nemestrina or the pig-tailed monkey, we want to determine the effects of weightlessness on: (1) the central nervous system; (2) the cardiovascular system; (3) the renal system; (4) general metabolism; (5) musculoskeletal metabolism, especially calcium mobility; and (6) behavior and performance.

Three missions are required to accommodate the experiment payloads. The missions are categorized by their nominal time in orbit and the objectives of the experiments. Each mission will have a backup in case of failure. The first flight is planned for the third quarter of 1966 and the last flight will occur by the first quarter of 1968.

The 3-day flight, Biosatellite A, consists of general biology experiments to determine effects on living organisms of the combination of radiation, weightlessness, and the absence of the Earth's rotation. The experiments include pepper and flowering plants, wheat seedlings, frog eggs, yeast, wasps, fruit flies, bacteria, amoeba, and embryonic beetles. Thirteen (13) experiments have been selected. Three of these, dealing with the development and growth of seedlings, have been combined.

The 21-day flight, Biosatellite C, consists of general biology experiments to determine the effects of weightlessness on plant morphogenesis, isolated human cells, gross body composition and function in mammals (rats), and circadian rhythms (biological clocks). Four experiments have been selected for flight.

The 30-day flight, Biosatellite D, consists of primate experiments to determine the effects of weightlessness on behavior and performance, the cardiovascular system, the nervous system (alertness, sleep-wakefulness, fatigue), and general metabolism. Two (2) experiments have been selected for this flight, one of which deals with the primate in flight whereas the other is concerned with pre- and post-flight studies of calcium mobilization and loss from bone.

Biosatellite Project personnel of the Ames Research Center are cooperating with and assisting the investigators in the engineering and design of experiment flight hardware, life support systems, and telemetry and data retrieval requirements. Experiment packaging and instrumentation have been developed and tested; and, in most instances, flight hardware is currently being fabricated.

The General Electric Company was awarded the contract to design, fabricate and test the six spacecraft as well as the associated ground equipment. This company has also been contracted with to develop most of the flight packages for the experiments along with the radiation source holder and shielding mechanism. Three other contractors (North American Aviation, Northrop Space Laboratories, and Texas Instrument Company) are assisting the experimenters in the design and development of flight-qualified packages for the experiments.

The Biosatellite will be launched from Cape Kennedy by the two-stage, thrust augmented Thor Delta launch vehicle. It will be placed into an orbit at a height consistent with the lifetime requirements of the experiments, for example, about 180 nautical miles for the 30-day primate mission. The orbital inclination of 33.5° permits reception of telemetry data under most circumstances during each orbit at one of the following ground stations: Fort Myers, Florida; Lima, Peru; Quito, Equador; and Santiago, Chile. Telemetry data reception might be missed by the ground stations during one orbit, but no two orbits in succession will be missed.

The data will be transmitted by telemetry at a rate of 256 words per frame and either 1 frame/second (3 and 21-day flights) or 12.5 frames per second (30-day flight) from the Biosatellite to the ground station the three to five minutes the satellite is within range of the ground station during a pass. Forty preselected data channels are separated and transmitted to the Control Center after each pass from the stations at Lima and Quito to enable personnel in the Control Center to assess the spacecraft or experiment status. Two minutes of the data train will be transmitted from Ft. Myers on a high speed teletype line for immediate assessment while the station at Santiago will process and transmit three complete frames of data almost immediately following station pass. Conditions of vibration and acoustic environment will be telemetered to the ground during the powered boost phase. After engine cut-off this environment will be regularly recorded internally. Up to 70 different commands may be sent in digital code to the spacecraft for control of the spacecraft functions.

All satellites are to be recovered. The experiments are contained in the re-entry vehicle while various support equipment is located in the adapter section. The adapter is separated from the re-entry vehicle prior to the retro maneuver. Following re-entry into the sensible atmosphere, a drogue parachute is deployed followed by the main parachute. Shortly thereafter the heat shield is dropped. The capsule is to be caught prior to impacting the water by Air Force recovery aircraft. In the event it is missed, alternative water recovery methods will be utilized. Recovery aids and life support equipment will function for a minimum of 6 hours. It is planned that delivery of the recovered capsule will be made to the laboratory at Hickam Air Force Base, Honolulu, within 6 hours for examination of the experiments.

Investigations and Investigators

Biosatellite (3-day flight)

General Biology Experiments

1. Drs. S. W. Gray and B. F. Edwards (combined with P-1096 and P-1138)
Emory University
Atlanta, Georgia

Experiment P-1020 -- Determination of the effect of weightlessness on the growth and orientation of roots and shoots of wheat seedlings.

2. Dr. Charles J. Lyon (combined with P-1020 and P-1138)
Dartmouth College
Hanover, New Hampshire

Experiment P-1096 -- Determination of the effects of zero gravity on the emergence of wheat seedlings.

3. Drs. H. M. Conrad and S. P. Johnson (combined with P-1020 and P-1096)
Space and Information Systems Division
North American Aviation, Inc.
12214 Lakewood Boulevard
Downey, California

Experiment P-1138 -- The effects of weightlessness on the orientation of roots and shoots of wheat seeds.

4. Dr. Richard Young
Ames Research Center
Moffett Field, California

Experiment P-1047 -- Effects on cell fertilization and development in a gravity-dependent system, the frog egg.

5. Drs. J. C. Finn and S. P. Johnson
North American Aviation Space and Information Division
Torrence, California

Experiment P-1017 -- Effects of weightlessness on plant growth through measurements of the angle between leaf and stem of a pepper plant which is controlled by the plant hormone, auxin.

6. Dr. Richard W. Price
Colorado State University
Fort Collins, Colorado
and
Dr. D. E. Ekberg
General Electric Company
Philadelphia, Pennsylvania

Experiment P-1035 -- Study in the amoeba (Pelomyxa carolinensis) the effects of zero gravity on the orderly synchronous division of nuclei and on the formation of food vacuoles and utilization of ingested nutrients.

Radiation Experiments

7. Dr. J. V. Slater
University of California
Berkeley, California

Experiment P-1039 -- Examine the effects of radiation and zero gravity on embryonic differentiation and development of the pupae of Tribolium (flour beetle).

8. Dr. I. I. Oster
Institute for Cancer Research
Philadelphia, Pennsylvania

Experiment P-1160 -- Larvae of Drosophila (fruit fly) which have newly hatched from eggs will be studied to learn of the effects of radiation and zero gravity on the rapidly growing cells of the larvae as they hatch into adults following recovery.

9. Drs. E. Altenberg and L. Browning
Texas Medical Center, Inc.
Houston, Texas

Experiment P-1159 -- Effects of zero gravity on radiation induced damage (mutation and chromosome breaking) in mature reproductive cells of a known genetic strain of female Drosophila previously mated with known genetic males.

10. Drs. A. H. Sparrow and L. A. Schairer
Brookhaven National Laboratory
Upton, New York

Experiment P-1123--Determination of influence of radiation and zero gravity on mutation processes in budded stalks of <u>Tradescantia</u> (blue-flowering plant) by observing induced color changes.

11. Dr. R. C. Von Borstel
Oak Ridge National Laboratory
Oak Ridge, Tennessee
and
Dr. D. S. Grosch
North Carolina State of the
University of North Carolina
Raleigh, North Carolina

Experiment P-1079 -- Male <u>Habrobracon</u> (parasitic wasps) will be exposed to several levels of radiation during zero gravity. Post-flight, they will be mated to evaluate the extent of genetic changes.

12. Dr. F. J. DeSerres
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Experiment P-1037 -- Chromosomal mutations in <u>Neurospora</u> (bread mold) following exposure to a known gamma source during zero gravity.

13. Dr. R. H. T. Mattoni
North American Aviation
Downey, California
and
Drs. W. T. Romig and W. T. Ebersold
University of California
Los Angeles, California

Experiment P-1135 -- Slowly growing lysogenic bacteria (<u>Escherichia coli</u>) will be exposed simultaneously to zero gravity and radiation to determine whether or not viruses can proliferate within irradiated bacteria under zero gravity.

Biosatellite (21-day flight)

1. Dr. A. H. Brown
University of Pennsylvania
Philadelphia, Penna.
and
Dr. Orville Dahl
University of Minnesota
Minneapolis, Minnesota

Experiment P-1003 -- Study of plant morphogenesis under weightlessness in a small terrestrial angiosperm (Arabidopsis) to determine whether growth differs qualitatively and quantitatively from plants grown in earth gravitational field.

2. Dr. G. C. Pitts (combined with P-1093)
University of Virginia
Charlottesville, Virginia

Experiment P-1145 -- Effect of weightlessness on gross body composition and metabolism with special reference to atrophy of skeletal muscle and bone, which result from disuse, and to determine patterns of energy expenditure.

3. Dr. F. Halberg (combined with P-1145)
University of Minnesota
Minneapolis, Minnesota

Experiment P-1093 -- Metabolic Rhythms as a Temporal Gauge of Mammalian Performance in Extraterrestrial Space.

4. Dr. P. O'B. Montgomery
University of Texas
Southwestern Medical School
Dallas, Texas

Experiment P-1084 -- Determination of zero gravity influences on isolated human cells to observe capacity of cell to maintain its membrane to undergo normal mitotic cycles, and to perform normal biochemical and physiologic functions.

Biosatellite (30-day flight)

1. Dr. W. R. Adey
University of California
Los Angeles, California;

Dr. P. J. Meehan
University of Southern California
Pasadena, California;

Dr. J. H. Rho
Jet Propulsion Laboratory
Pasadena, California;

and

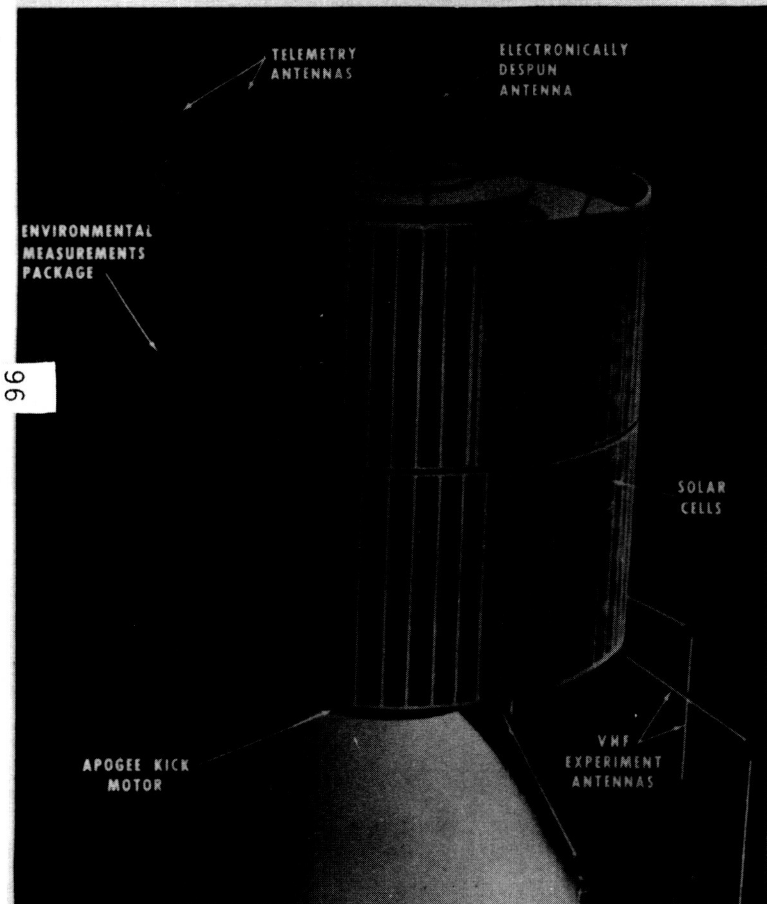
Dr. N. Pace
University of California
Berkeley, California

Experiment P-1001 -- Monitoring of brain functions and performance and cardiovascular and metabolic activities in the primate under prolonged (30 days) weightlessness.

2. Dr. P. B. Mack
Texas Woman's University
Denton, Texas

Experiment P-1062 -- Investigation of losses of bone mineral (calcium) in primates due to immobilization during prolonged weightlessness through radiographic bone densitometry and intensive biochemical analyses pre- and post-flight, as well as analyses of excreta collected during flight.

APPLICATIONS TECHNOLOGY SATELLITE
ATS-B



LAUNCH WEIGHT	1539 LBS
EXPERIMENTS	14
POWER	148 WATTS
STABILIZATION	SPIN
DESIGN LIFE	3 YEARS
LAUNCH VEHICLE	ATLAS/AGENA & APOGEE KICK MOTOR
ORBIT	SYNCHRONOUS, GEOSTATIONARY
STATUS	LAUNCH SCHEDULE 4TH QTR 1966

NASA SP65-16318
12-8-65

APPLICATIONS TECHNOLOGY SATELLITES

The Applications Technology Satellites (ATS) consist of five flights to test promising technology that is common to a number of satellite applications, and to conduct various space environmental investigations. ATS-B, the first of the series, is scheduled for launch in the fourth quarter of 1966, to be followed by ATS-A in the second quarter of 1967. C, D, and E are scheduled in that order for launch in 1966 and 1967.

The ATS-B and C spacecraft are of similar design. Both will be spin stabilized in geostationary orbits. The ATS-A, D and E spacecraft will be gravity gradient stabilized with ATS-A in a 6000 n.mi. orbit and ATS-D and E in geostationary orbits. The D and E spacecraft are similar to the A spacecraft except that an apogee kick motor is added for the two synchronous altitude missions.

The experiments selected as of October 1965 are as follows:

ATS-B

1. Communications -- a microwave dual mode transponder and an electronically despun antenna to permit investigations of multiple access in the SSB/PM mode and of wideband color TV transmissions in the FM/FM mode.
Hughes Aircraft Company

2. VHF Transponder -- an FM/FM transponder for experiments between aircraft and ground stations involving voice and data communications.
Hughes Aircraft Company

3. Meteorological TV -- a high resolution spin scan camera system for obtaining cloud pictures from synchronous altitude.
University of Wisconsin/V. E. Suomi

4. Nutation Sensor -- two sensitive accelerometers to detect nutation as small as one-thousandth of a degree.
Geophysics Corporation of America

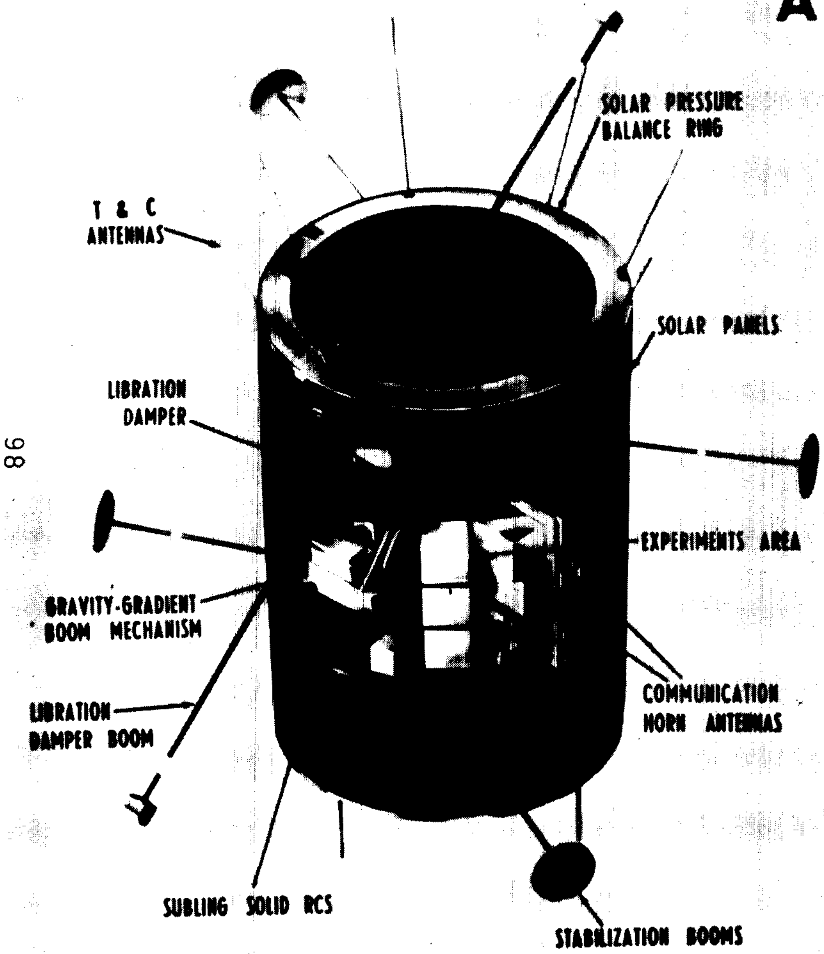
5. Ion Engine Thruster -- a light-weight, low-thrust device to evaluate for station keeping applications.
Lewis Research Center

6. Magnetic Field Measurements -- fluxgate magnetometers for field strength determinations.
UCLA/P. J. Coleman, Jr.

7. Thermal Coating Degradation -- effect of exposure to synchronous altitude environment on various thermal coatings.
Goddard Space Flight Center/J. J. Triolo

APPLICATIONS TECHNOLOGY SATELLITE

ATS-A



LAUNCH WEIGHT	695 LBS
EXPERIMENTS	12
POWER	139 WATTS
STABILIZATION	GRAVITY GRADIENT
DESIGN LIFE	3 YEARS
LAUNCH VEHICLE	ATLAS/AGENA
ORBIT	6000 N.M. CIRCULAR 28° INCLINATION
STATUS	LAUNCH SCHEDULED FOR 2ND QTR 1967

NASA SP65-16320
12-8-65

8. Solar Cell Degradation -- radiation damage measurements of various shielded solar cells.
Goddard Space Flight Center/R. C. Waddel

9. Electron Content of the Ionosphere -- Ground Station Measurement at VHF frequencies to determine propagation characteristics and electron density of the ionosphere.
Stanford University/O. K. Garriott

10. Energetic Particle Measurements --

	Electrons	Protons	Alpha Particles
a. Rice University/ J. W. Freeman, Jr. M. M. McCants, D. T. Young	--	0.25 - 50 ev	0.25 - 50 ev
b. TRW, Inc./ F. B. Harrison	5 - 30 Kev	160 ev - 30 Kev	--
c. University of Minnesota/ J. R. Winckler, R. Arnoldy	50 Kev - 1 Mev	--	--
d. Bell Telephone Labs/ W. L. Brown C. S. Roberts	300 Kev - 1 Mev $>$1.0 Mev	0.7 - 100 Mev	1.8 - 85 Mev
e. Aerospace Corporation/ G. A. Paulikas, S. C. Freden, J. B. Blake	0.2 - 2 Mev $>$ 2.0 Mev	5 - 55 Mev	--

ATS-A

1. Communications -- microwave transponder with multiple access SSB/PM and wideband FM/FM modes together with horn antennas.
Hughes Aircraft Company

2. Gravity Gradient Stabilization -- four 133 ft. booms to provide spacecraft stabilizing torques and two 45 ft. damper booms attached to two interchangeable passive dampers.
General Electric Company

3. Meteorological TV -- two cameras for cloud cover observations, one high resolution and the other wide angle together with Nimbus type recorder.
Radio Corporation of America.

4. Earth's Albedo -- sensors for obtaining background data applicable to detection of nuclear tests.
Sandia Corporation/Department of Defense

5. Thermal Coating Degradation -- effect of medium altitude space environment on various thermal coatings.
Goddard Space Flight Center/J. J. Triolo

6. Solar Cell Degradation -- radiation damage measurements of various shielded solar cells.
Goddard Space Flight Center/R. C. Waddel

7. Cosmic Radio Noise -- integrated noise measurements from 250 Kc/s to 2.5 Mc/s.
Goddard Space Flight Center/R. G. Stone, J. K. Alexander

8. Electric Fields -- electrometer measurements of ambient electric fields.
Goddard Space Flight Center/T. Aggson, J. P. Heppner

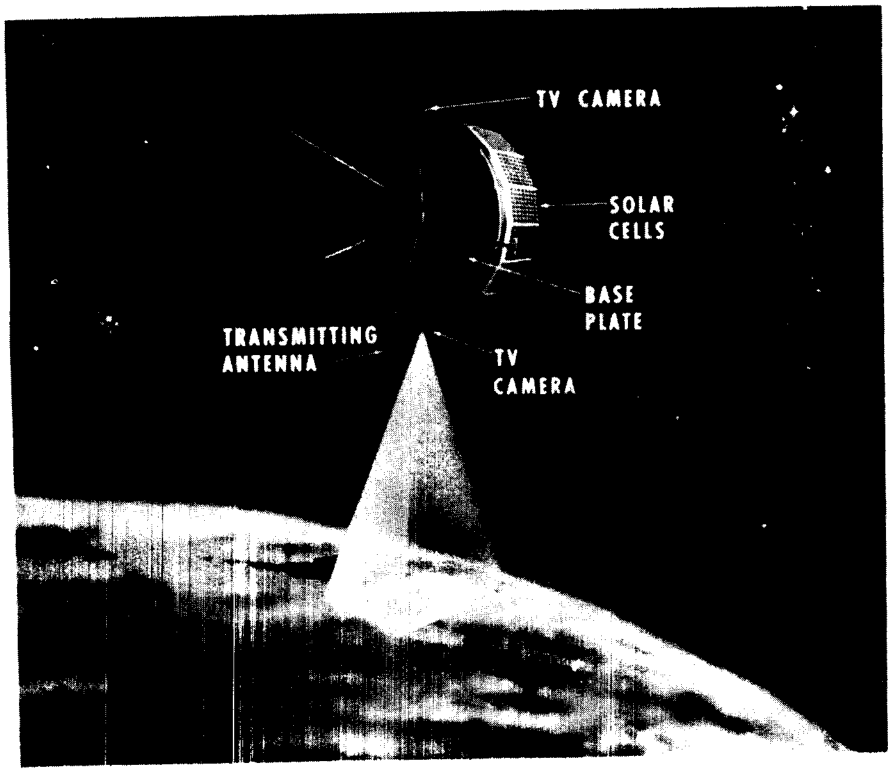
9. VLF Power Spectrum -- electromagnetic radiation measurements from 5 to 45 Kc/s.
Bell Telephone Laboratories/C. S. Roberts

10. Energetic Particle Measurements --

	Investigator	Electrons	Protons	Alpha Particles
a.	University of Minnesota/ J. R. Winckler, R. Arnoldy	50 Kev - 1 Mev	--	--
b.	University of California at San Diego/C. E. McIlwain, J. Valerio	$>$0.5 Mev $>$1.0 Mev	$>$12 Mev $>$20 Mev	--
c.	Bell Telephone Laboratories/ W. L. Brown, C. S. Roberts	0.5 - 1.0 Mev $>$1 Mev	0.7 - 100 Mev	1.8 - 85 Mev

The experiment complements for flights C, D, and E have not yet been selected.

TIROS OT-3



GROSS WEIGHT	300 LBS.
INSTRUMENT WEIGHT	60 LBS.
SENSORS	2 TV CAMERAS
POWER	20 WATTS
STABILIZATION	SPIN
DESIGN LIFE	6 MONTHS
LAUNCH VEHICLE	DELTA
ORBIT	APOGEE 400 MI. PERIGEE 400 MI INCLINATION 98.7°
STATUS	TO BE LAUNCHED EARLY 1966

NASA SF64-220
12-8-65

TIROS

The Television Infra-Red Observation Satellites (TIROS) are a series of spin-stabilized meteorological spacecraft. Weighing from 260 to 300 plus pounds, they have been launched into inclined, and more recently into nearly polar, orbits to obtain television and infrared data for use by meteorologists both in research and for operational purposes. Further, these satellites have been used to advance the space technology utilized in meteorological satellites.

The success of the series has led to the extension of the objectives to include developing an improved operational data coverage capability and extending the R&D capability for this type spacecraft.

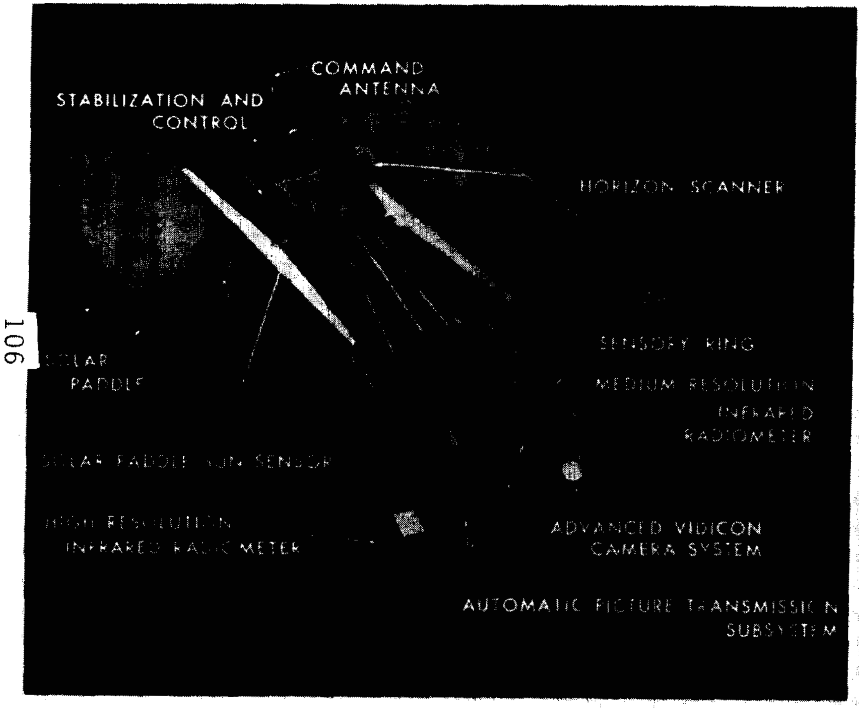
Probably the greatest single contribution of the meteorological satellite program to date is the basis that it has provided for the implementation of the TIROS Operational Satellite (TOS) system -- an operational system based on TIROS technology. Implementation for TOS is planned for early in calendar year 1966. In the initial system two spacecraft types will be used. One will include APT to provide direct local readout of cloud cover data and the second, incorporating AVCS, will provide global cloud cover to be read out at Command and Data Acquisition (CDA) stations. It is significant to note that both of these camera systems were developed for and successfully flown on Nimbus I. The basic spacecraft to be used in the operational system is based on the wheel configuration of TIROS and successfully demonstrated by TIROS IX. In the wheel configuration the spin axis is turned so as to be perpendicular to the orbital plane. Thus, as the spacecraft operates in a nearly polar orbit it will sweep out a pole-to-pole swath taking a picture, as required, when the cameras look directly down at the earth. The earth-oriented pictures will be provided continually by the wheel configured satellites. This will be the mode of operation for the TOS series and all but the first (TIROS X) of the developmental OTS series. TIROS X, the first Weather Bureau-funded TIROS spacecraft launched in July 1965 to provide coverage during the hurricane season, now continues to provide nearly global coverage on a daily basis.

Plans include the development of a spacecraft to incorporate the APT and AVCS capability into a single spacecraft by the addition of a tape recorder into an APT spacecraft. This will provide stored picture data for global use as well as local readout of cloud photographs from a single spacecraft. The system will transmit the picture at slow speed to the local APT receivers and simultaneously record the picture at slow speed on the tape recorder. When the spacecraft is within range of the CDA stations, the system will playback at fast speed the pictures stored on the tape recorder to provide global cloud data. The second buy of TOS spacecraft will include the option to convert to an "APT with Tape Recorder" configuration subsequent to a satisfactory demonstration of feasibility of the system.

Plans also include the development of a spacecraft (TIROS J) to provide a nighttime cloud data capability. TIROS J will be a wheel configured spacecraft, operating at the TOS System altitude (approximately 750 NM), and includes a redundant pair of HRIR radiometers to provide local and global nighttime data. The sensor is the type developed for and successfully demonstrated on Nimbus I. The instrument contains a scanning element which revolves the optical axis through a plane at the video line rate and depends on orbital motion to provide a complete video system. Due to compound motions of the optics and the spacecraft, the resultant scan line is oriented approximately 45° from the subtrack.

In the TOS program two spacecraft are required to provide daytime local and global cloud pictures until late in 1967. If the APT with Recorder developments are successful, then a spacecraft with the combined local and global capability will be launched in late 1967 in lieu of a single capability APT spacecraft. Present plans are to convert the TOS second buy to the local and remote readout capability. The first nighttime cloud capability for TOS is planned in 1969 and is dependent on a successful flight test of a TIROS J spacecraft in the R&D program.

NIMBUS C



GROSS WEIGHT	920 LBS.
INSTRUMENT WT	196 LBS.
EXPERIMENTS	4
POWER	450 WATTS
STABILIZATION	ACTIVE 3 AXIS
DESIGN LIFE	SIX MONTHS TO ONE YEAR
LAUNCH VEHICLE	TAT -AGENA B
ORBIT	CIRCULAR 600 NM INCLINATION 80° RETROGRADE
STATUS	TO BE LAUNCHED MID - 1966

NASA SF64-222
REV. 12/8/65

N I M B U S

Nimbus is a three-axis, Earth-stabilized, research and developmental meteorological satellite capable of providing full Earth coverage on a daily basis by means of a nearly polar orbit having an inclination of approximately 80 degrees to the equator. The Earth's rotational movement provides the mechanism for longitudinal coverage while latitudinal coverage is obtained by the spacecraft's orbital motion. The satellite will always view the Earth at nearly local noon on the sunlit side and nearly midnight on the dark side.

The overall Nimbus objectives are to conduct a research and development program aimed at developing and exploiting space technology for meteorological research purposes. The program includes launch and operational phases for a series of meteorological satellites exhibiting evolutionary advances in operating characteristics, and carrying payloads of significant experiments for atmospheric research and operational use. The satellite consists of three major subsystems -- power, stabilization, and the sensory ring. The latter houses the advanced sensors. For this application, Nimbus serves as a meteorological observatory in space. As such, the spacecraft constitutes a platform for sensor testing, a platform for subsystem testing, a platform where special atmospheric observations can be made, and finally a platform from which simultaneous measurements can be made. These measurements will be of the many atmospheric parameters which are essential to the full description of the atmosphere and the understanding of it. It is also useful to take measurements simultaneously of space environmental factors (the solar environment) and the co-existing behavior of the Earth's atmosphere, therefore permitting a time correlation of the two.

Nimbus C

This will be the second Nimbus spacecraft to be flown and will be launched in 1966. It will include the Advanced Vidicon Camera System (AVCS), the Automatic Picture Transmission (APT) subsystem and the High Resolution Infrared Radiometer (HRIR), all of which were carried aboard Nimbus I, plus the Medium Resolution Infrared Radiometer (MRIR) -- a five channel radiometer aimed at a major experiment in studying the global heat budget. Nimbus C, originally the backup for Nimbus I, will incorporate a correction to the solar array drive which caused the failure of the first Nimbus spacecraft. Nimbus I was launched August 23, 1964, and ceased providing useful data on September 23, 1964.

The AVCS is a three-camera array, each camera utilizing a one-inch vidicon with an 800 TV line resolution. The system is capable of providing full global daylight cloud cover data.

The APT subsystem automatically snaps a TV picture and by a slow scan technique transmits a cloud cover picture directly to relatively inexpensive ground stations within radio range of the satellite.

The HRIR uses 3.4 to 4.2 micron region of the infrared spectrum to provide nighttime readout of cloud cover data. This information will be broadcast to specially equipped APT stations as well as to the conventional CDA stations. A resolution of almost 5 miles has been achieved.

The MRIR is a five-channel radiometer that provides data concerning the emitted and reflected radiation of the Earth's surface in five spectral bands:

Channel 1 - Water vapor absorption band, 6.5 to 7.0 microns.
Channel 2 - Atmospheric window, 10 to 11 microns.
Channel 3 - Stratospheric temperatures, 14 to 16 microns.
Channel 4 - Terrestrial radiation, 5 to 30 microns.
Channel 5 - Albedo, 0.2 to 4 microns.

These data will be obtained with a resolution of almost 30 miles.

Nimbus B

This spacecraft will be launched in 1967 into an orbit similar to Nimbus C at an altitude of approximately 600 nautical miles. The basic spacecraft will be essentially identical to Nimbus I and Nimbus C. However, the majority of the experiments to be flown will be different. The experiments selected for this flight and the experimenters are listed below:

(a) The Image Dissector which will provide a continuous daylight picture of the Earth's cloud cover.
M. Schneebaum
Goddard Space Flight Center

(b) The High Resolution Infrared Radiometer for detection of the thermal radiation of the Earth and its atmosphere to produce cloud cover pictures and to measure temperatures of the surface or the cloud tops at night.
L. Foshee
Goddard Space Flight Center

(c) The Solar UV Experiment which will monitor the ultraviolet solar flux in five bands to detect time variations in relative intensity.
D. Heath
Goddard Space Flight Center

(d) The Infrared Interferometer Spectrometer which will provide a continuous spectrum of the Earth's atmospheric radiation in the 5 to 20 micron region to determine the amount of ozone and water vapor and to infer the temperature of the atmosphere.
R. Hanel
Goddard Space Flight Center

(e) The Satellite Infrared Spectrometer which will measure the Earth's spectral radiances in the carbon dioxide absorption band for inference of atmospheric temperature structure by utilizing narrow intervals within the 15 micron CO_2 band.

D. Wark
Environmental Science Services Administration

(f) The Interrogation, Recording, and Location System which will make collections of scientific data relating to the surface of the Earth and its atmosphere from fixed or free-floating platforms.

G. Hogan
Goddard Space Flight Center

(g) The Medium Resolution Infrared Radiometer which will measure the intensity and distribution of emitted infrared and reflected radiation of the Earth and atmosphere in five selected channels.

A. McCulloch
Goddard Space Flight Center

(h) The 50-watt SNAP-19 Radioisotope Thermoelectric Generator which will assess the operational capability of radioisotopic power for meteorological satellites and to augment the satellite's power supply.

C. Baxter
Atomic Energy Commission

Nimbus D

Following the launch of Nimbus B, it is planned to launch a fourth spacecraft, Nimbus D in 1969. In this satellite it is planned to exploit further the atmosphere under techniques developed for Nimbus B and some new techniques in as yet unexplored regions of the electromagnetic spectrum. Currently, the list of candidates for Nimbus D include:

(a) Image Orthicon Camera System for day-night cloud imaging.

J. Moody
Goddard Space Flight Center

(b) Dielectric Tape Camera for increased resolution and higher fidelity of cloud pictures.

J. Arlauskas
Goddard Space Flight Center

(c) Microwave Radiometer (18-20 gc) for effective temperature measurements of the surface under clouds.

P. Thaddeus
Goddard Space Flight Center

(d) Sferics (using 600 mc with a resolution of around 200 miles) for global measurement of thunderstorm field strength both day and night.

S. Rossby
University of Wisconsin

(e) WEFAX (Weather Facsimile) experiment with the transfer of unique weather data and maps to APT users.

M. Schneebaum
Goddard Space Flight Center

(f) Improved Infrared Interferometer Spectrometer (8-40 microns).

R. Hanel
Goddard Space Flight Center

(g) Improved Interrogation, Recording, and Location System to be able to handle more instrumented platforms.

G. Hogan
Goddard Space Flight Center

(h) Improved Satellite Infrared Spectrometer for wider geographical coverage.

D. Wark
Environmental Science Services Administration

(i) High Resolution Infrared Radiometer (10-11 microns) to experiment with acquiring both day and night cloud cover information with an infrared system.

A. McCulloch
Goddard Space Flight Center

(j) Ultraviolet Spectrometer to measure the total ozone and vertical ozone distribution above 25 kilometers.

D. Wark
Environmental Science Services Administration

(k) Cloud-top Altitude Spectrometer to measure the cloud-top pressure altitudes.

F. Saiedy
Environmental Science Services Administration

(l) Filter-wedge Spectrometer to measure the water vapor content and its vertical distribution.

W. Horvis
Goddard Space Flight Center

(m) Improved Image Dissector Camera.

G. Branchflower
Goddard Space Flight Center

(n) Global Radar for Ocean Waves to chart the wave height over the world's oceans to deduce surface wind field and for real-time forecast of wave and wind field.

W. Pierson
New York University

R. Moore
University of Kansas

This is only a partial list of the possible candidates for Nimbus D and careful consideration will be given to these and possibly others before a final selection is made for this flight.

MANNED SPACE SCIENCE

The Manned Space Science effort is a program of science and applications to utilize and expand the capability of man in space in fulfillment of the broad objectives of NASA. The responsibility for the accomplishment of a meaningful program of scientific investigation in manned space flights devolves upon the Director, Manned Space Science within the Office of Space Science and Applications (OSSA). To define and develop investigations to be carried out on manned missions, close coordination with the Office of Manned Space Flight (OMSF) is maintained by OSSA. To assist OSSA in defining, evaluating, and reviewing the scientific aspects of these investigations, a group of advisory subcommittees has been established whose members are prominent in the scientific community, NASA and government agencies.

SCIENTIST - ASTRONAUTS

An important phase of the Manned Space Science Program is that of Scientist - Astronaut selection and training. Since the implementation of this program in 1965, six scientists have been chosen for training as astronauts. They are presently undergoing rigorous training in jet flying, astronautics and space flight techniques. In addition, they are receiving specialized training in the scientific aspects of the Apollo missions. NASA is considering additional recruitment of qualified scientists to enter the astronaut program and start pilot training in calendar year 1966. The possibility of using scientists as passengers rather than crew members is being investigated. The advantage of using scientists of exceptional competence as non-crew members would be in utilizing their scientific talents on a full-time rather than part-time basis.

The program of manned space science investigation, which started with a few simple scientific experiments in the Mercury flights, is evolving into an increasingly sophisticated program of coordinated investigations which will require the presence of scientifically trained astronauts for its sucessful accomplishment. With the evolution of the Manned Space Flight Program and the greater availability of space, weight and power for experiments over long duration flights, a well planned and coordinated program for science investigations is required.

Such a program is being developed and earth-orbital, lunar-orbital, and lunar surface missions. These programs are as follows:

MANNED EARTH ORBITAL PROGRAMS

GEMINI - The Gemini program has provided an opportunity for astronaut-conducted scientific experiments. Experimental results from Gemini III, IV, V, and VII include the following scientific experiments:

S-5, SYNOPTIC TERRAIN PHOTOGRAPHY
By Paul D. Lowman, Jr., Ph.D.; Co: None
NASA Goddard Space Flight Center

S-6, SYNOPTIC WEATHER PHOTOGRAPHY
By Kenneth M. Nagler; Co: S. Goules
United States Weather Bureau, ESSA

S-4, ZERO g AND RADIATION ON BLOOD
By Michael A. Bender, Oak Ridge National Laboratory; P. Carolyn Gooch, Oak Ridge National Laboratory; and Sohei Kondo, Oak Ridge National Laboratory

S-8, VISUAL ACUITY IN THE SPACE ENVIRONMENT
S. Q. Duntley; Co: None
Scripps Institute of Oceanography

S-6, SPECTROPHOTOGRAPHY OF CLOUDS
F. Saiedy; Co: None
United States Weather Bureau

S-1, ZODIACAL LIGHT AND AIRGLOW PHOTOGRAPHY
E. P. Ney, W. Huch
Institute of Physics, University of Minnesota

S-28, DIM SKY PHOTOGRAPHY
L. Dunkelman
Goddard Space Flight Center

In addition, experiment S-2 titled "Sea Urchin Egg Growth Under Zero-G" was flown on GEMINI III. This experiment by R. S. Young of Ames Research Center was to investigate the effects of weightlessness on the development of fertilized sea urchin eggs. Due to equipment failure, this experiment was not completed.

The following is a list of experiments which will be flown on forth-coming Gemini Flights:

1. S-11, AIRGLOW HORIZON PHOTOGRAPHY
   M. J. Koomen, D. M. Packer, R. Tousey
   Naval Research Laboratory
2. S-3, FROG EGG GROWTH UNDER ZERO - G
   R. S. Young; Co: None
   Ames Research Center

3. S-9, NUCLEAR EMULSIONS
M. M. Shapiro; Co:
Naval Research Laboratory

C. E. Fichtel
Goddard Space Flight Center
4. S-26, GEMINI ION WAKE MEASUREMENTS
D. Medved; Co: R. Speiser
Electro-Optical Systems, Inc.
5. S-12, COLLECTION OF MICROMETEORITES
C. L. Hemenway; Co: J. Hotchin
Dudley Observatory
6. S-13, UV PHOTOGRAPHY OF CELESTIAL SOURCES
K. G. Henize; Co: A. Boggess, III
Northwestern University

APOLLO - The Apollo-Earth Orbital program is a continuation of the Gemini program and in certain areas Gemini experiments will be expanded and improved to take advantage of the increased weight, space and power available. The following is a list of experiments which have been approved for the Earth-Orbital Apollo flights:

1. S-18, MICROMETEORITE COLLECTION
C. Hemenway; J. Hotchin
Dudley Observation
2. S-21, AIRGLOW HORIZON PHOTOGRAPHY
M. Koomen; Co: R. Seal; D. Packer
Naval Research Laboratory
3. S-5, SYNOPTIC TERRAIN PHOTOGRAPHY
P. Lowman; Co: None
Goddard Space Flight Center
4. S-6, SYNOPTIC WEATHER PHOTOGRAPHY
K. Nagler; Co: S. Goules
United States Weather Bureau
5. S-17, X-RAY ASTRONOMY
R. Giacconi; Co: B. Rossi; H. Gursky; J. Waters
American Science and Engineering Co.
6. S-19, UV STELLAR PHOTOGRAPHY
K. Henize
Northwestern University
7. S-20, SOLAR SPECTRAL PHOTOGRAPHY IN EXTREME UV AND SOFT X-RAY
R. Tousey
Naval Research Laboratory
8. S-16, EAST-WEST ASYMMETRY (TRAPPED PARTICLES)
H. Heckman; Co: W. Barkas
University of California, Berkeley
9. S-22, LOW "Z" COSMIC RADIATION MEASUREMENTS
C. Fichtel; Co: None
Goddard Space Flight Center

10. S-23, HEAVY ION COSMIC RAY MEASUREMENTS
C. Waddington; Co: P. Freier
University of Minnesota
11. S-14, FROG OTOLITH FUNCTIONS DURING ZERO - G
T. Gualtierroti; Co: None
Ames Research Center
12. S-15, ZERO - G CELL MICROSCOPY
P. Montgomery
Dallas County Hospital District

In addition to those experiments which have been approved for the early Apollo Earth Orbital flights, development of several interface devices to accommodate experiments is proceeding. An airlock device will allow experiments which require exposure to the outisde environment to be stored in cannisters within the Command Module and raised to a position outside the spacecraft for operation. Use of this airlock will eliminate the need for astronaut extra-vehicular activity in performing experiments such as the trapped radiation, micrometeorite collection, UV stellar photography, and X-UV solar photography experiments. A further study which will facilitate the incorporation of experiments in the Service Module, is the pallet concept. Several versions are being considered. The first is essentially a self-contained palletized package which not only includes experiments, but also power supplies, data acquisition and telemetry systems, booms and environmental control systems. Another type of pallet under study is a stablized platform to accommodate those experiments which require highly accurate pointing.

APOLLO APPLICATIONS PROGRAM - Beyond the early Apollo flights are those of the Apollo Applications Program (AAP). Earth orbital flights of AAP will provide the opportunity to accommodate experiments of greater weight and/or complexity than previously possible by using slightly modified Apollo equipment. For example, by stripping the lunar components from the Lunar Excrusion Module (LEM) and flying it in earth orbit, added weight and space for science and applications will become available.

The area of earth sciences and resources is included in the AAP not only because it has useful earth applications, but also because many of the experimental instruments and techniques for studying the earth's surface are similar to those which would be employed for studying the lunar surface from lunar orbiters. Most of the experimental techniques to be used for the study of the terrestrial and lunar surface from extended orbital spaceflight missions are included within the rapidly evolving field of remote sensing.

We are working with scientific and application-oriented groups to determine the scientific and application values of such surveys, and their reactions have been enthusiastic--especially in application areas such as agriculture, oceanography, forest control, and related fields.

One major advantage of orbital sensing is synoptic or broad scale coverage. One space photo will cover from 100 to 2000 times as much area as most aerial photos.

The use of infrared thermal imagery for the study of geologic features is being investigated. By this method thermal anomalies which later became volcanically active were detected in Hawaii. This suggests that some volcanic eruptions may be preceded by observable thermal anomalies.

Studies are presently underway to determine how known structural features appear in radar pictures and how to interpret the radar information.

The Manned Space Science Office, in conjunction with the National Academy of Sciences and the Woods Hole Oceanographic Institution, has already held comprehensive program definition conferences in the fields of geography and oceanography. An aircraft flight program with the Universities of Purdue and Michigan has been underway for a year in the field of agriculture. To agument these activities from the disciplinary point of view, cooperative programs with the Departments of Agriculture, Interior, and Navy are planned in a number of earth application areas.

An important area to be considered in earth-orbital missions is that of determining the nature of galactic sources. Investigations are planned or are being studied for feasibility to (1) map the positions and disturbances of the galactic sources, and (2) determine the differential energy and differential angular distribution of radiation emitted from these galactic sources. The specific parts of the electromagnetic spectrum of interest for the manned space science programs are the microwave, infrared, ultra violet, x-ray, and gamma ray regions.

APOLLO SCIENCE PROGRAM - A significant part of the Manned Space Science program consists of scientific exploration of lunar and planetary bodies. We are interested in the origin of the moon and how this relates to the origin of the solar system. Did the moon originate from the earth; independently, but at the same time as the earth; or is it a body from outside our solar system that was captured by the earth? What has been the thermal history of the moon? Was it formed in a hot or cold state, and what is the state of its interior now? Is it similar to the earth with a molten core, or is it relatively uniform in composition?

Experiments and instruments are being planned which will most intelligently give information concerning these questions. A three-axis seismometer placed on the moon's surface can be expected to explore the interior to its center. In the event there are no large moon quakes, meteorite impacts or abandoned spacecraft impacts can be used to provide seismic energy.

Heat flow measurements will furnish information on the distribution of radioactive elements and the present thermal history of the moon, including volcanism. A shallow probe or drilled hole is a necessity to obtain heat flow measurements.

In regard to the lunar magnetic field, it is generally believed that planetary magnetic fields are related to the presence of a molten magnetic core. So another question is the size of the lunar magnetic field and its interaction with the solar wind. Does the shock front lie above or below the lunar surface.

Highest priority in the Apollo program has been given to the return of lunar samples which will furnish information on the gross composition of the lunar surface.

Analysis of the samples will be performed on earth rather than on the lunar surface. A sample receiving laboratory is planned at the Manned Spacecraft Center in Houston. The primary functions of this laboratory will be to provide quarantine facilities, to log in the samples, to prepare preliminary descriptions, and to perform those tests which must be made as soon as possible, e.g., detection and identification of viable organisms, and measurement and analysis of short-lived radioactive nuclides and occluded gases. As soon as the quarantine period is over and these preliminary analyses are completed the samples will be transferred to scientists throughout the country for analysis in their own laboratories.

Most of the experiments during the early Apollo lunar mission are of the type which must be left on the moon and continue to function after the astronauts have returned to earth. To accomplish this task, the concept of an Apollo Lunar Surface Experiments Package (ALSEP) has been developed. This is an integrated package of experiments that will be carried in the scientific experiments bay of the LEM. Power for one year's operation on the lunar surface will be obtained from a radioactive thermal generator. On the lunar surface, the astronaut will remove the ALSEP from the bay, place it on the surface, and deploy and implant those sensors that require such treatment. He will insure that the seismometer is in close contact with the surface, that the magnetometer is not sitting on a piece of iron rock, and that the heat probe is implanted beneath the surface.

ADVANCED LUNAR SCIENCE EXPERIMENTS (APOLLO APPLICATIONS PROGRAM - AAP)

Since less than 1 percent of the lunar surface will be visited in the near future, a major source of scientific knowledge will come from orbiting-spacecraft. Extensive information can be easily obtained for the following reasons:

1. Variation of orbital inclinations will permit mapping of the entire lunar surface.
2. Absence of atmosphere allows all regions of electromagnetic spectrum to be accessible.

Thus, Manned Lunar Orbiters can provide useful additions to the subsurface information obtained from geophysical studies and to the local studies from fixed traversing surface experiments. Orbital investigations offer the potential of identifying local areas of the lunar surface with unusual properties which might be of interest for future manned exploration.

Two significant milestones have been passed in presenting the potential of the Advanced Lunar Mission concept to the scientific community. These have been in the form of conferences involving more than 100 scientists from both inside and outside the government. The first of these conferences was held at MSFC in April 1965 and the second was the recently completed conference at Falmouth, Massachusetts.

In general, the Working Groups participating at Falmouth recommend a more extensive mission capability in terms of payloads and man hours on the lunar surface.

In planning for such missions it appears that an optimum combination of missions would be one or two surface missions and one orbital mission per year. We would wish to emplace a number of geophysical observatories to operate at the same time.

These missions would not be devoted solely to exploring the moon. Even on Apollo a part of the science package is devoted to using the moon as a stable platform from which to monitor extra-lunar particles and fields. Furthermore, the moon may prove to be a unique location for valuable and exciting astronomical studies. Environmental data must be collected to see if telescopes and laboratories are feasible on the moon. The Manned Space Science Office is supporting definition and preliminary design studies by some experimenters or experiment teams with the intent of beginning to select principal investigators for the AAP missions.

SUMMARY OF NASA LAUNCH VEHICLES

Introduction

The following summarizes the capabilities of NASA launching vehicles for space research and exploration. The vehicles fall into two general categories:

1. Sounding rockets

2. Satellite and space probe vehicles

The sounding rockets are relatively inexpensive and simple to operate but are limited to small payloads and vertical-or-near-vertical flights. The satellite and space probe vehicles are ranged from the Scout all-solid launch vehicle to very large vehicles capable of launching man-carrying spacecraft on missions to the lunar surface and return.

Sounding Rockets

Description: A family of six sounding rockets is used in the geophysical sounding program. These are relatively simple rockets that can be launched at precise times from several sites. About 200 are being launched this year from Wallops Island, Fort Churchill, White Sands, and foreign sites.

The types of programs in which these rockets are being used show a strong dependency of objectives or requirements of subsequent firings on the findings of the initial firings in a given family of observations. Consequently, specific long-range firing schedules are not practical for sounding rockets. Based on projected research program planning, a sufficient number of each rocket type is ordered to satisfy the various program needs foreseen.

Typical sounding rockets now utilized are listed in the following table with their nominal costs and capabilities:

Vehicle	Cost (Thousands of Dollars)	Capability Altitude (miles)	Capability Payload Wt. (pounds)
Nike-Apache	7.5	150	50
Aerobee 150, 150A	30	150	150

Vehicle	Cost (Thousands of Dollars)	Capability Altitude (miles)	Payload Wt. (pounds)
Aerobee 300	38	230	50
Argo D-4	50	625	100
Argo D-8	140	1150	130
Nike-Cajun	6	100	50
Nike-Tomahawk	15	210	100

Two additional sounding rockets have been added to the above available vehicles during calendar year 1965.

They are the following:

Vehicle	Cost (Thousands of Dollars)	Altitude (miles)	Payload Wt. (pounds)
Aerobee 350	150	290	150
Astrobee 1500	150	1200	130

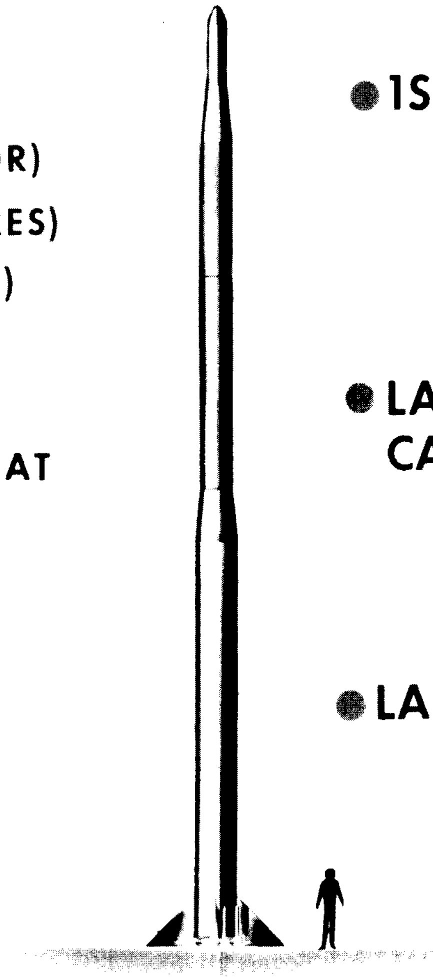
SATELLITE AND SPACE PROBE VEHICLES

The objectives of the Launch Vehicle and Propulsion Programs are to provide vehicles with the capability to perform reliably and economically the unmanned orbital, lunar, planetary, and interplanetary missions. Satellite and space probe vehicles currently available in the program are Scout, Delta, Thor-Agena, Atlas-Agena. Vehicles under development to support future missions are Atlas-Centaur.

A description of each launch vehicle, along with its capabilities is provided in the following pages:

SCOUT

- **STAGES**
  - 1ST STAGE - SOLID (ALGOL)
  - 2ND STAGE - SOLID (CASTOR)
  - 3RD STAGE - SOLID (ANTARES)
  - 4TH STAGE - SOLID (ALTAIR)
- **MISSION CAPABILITY**
  - 300 N. MI. ORBIT 300 LBS. AT 38° INC.
- **USE**
  - ORBIT
  - HIGH ALTITUDE PROBE
  - RE-ENTRY



- **INITIATED**
  - LATE 1958
- **1ST LAUNCHING**
  - R & D
JULY 1960
  - OPERATIONAL
MAR. 1962
- **LAUNCH RATE CAPABILITY**
  - WALLOPS ISL. - 2/MO.
  - WTR - 2/MO.
- **LAUNCH SITES**
  - WALLOPS IS. - (2)
  - WTR - (1)

NASA S63-300
REV. 12/8/65

SCOUT

Description: Scout is the smallest of the launch vehicle family. All of its four stages use solid rockets. Because of its relative simplicity, the Scout can be launched from relatively inexpensive installations. It is a low-cost vehicle which can be used for a large variety of scientific payloads such as high velocity probes, reentry experiments and satellites. Its guidance and control system incorporates a digital programmer and 3-axis stabilization for all except the spin-stabilized fourth stage. Ling-Temco-Vought, Dallas, Texas, is the vehicle prime contractor and is responsible for all vehicle items except the motors. The motors are obtained from Aerojet, Sacramento, California; Thiokol, Huntsville, Alabama; and the Allegany Ballistics Laboratory, Cumberland, Maryland.

Mission Capability: The present Scout is capable of placing 300 pounds in a 300 n.m. easterly orbit.

Schedule: Starting with the first flight on July 1, 1960, eight developmental and twenty-nine operational vehicles have been flown to date. A well integrated Scout program has been established between NASA and DOD. Forty-nine vehicles will have been procured through CY 1964 to fulfill NASA, AEC, and DOD requirements. In addition, a fully integrated logistic support system for the two Scout launch sites (Wallops Island and WTR) has been established by NASA with joint funding.

DELTA

Description: The Delta is a three-stage vehicle, in which the first stage consists of a production Thor space launch booster. The second stage is a modified version of the Vanguard second stage. A radio guidance system (BTL) is installed in the second stage to provide velocity and attitude control. This includes coast-phase attitude control which affords much higher orbits with Delta than with previous vehicles since a prescribed vehicle attitude can be maintained up to 2000 seconds after second-stage burnout. An ABL X-258 solid propellant rocket motor is used as the Delta third stage. Prior to ignition, this stage is spun up to approximately 150 rpm to obtain spin stability after separation, since neither guidance nor autopilot is carried in the third stage.

Mission Capability: The Delta is capable of launching a 120-pound space probe or putting an 800-pound payload into a 350 n.m. circular orbit.

Schedule: The first Delta flight was scheduled for 1960. Delta has been successful in 23 out of 26 launch attempts.

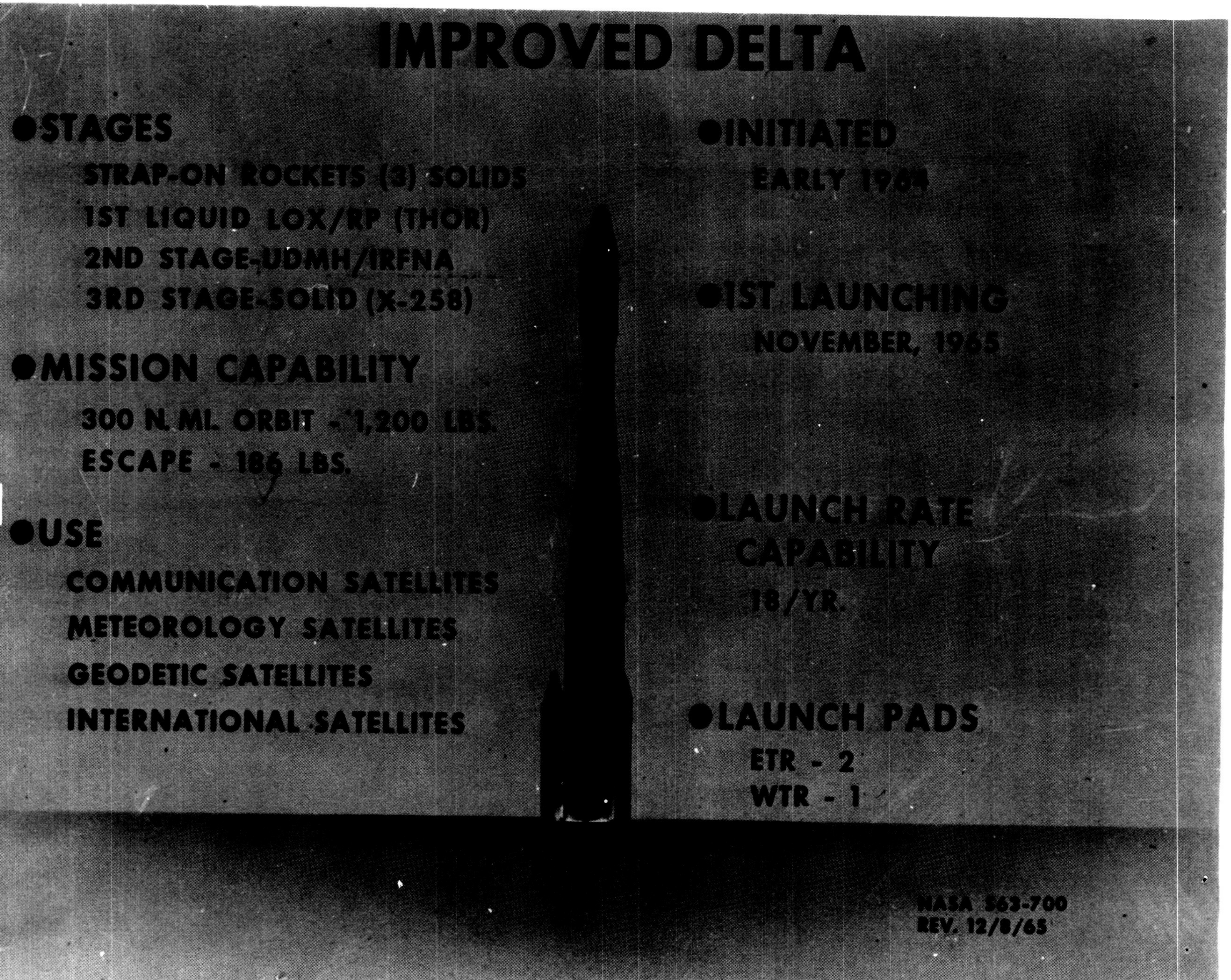
Additional vehicles have been ordered for use with scientific, meteorological and active communication satellite programs. These launches will continue well into calendar year 1967, and perhaps beyond, at a rate of eight to ten per year.

THRUST AUGMENTED DELTA (TAD)

Description: The Thrust Augmented Delta is a three and one half stage vehicle which differs from the Delta in that it utilizes the USAF developed, improved Thor Booster as a first stage. The improved Thor (SLV-2A) employs three (3) THIOKOL XM-33-#2 solid propellant rocket motors mounted around the base of the Thor Booster increasing the lift off thrust from 170,000 lbs. to 330,000 lbs. The solid motors are expended at approximately 40 seconds and are separated from the booster at an appropriate time thereafter. The upper stages are not changed from the standard Delta.

Mission Capability: This vehicle combination is capable of placing 1,000 lbs. into a 300 n.m. circular orbit and of placing 135 pounds to escape.

Schedule: The Thrust Augmented Delta was first launched successfully on Delta No. 26 which placed SYNCOM-C into synchronous transfer orbit on 17 August 1964.


IMPROVED DELTA
●STAGES
STRAP-ON ROCKETS (3) SOLIDS
1ST LIQUID LOX/RP (THOR)
2ND STAGE-UDMH/IRFNA
3RD STAGE-SOLID (X-258)
●MISSION CAPABILITY
300 N. MI. ORBIT - 1,200 LBS.
ESCAPE - 186 LBS.
●USE
COMMUNICATION SATELLITES
METEOROLOGY SATELLITES
GEODETIC SATELLITES
INTERNATIONAL SATELLITES
●INITIATED
EARLY 1964
●1ST LAUNCHING
NOVEMBER, 1965
●LAUNCH RATE CAPABILITY
18/YR.
●LAUNCH PADS
ETR - 2
WTR - 1
NASA S63-700
REV. 12/8/65

IMPROVED DELTA

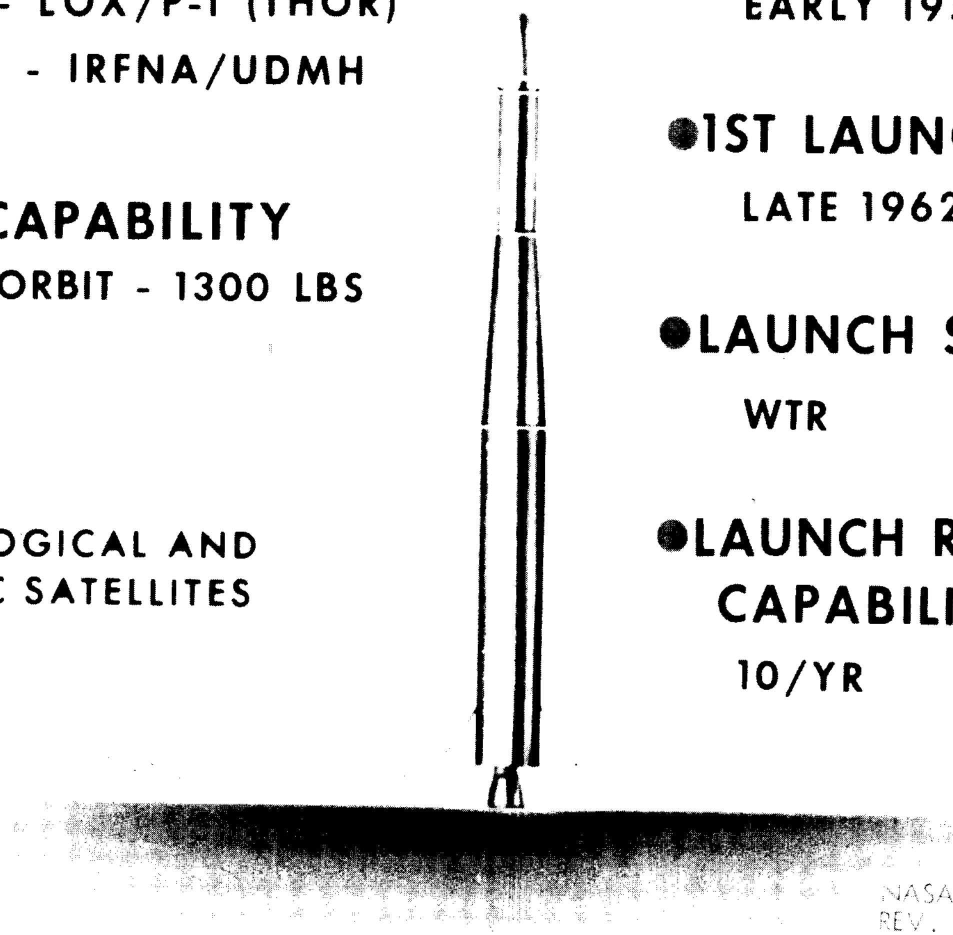
Description: The Improved Delta differs from the previous Delta in that the second stage tank diameter will be increased to provide additional propellant capacity (i.e., 54 inch diameter), and the larger diameter Nimbus fairing (i.e., 60 inch diameter) will be adopted for Delta use to provide additional payload volume. The improved second stage will be flown with or without first stage thrust augmentation and the X-258 third stage will be retained.

Mission Capability: The vehicle combination is capable of placing 1200 pounds into a 300 n.m. circular orbit and of placing 186 pounds to escape in the thrust augmented configuration.

Schedule: The Improved Delta became operational with the launching of the GEOS A Satellite in November 1965.

THOR-AGENA

- **STAGES**
  - 1ST STAGE - LOX/P-1 (THOR)
  - 2ND STAGE - IRFNA/UDMH (AGENA)
- **MISSION CAPABILITY**
  - 300 N. MI. ORBIT - 1300 LBS
- **USE**
  - METEOROLOGICAL AND SCIENTIFIC SATELLITES



- **INITIATED**
  - EARLY 1959 (DOD)
- **1ST LAUNCHING**
  - LATE 1962 (NASA)
- **LAUNCH SITE**
  - WTR
- **LAUNCH RATE CAPABILITY**
  - 10/YR

NASA S63-701
REV. 12-8-63

THOR AGENA

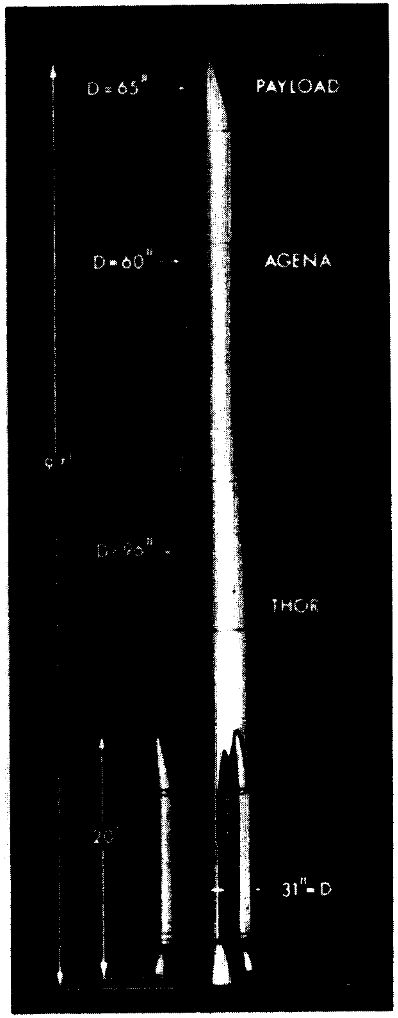
Description: The Thor Agena is a two stage rocket consisting of a Thor first stage using liquid oxygen and RP-1 propellants and an Agena second stage using UDMH and IRFNA as the propellants. The vehicle is eight feet in diameter and weighs 125,000 pounds, booster thrust is 170,000 pounds and the Agena second stage thrust is 16,000 pounds.

Mission Capability: This vehicle is capable of launching a payload of 1,300 pounds into a 300 n.m. circular polar orbit or an 850 pound Nimbus spacecraft into a 500 n.m. circular polar orbit. There is no Thor Agena capability from the ETR at present.

Schedule: The ISIS-X mission scheduled in the fourth quarter of 1965 will probably be the last Thor Agena scheduled by NASA. Currently planned Agena missions, other than the ISIS-X, require either the TAT Agena or Atlas Agena vehicle combination.

THRUST AUGMENTED THOR-AGENA

- **STAGES**
  - STRAP ON ROCKETS (3) SOLIDS
  - 1ST STAGE - LOX/RP-1 (THOR)
  - 2ND STAGE - IRFNA/UDMH (AGENA)
- **MISSION CAPABILITY**
  - 1800 LBS. AT 300 NM (POLAR ORBIT)
- **USE**
  - METEOROLOGICAL AND SCIENTIFIC SATELLITES



- **INITIATED**
  - 1962 (DOD)
- **1st NASA LAUNCH**
  - OCT. 1965
- **LAUNCH SITE**
  - WTR
- **LAUNCH RATE CAPABILITY**
  - 8 PER YEAR

NASA SP65-16319
12-8-65

THRUST AUGMENTED THOR AGENA (TAT)

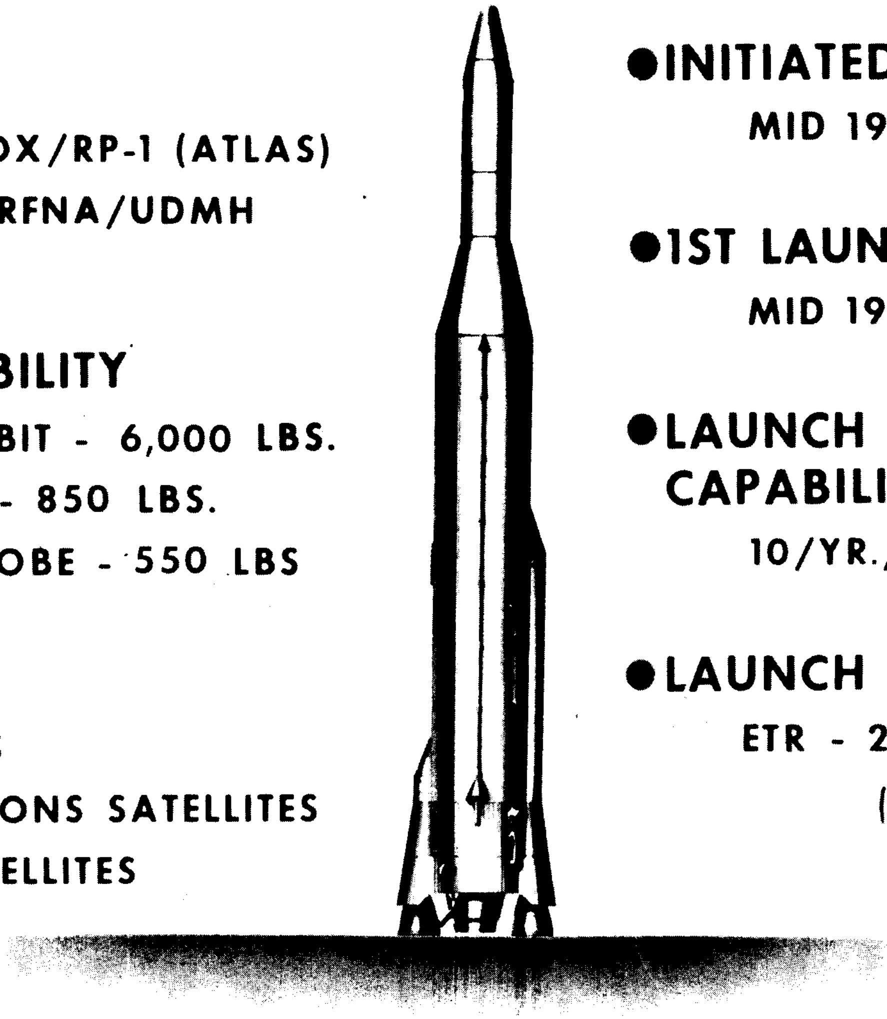
Description: The Thrust Augmented Thor Agena is a two and a half stage rocket consisting of a Thor booster with three solid rocket engines mounted around the periphery of the Thor base and an Agena as the second stage. The total lift-off thrust is increased to 300,000 pounds by the addition of the solid rocket engines. The solid rockets burn out at approximately 40 seconds after lift-off and are designed to drop away from the basic Thor vehicle at approximately 60 seconds.

Mission Capability: This vehicle combination is capable of placing a 1800 pound payload into a 300 n.m. circular polar orbit.

Schedule: Four TAT Agena launch vehicles are currently scheduled for launching in 1966. All current TAT Agena launches are for scientific and applications satellites, which require polar orbits.

ATLAS-AGENA

- **STAGES**
  - 1ST STAGE - LOX/RP-1 (ATLAS)
  - 2ND STAGE - IRFNA/UDMH (AGENA B)
- **MISSION CAPABILITY**
  - 300 N. MI. ORBIT - 6,000 LBS.
  - LUNAR PROBE - 850 LBS.
  - PLANETARY PROBE - 550 LBS
- **USE**
  - LUNAR PROBES
  - COMMUNICATIONS SATELLITES
  - SCIENTIFIC SATELLITES



- **INITIATED**
  - MID 1959 (DOD)
- **1ST LAUNCHING**
  - MID 1961 (NASA)
- **LAUNCH RATE CAPABILITY**
  - 10/YR./PAD
- **LAUNCH SITE**
  - ETR - 2 PADS
  - (1 PAD AVAILABLE FOR BACK-UP)

NASA S63-299
REV. 12/8/65

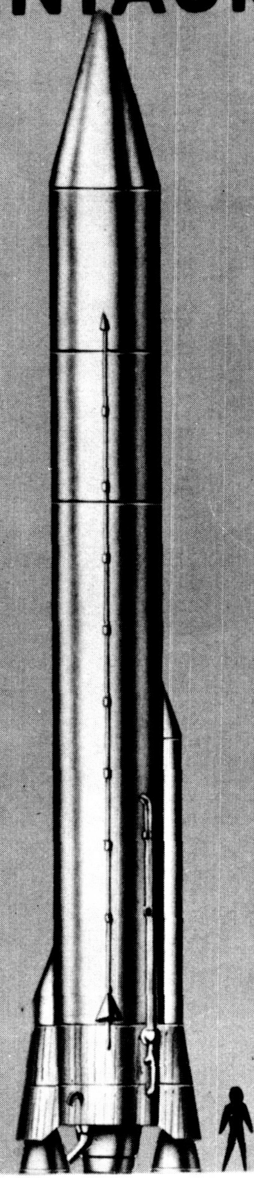
ATLAS AGENA

Description: Atlas Agena is a two stage vehicle. The first stage is a Standard model Atlas designed to accept a second stage. The Agena second stage is the same stage described for the Thor Agena. This vehicle combination is approximately 91 feet high exclusive of payload. The Atlas developes 367,000 pounds of thrust at sea level.

Mission Capability: The Atlas Agena was employed to launch the Ranger series of hard lunar landing missions and the Mariner planetary probes. It is currently scheduled to launch the Lunar Orbiter series, the Orbiting Astronomical Observatories, the Orbiting Geophysical Observatories, and the Applications Technological Satellites. This vehicle combination can place about 6,000 pounds into a 300 n.m. circular orbit, send over 950 pounds to the moon, or inject 600 pounds to Mars.

Schedule: Seven Atlas Agena launches are planned for 1966. Fourteen Atlas Agena launches have been completed to date commencing with Ranger I in 1961.

CENTAUR



- **STAGES**
  - 1st LIQUID
  - 2ND LIQUID (HIGH ENERGY)
- **MISSION CAPABILITY**
  - LUNAR PROBE 2,500 LBS
- **USE**
  - LUNAR AND PLANETARY EXPLORATION
- **INITIATED**
  - LATE 1958
- **1ST LAUNCHING**
  - R&D - MAY 1962
  - OPERATIONAL - 1966
- **LAUNCH RATE CAPABILITY**
  - 6 PER YEAR PER LAUNCH PAD
- **LAUNCH SITE**
  - ETR-2 PADS

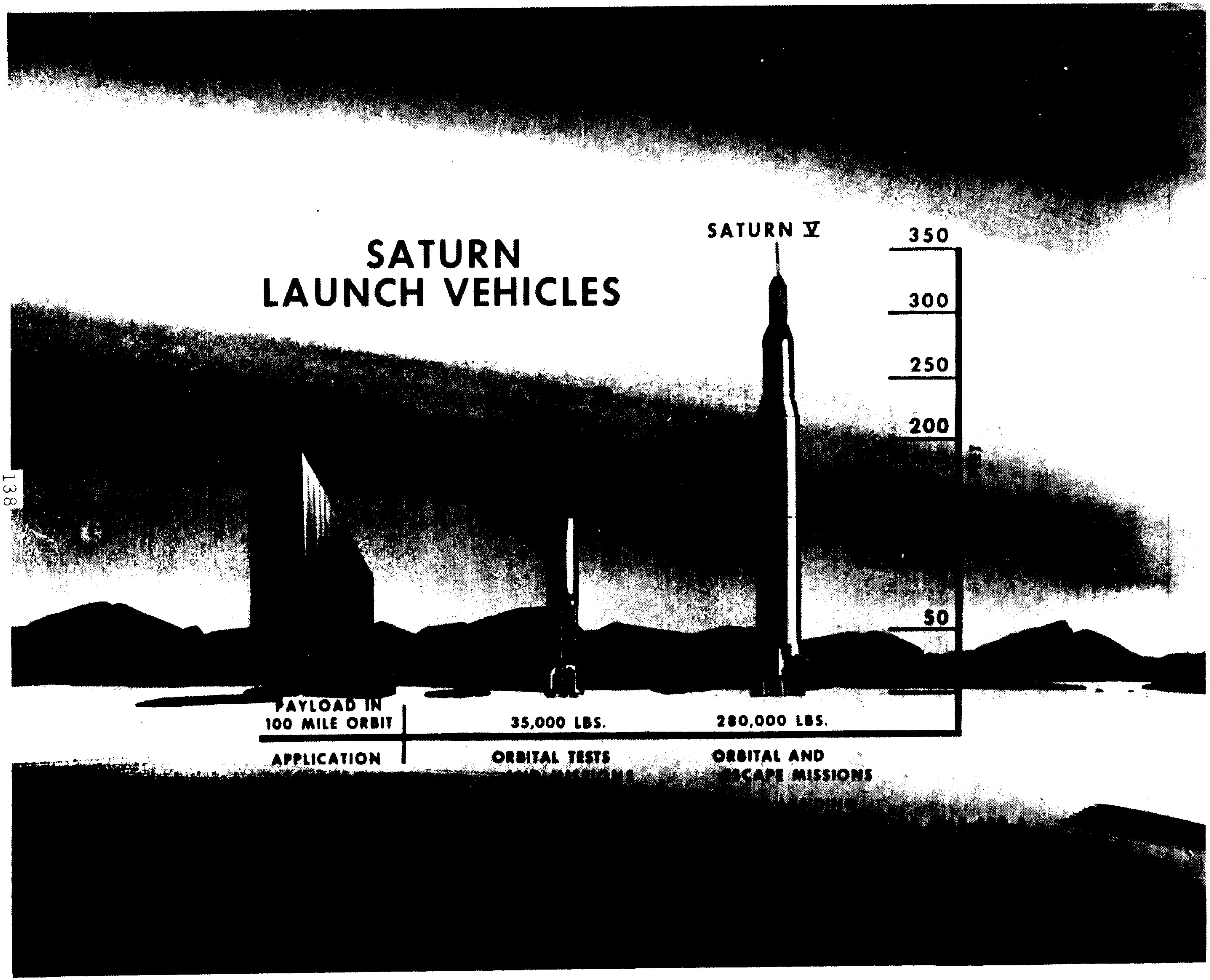
NASA S63-671
REV. 12/8/65

CENTAUR

Description: Centaur is a 10 ft. diameter high-energy upper stage powered by two Pratt and Whitney RL 10-A-3 liquid hydrogen-liquid oxygen engines of 15,000 pound thrust each. Centaur will use a modified Atlas-D as a first stage. This configuration is over 105 feet long and weighs about 300,000 pounds at launch.

Mission Capability: The high energy propellants used in Centaur give it a payload capability substantially above that of the Atlas-Agena D. Its performance advantages for high velocity missions is even more marked. It will be used by NASA principally for the Surveyor series of unmanned soft lunar landings.

Schedule: The first development flight of Centaur took place on May 8, 1961. The vehicle failed during first stage flight, probably due to aerodynamic forces. The fifth launch was unsuccessful because of an Atlas booster failure immediately after lift-off. The second, third, fourth and sixth development flights were successful. The development test program for direct ascent Surveyor missions was concluded in 1965 and will be followed by operational Surveyor launches. The development for the parking orbit ascent will be concluded in 1966. Centaur, as an upper stage for Atlas, is expected to remain operational throughout this decade.


SATURN
LAUNCH VEHICLES
SATURN V
350
300
250
200
50
PAYLOAD IN
100 MILE ORBIT
35,000 LBS.
280,000 LBS.
APPLICATION
ORBITAL TESTS
ORBITAL AND

SATURN 1B

<u>Description</u>: The 1B is a two-stage launch vehicle. The first stage (S-1B) to be powered by a cluster of H-1 engines developing a total sea level thrust of approximately 1,600,000 pounds. The second stage (S-IVB) to be powered by a single J-2 engine developing a total vacuum thrust of approximately 200,000 pounds. The first stage will be a slightly modified version of the S-1 stage developed by MSFC for the Saturn I. The second stage will be a slight modification to the S-IVB stage currently being developed by Douglas for use on the Saturn V based on design concepts from MSFC.

An instrument unit (a cylindrically shaped structure approximately 3 feet high) is mounted on top of the S-IVB to complete the launch vehicle. The launch vehicle guidance system and other electronics are peripherally mounted in the instrument unit.

<u>Mission Capability</u>: The primary mission of the IB launch vehicle two-stage configuration is to place an Apollo spacecraft, weighing approximately 35,000 pounds, without complete lunar mission propellants, into an earth orbit of approximately 105 nautical miles. The IB launch vehicle will also provide an early means of demonstrating the capability of the S-IVB stage and the instrument unit in support of the Saturn V Apollo program.

SATURN V

Description: The Saturn first stage (S-1C) will be powered by five Rocketdyne F-1 engines, each of which develops 1.5 million pounds of thrust for a total sea level thrust of 7.5 million pounds. The engines will be arranged in a square pattern of four gimballed engines with one fixed engine in the center of the square pattern. The S-IC will have a propellant capacity of approximately 4.5 million pounds consisting of liquid oxygen and hydrocarbon fuel in two tanks, each approximately 33 feet in diameter. The total length will be approximately 138 feet.

The second stage (S-II) will be powered by five J-2 engines developing 200,000 pounds thrust each, for a total vacuum thrust of 1,000,000 pounds. The propellant (liquid oxygen and liquid hydrogen) capacity will be in excess of 900,000 pounds. The second stage will be approximately 33 feet in diameter and approximately 82 feet long.

The third stage (S-IVB) will use one J-2 engine for a total vacuum thrust of 200,000 pounds. It will carry approximately 230,000 pounds of liquid oxygen and liquid hydrogen and will be 260 inches in diameter and 58 feet long.

The instrument unit for the Saturn V is basically the same as that for the Saturn IB and, as in the IB, comprises the topmost 3 feet of the vehicle.

Mission Capability: The Saturn V Launch Vehicle system will have sufficient payload capability to perform manned lunar-landing missions using a single lunar-orbital rendezvous. Also, it will provide a basic vehicle for manned circumlunar and lunar orbit missions, and for unmanned lunar and planetary explorations. This launch vehicle will have the capability of putting approximately 140 tons (including the S-IVB and instrument unit) in a low earth orbit and of sending more than 45 tons to the vicinity of the moon. Prime emphasis will be placed on the Apollo mission.

NASA sponsors a wide variety of research in space-related science and technology by universities and non-profit organizations. This research ranges from basic investigations to technological applications, and many of the scientific and technological advances recorded in this report were made possible by university efforts. During Fiscal Year 1965, $122.8 million was obligated to universities by all NASA sources. Of this amount $45.2 million was obligated by the Sustaining University Program. The balance of the funds supported project-type research.

Under the training element of the Program, we continue to aim at an annual yield of about 1,000 Ph.D.'s in space-related science and technology. In September 1965, 1,275 new students entered, bringing the total to 3,132 students in training. As of August 31, 1965, 86 students have completed their Ph.D.'s under the predoctoral program. Of this group, 64 have remained in the academic community in university research or teaching or postdoctoral work. Eighteen have taken positions in industrial laboratories, and four are in Government laboratories. The 142 universities currently participating are:

Adelphi University
Alabama, University of
Alaska, University of
Alfred University
Arizona State University
Arizona, University of
Arkansas, University of
Auburn University
Boston College
Boston University
Brandeis University
Brigham Young University
Brooklyn, Polytechnic Institute of
Brown University
California Institute of Technology
California, University of (Berkeley)
California, University of (Los Angeles)
California, University of (Riverside)
California, University of (San Diego)
Carnegie Institute of Technology
Case Institute of Technology
Catholic University of America
Chicago, University of
Cincinnati, University of
Clark University

Clarkson College of Technology
Clemson University
Colorado School of Mines
Colorado State University
Colorado, University of
Columbia University
Connecticut, University of
Cornell University
Dartmouth College
Delaware, University of
Denver, University of
Duke University
Duquesne University
Emory University
Florida State University
Florida, University of
Fordham University
George Washington University
Georgetown University
Georgia Institute of Technology
Georgia, University of
Hawaii, University of
Houston, University of
Howard University
Idaho, University of
Illinois Institute of Technology
Illinois, University of
Indiana University
Iowa, University of
Iowa State University
Johns Hopkins University
Kansas State University
Kansas, University of
Kent State University
Kentucky, University of
Lehigh University
Louisiana State University
Louisville, University of
Maine, University of
Maryland, University of
Massachusetts Institute of Technology
Massachusetts, University of
Miami, University of
Michigan State University
Michigan, University of
Minnesota, University of
Mississippi State University

Mississippi, University of
Missouri, University of
Missouri, University of, at Rolla
Montana State University
Montana, University of
Nebraska, University of
Nevada, University of
New Hampshire, University of
New Mexico State University
New Mexico, University of
New York, The City University of
New York, State University of (Stony Brook)
New York University
North Carolina State College
North Carolina, University of
North Dakota State University
Northeastern University
Northwestern University
Notre Dame, University of
Ohio State University
Ohio University
Oklahoma State University
Oklahoma, University of
Oregon State University
Pennsylvania State University
Pennsylvania, University of
Pittsburgh, University of
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rhode Island, University of
Rice University
Rochester, University of
Rutgers - The State University
Saint Louis University
South Carolina, University of
South Dakota, University of
Southern California, University of
Southern Methodist University
Southern Mississippi, University of
Stanford University
Stevens Institute of Technology
Syracuse University
Temple University
Tennessee, University of
Texas A&M University
Texas Christian University

Texas Technological College
Texas, University of
Toledo, University of
Tufts University
Tulane University
Utah State University
Utah, University of
Vanderbilt University
Vermont, University of
Virginia Polytechnic Institute
Virginia, University of
Washington State University
Washington, University of (Seattle)
Washington University (St. Louis)
Wayne State University
West Virginia University
Western Reserve University
William & Mary, College of
Wisconsin, University of
Worcester Polytechnic Institute
Wyoming, University of
Yale University
Yeshiva University

The research facilities segment of the Program continues to provide some of the required laboratory space at universities heavily engaged in research and training activities supporting the national space program. NASA has made a total of thirty-three facilities grants to date. Table I shows pertinent information about each award. It should be noted that ten of these structures have already been completed and occupied, and that six more are beyond 95 percent complete at this time. These first sixteen essentially completed structures represent about 450 thousand square feet of research laboratory space which otherwise would not have been available to the universities for the conduct of aeronautical and space-related research and training. In the remaining grants, eleven grantees have buildings under construction and six grantees have buildings under design. No awards have yet been made with FY 1966 funds.

The need for this program continues to grow in spite of extensive other federal support of general purpose facilities at universities. There is serious question, however, whether the present course being followed by NASA will achieve more than a small portion of our needs. The support of research in universities continues to grow. Training of scientists in the aeronautical and space-related sciences is gaining more widespread support. These activities are crucial to the accomplishment of the national mission of space exploration and both demand adequate research laboratories for their successful accomplishment. This demand cannot be fulfilled if the NASA trend of decreasing its facilities support continues.

TABLE I

SUMMARY OF RESEARCH FACILITIES

NOVEMBER 1, 1965

FISCAL YEAR	INSTITUTION	INVESTIGATOR/TOPIC	AREA (1000 SF)	PER CENT COMPLETE	COST ($ 1000)
1962	RPI	WIBERLEY/MATERIALS SCIENCES	60	100	$ 1,500
	STANFORD	LEDERBERG/EXOBIOLOGY	15	95	535
	CHICAGO	SIMPSON/SPACE & ASTROPHYSICS	45	100	1,750
	IOWA	VAN ALLEN/PHYSICS & ASTRONOMY	24	95	610
	CALIFORNIA (BERKELEY)	SILVER/SPACE SCIENCES	44	80	1,990
	HARVARD	SWEET/BIOMEDICINE	5	100	151
1963	MINNESOTA	NIER/PHYSICS	17	100	542
	M.I.T.	HARRINGTON/SPACE SCIENCES	75	10	3,000
	COLORADO	RENSE/ASTROPHYSICS	32	100	792
	CALIFORNIA (LOS ANGELES)	LIBBY/SPACE SCIENCES	69	95	2,000
	WISCONSIN	HIRSCHFELDER/ THEORETICAL CHEMISTRY	12	10	365
	MICHIGAN	NORMAN/SPACE SCIENCES	56	100	1,436
	PITTSBURGH	HALLIDAY/SPACE SCIENCES	47	100	1,500
	PRINCETON	LAYTON/PROPULSION SCIENCES	26	100	625
	LOWELL OBSERVATORY	HALL/PLANETARY SCIENCES	9	100	237
1964	TEXAS A&M	WAINERDI/SPACE SCIENCES	34	10	1,000
	MARYLAND	MARTIN/SPACE SCIENCES	77	20	1,497
	SOUTHERN CALIFORNIA	MEEHAN/HUMAN CENTRIFUGE	4	100	160
	CORNELL	GOLD/SPACE SCIENCES	38	1	1,350
	RICE	DESSLER/SPACE SCIENCES	68	15	1,600
	PURDUE	ZUCROW/PROPULSION SCIENCES	5	95	840
	WASHINGTON (ST. LOUIS)	NORBERG/SPACE SCIENCES	25	98	600
	NEW YORK	FERRI/AERONAUTICS	13	15	582
	GEORGIA TECH	PICHA/SPACE SCIENCES & TECHNOLOGY	51	45	1,000
	ARIZONA	RHODES/SPACE SCIENCES	51	10	1,200
	ILLINOIS	COMPTON/SPACE SCIENCES	51	1	1,125
	PIB	BLOOM/AEROSPACE SCIENCES	16	98	632
1965	CASE	NARA/SPACE ENGINEERING	69		2,226
	ROCHESTER	FENN/SPACE SCIENCES	35		1,000
	FLORIDA	GRINTER/SPACE SCIENCES	53		1,190
	MINNESOTA	CHESTON/SPACE SCIENCES	83		2,500
	DENVER	AMME/SPACE SCIENCES	38		900
	STANFORD	RAMBO/SPACE ENGINEERING	65		2,080
	TOTALS		1,310		38,515

The research part of the Sustaining University Program complements NASA's project research activity by encouraging multidisciplinary investigations, aiding the development of new and promising research activities, consolidation of related research projects into a unified program and the filling of gaps between existing projects. This carefully developed research endeavor affords universities the maximum opportunity to balance and strengthen space-related work and serves to stimulate the development of new ideas and talent, particularly in those areas which fall outside the specific responsibilities of an individual NASA organizational element, but which are of vital importance to the national space program.

To the university already heavily involved in space-related research, this program provides an opportunity to make more efficient use of its assets. To the school which has not been engaged previously in space research to an appreciable degree, it provides an incentive for the university researcher to remain at his institution where he can create an attractive nucleus of interest for young researchers which offsets the drift of talent to the larger and better known institutions. The effect is to broaden the base of university participation in the space program and increase the overall national research capability. Institutions currently participating in research supported by the Sustaining University Program are:

Adelphi University
Alabama, University of
Brown University
California, University of (Berkeley)
California, University of (Los Angeles)
California Institute of Technology
Denver, University of
Duke University
Florida, University of
Graduate Research Center of the Southwest
Georgia Institute of Technology
Kansas State University
Kansas, University of
Louisville, University of
Maine, University of
Maryland, University of
Massachusetts Institute of Technology
Minnesota, University of
Missouri, University of
Montana State University
New Mexico State University
Oklahoma State University

Pennsylvania State University
Pennsylvania, University of
Pittsburgh, University of
Purdue University
Southern Methodist University
Texas A&M University
Vermont, University of
Virginia, University of
Virginia Polytechnic Institute
Washington University (St. Louis)
West Virginia University
William and Mary, College of
Wisconsin, University of

COSTS OF LAUNCHED SPACECRAFT (MILLIONS OF DOLLARS)

Orbiting Astronomical Observatories

Spacecraft	(10)	$ 460.6
Atlas-Agena	(10)	112.8
Total		$ 573.4

Unit cost $57.34 million

Orbiting Geophysical Observatories

Spacecraft	(11)	$ 352.4
Atlas-Agena	(8)	66.2
Thor-Agena	(3)	19.0
Total		$ 437.6

Unit cost $39.78 million

Orbiting Solar Observatories

Spacecraft	(8)	$ 78.2
Delta Dev. Veh.	(1)	2.5
Delta Proc. Veh.	(7)	21.2
Total		$ 101.9

Unit cost $12.74 million

Advanced Orbiting Solar Observatories

Spacecraft	(4)	$ 163.9
TAT Agena	(4)	24.6
Total		$ 188.5

Unit cost $47.12 million

Beacon Explorer

Spacecraft	(3)	$ 4.1
Scout	(2)	2.8
Delta	(1)	2.9
Total		$ 9.8

Unit cost $3.27 million

Atmospheric Explorers

Spacecraft	(2)	$ 7.7
Delta	(2)	5.9
Total		$ 13.6

Unit cost $6.80 million

Ionosphere Explorers

Spacecraft	(2)	$ 3.8
Scout	(1)	1.5
Total		$ 5.3

Unit cost $2.65 million

Air Density/Injun Explorers

Spacecraft	(6)	$ 6.4
Scout	(6)	8.4
Total		$ 14.8

Unit cost $2.47 million

Geodetic Explorers

Spacecraft	(4)	(2) Active (2) Passive	$ 14.7
Delta	(2)		7.0
Thor-Agena	(2)		13.7
Total			$ 35.4

Unit cost $8.85 million

Radio Astronomy Explorers

Spacecraft	(6)	$ 40.7
Delta	(6)	21.0
Total		$ 61.7

Unit cost $10.28 million

OWL Explorers

Spacecraft	(2)	$ 3.9
Scout	(2)	2.8
Total		$ 6.7

Unit cost $3.35 million

International Satellites

Spacecraft	(19)	$ 24.0
Scouts	(11)	15.4
Delta Dev.	(1)	2.5
Delta Proc.	(3)	10.5
Thor-Agena	(2)	19.8
Total		$ 72.2

Unit cost $4.24 million

Does not include spacecraft cost funded by International Groups.

Energetic Particles Satellites

Spacecraft	(4)	$ 7.5
Delta Dev.	(2)	5.5
Delta Proc.	(2)	5.8
Total		$ 18.8

Unit cost $4.70 million

Probes

IMP

Spacecraft	(11)	$ 48.2
Delta	(11)	36.8
Total		$ 85.0

Unit cost $7.73 million

Lunar Orbiter

Spacecraft	(5)	$ 143.5
Atlas-Agena	(5)	40.9
Total		$ 184.4

Unit cost $36.9 million

PIONEER

Spacecraft	(9)	$ 89.1
Delta	(9)	31.5
Total		$ 120.6

Unit cost $13.4 million

PIONEER 50

Spacecraft	(14)	$ 24.4
Scout	(14)	28.0
Total		$ 52.4

Unit cost $3.7 million

Ranger

Spacecraft	(9)	$ 170.6
Atlas-Agena	(9)	96.9
Total		$ 267.5

Unit cost $29.7 million

Surveyor Lander

Spacecraft	(10)	$ 523.5
Centaur	(10)	189.3
Total		$ 712.8

Unit cost $71.3 million

Mariner-Mars 1964

Spacecraft	(2)	$ 86.9
Atlas-Agena	(2)	26.9
Total		$ 113.8

Unit cost $56.9 million

Applications Technology Satellites

Spacecraft	(5)	$ 110.3
Atlas-Agena	(5)	39.6
Total		$ 149.9

Unit cost $30.0 million

Voyager

Spacecraft	(4)	$ 990.0
Saturn V	(2)	230.0
Total		$1,220.0

Unit cost $305.0 million

Tiros

Spacecraft	(10)	$ 47.8
Delta Dev.	(5)	12.5
Delta Proc.	(5)	15.1
Total		$ 75.4

Unit cost $7.54 million

Nimbus

Spacecraft	(4)	$ 195.4
Thor-Agena	(4)	34.6
Total		$ 230.0

Unit cost $57.5 million

Echo

Spacecraft	(3)	$ 11.5
Delta Dev. Veh.	(2)	5.0
Thor-Agena	(1)	8.6
Total		$ 25.1

Unit cost $8.4 million

Probes

BIOSATELLITES

Spacecraft	(6)	$ 79.9
Delta	(6)	21.0
Total		$ 100.9

Unit cost $13.3 million

Relay

Spacecraft	(2)	$ 34.3
Delta	(2)	6.0
Total		$ 40.3

Unit cost $20.2 million

Syncom

Spacecraft	(3)	$ 22.9
Delta	(3)	9.3
Total		$ 32.2

Unit cost $10.7 million