SPACEFLIGHT

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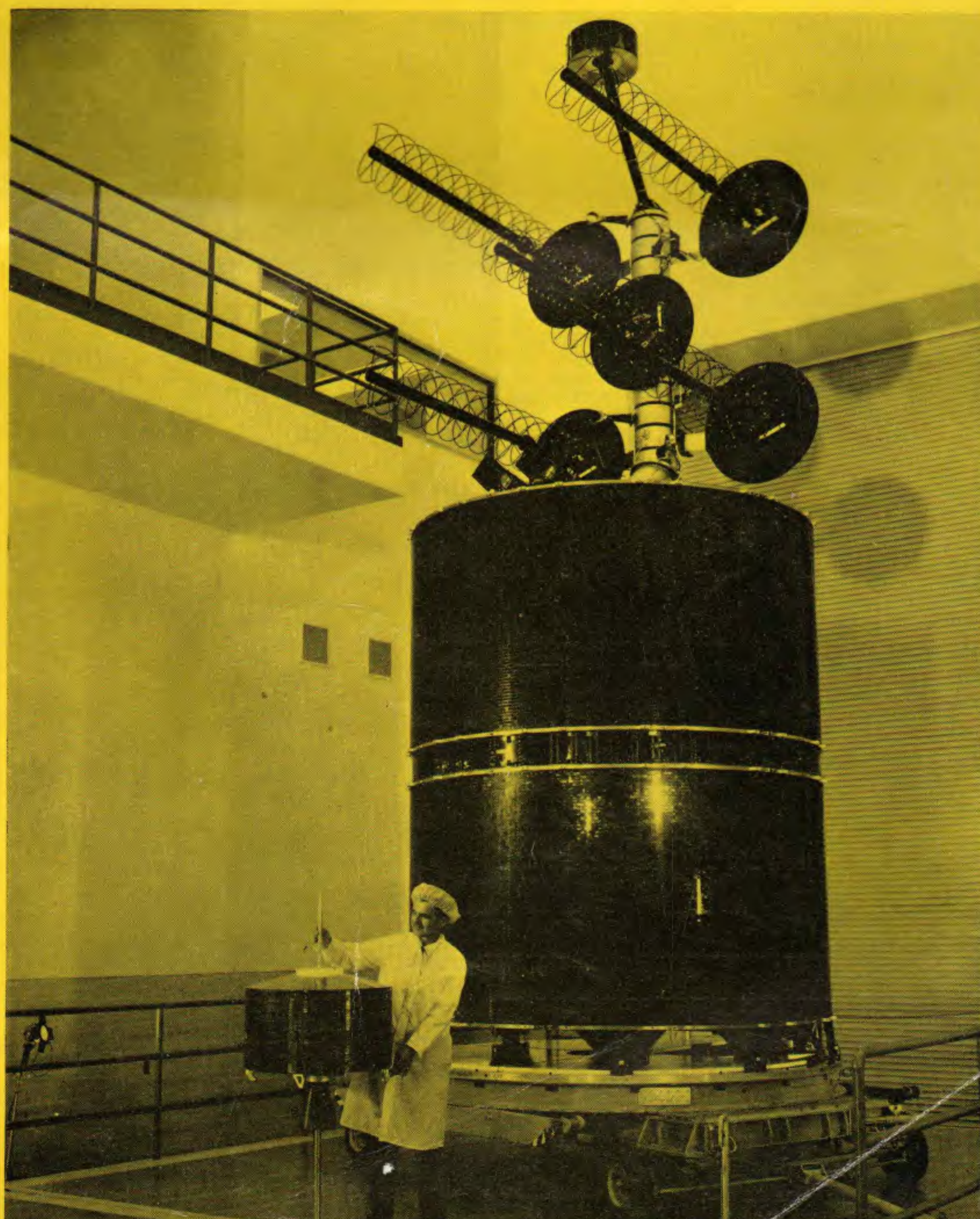

SPACEFLIGHT

A Publication of The British Interplanetary Society

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Volume 11 No 5 May 1969

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COVER

Largest communications satellite TACSAT 1 was launched into synchronous orbit by Titan 3C from Cape Kennedy on 9 February. The 1600 lb spacecraft, built by Hughes Aircraft Company under the direction of the U.S.A.F.'s Space and Missile Systems Organization (SAMSO), is being used by the U.S. Air Force, Army and Navy for experiments in communications among military units in the field, aircraft and ships at sea. While the drum shaped body is spin-stabilized at 54 rpm, the UHF helical antennae at the top are kept stationary and aimed at the Earth. Signals are so powerful, they can be picked up by portable ground terminals with receiving dishes as small as 1 ft across.

Hughes Aircraft Company

MILESTONES

March

3 Apollo 9 with three astronauts Col James McDivitt, Col David Scott and Russell Schweikart, launched by Saturn 5 from Kennedy Space Centre at 1700 BST (1100 local time). After entering a near-circular orbit at about 118 miles altitude inclined at 32·57° to equator, transposition and docking manoeuvre by Apollo CSM extracts Lunar Module from orbiting S-IVB stage. Apollo spacecraft, now comprising LM/CSM, redirected into new orbit of 130–151 miles by firing SPS engine for 5 sec over Hawaii.

4 Apollo 9 astronauts test LM/CSM systems including further burns of the SPS engine.

5 Apollo 9 astronauts don spacesuits and Schweikart and McDivitt transfer through docking tunnel to Lunar Module. Tests include extension of landing legs of LM. First telecast to Earth via Westinghouse 8 lb Moon camera. LM descent stage engine test-fired for first time in space during run lasting nearly 6 min over wide thrust range. After transfer back to CM, SPS engine fired again to circularize orbit at 143–148 miles.

6 Schweikart and McDivitt return to LM and, after both spacecraft are depressurized, the hatches are opened. Schweikart climbs out onto porch of LM to stand in "golden slipper" foot retraints for 37·5 min. Scott reaches out of CM to retrieve thermal samples. Second telecast to Earth by Schweikart shows views of docked spacecraft and Earth some 145 miles below. After resealing of hatches, spacecraft are repressurized and astronauts return to CSM.

7 McDivitt and Schweikart return to Lunar Module for rendezvous and docking experiments. Lunar Module separates from Apollo CSM parent and descent engine fires twice to achieve 154–160 orbit about 12 miles higher than CSM. Maximum separation distance 4 hr later exceeds 100 miles. Descent stage separates and 3500 lb thrust ascent stage engine fired. Some 6 hr later ascent stage briefly redocked with CSM for crew transfer and then separated empty for re-direction into high elliptical orbit by ground command, the engine burning to depletion for about 6 min.

8 Apollo 9 astronauts begin more leisurely programme of experiments lasting 5 days. Includes landmark sighting in simulation of return flight from Moon and multi-spectral photography for Earth-resources study with special application to agriculture.

13 Command Module of Apollo 9 splashes down in the Atlantic some 3 miles from aircraft carrier *USS Guadalcanal* at 1701 BST with recovery procedures televised to world audience via Intelsat communications satellites.

14 President Nixon confirms Dr Thomas O. Paine as Administrator of National Aeronautics and Space Administration.

25 NASA confirms that Apollo 10 with astronauts Thomas Stafford, John Young and Eugene Cernan, will be a 99% "dress rehearsal" for lunar landing. Apollo LM/CSM to enter lunar orbit for LM separation with two astronauts. Landing craft to dip within 10 miles of Moon's surface in elliptical orbit returning to Apollo parent for rendezvous and docking. Launch date 18 May will allow observation of Apollo landing site 2 as the area of primary interest and also permit observation of site 3 after sunrise on the Moon. (Apollo site 1 was the area of primary interest during the December flight of Apollo 8).

28 US launches 910 lb Mariner 7 by Atlas-Centaur from Kennedy Space Centre to photograph south polar regions of Mars from 2000 miles on 5 August.

NASA'S YEAR OF TRIUMPH

In 1968, its 10th Anniversary year, the National Aeronautics and Space Administration marked a decade of progress in all aspects of space exploration and rallied its resources for the lunar landing scheduled this summer. The year saw the first two manned launches—Apollo 7 and 8—in the Apollo programme plus successful missions by unmanned satellites which brought new knowledge of the Solar System which American astronauts hope to explore after the lunar landing.

Unmanned Spacecraft

Surveyor 7, NASA's first 1968 mission, wrote a rewarding scientific finish to the Surveyor lunar photography programme which successfully soft-landed five spacecraft on the Moon. Scientists, astronomers and engineers estimate that, in the brief months since the summer of 1964 when NASA's Ranger spacecraft flew its first successful mission, man has learned more about the Moon than in all the 350 years since Galileo first viewed it through his telescope.

Other significant 1968 unmanned satellites include the Radio Astronomy Explorer (RAE), launched 4 July, and the Orbiting Astronomical Observatory (OAO-2), launched on 7 December.

RAE, with its antenna booms extending more than 1500 ft from tip to tip, has the largest span of any spacecraft orbited to date. It has monitored low-frequency radio signals from space sources, including the Milky Way, the Sun and Earth itself.

Its data will provide astronomers with their first detailed radio map of the Milky Way and, by mapping thousands of unidentified radio sources throughout the sky, scientists hope to learn about some which, by process of elimination, may prove to come from beyond our galaxy.

The OAO-2 is the heaviest (4400 lb) and most complex unmanned spacecraft launched by the United States to date. Its successful orbit and operation provides astronomers with a new vantage point for "seeing" in the ultraviolet, infrared, X-ray and gamma radiations and thereby observing most of the parameters necessary for understanding the Solar System's make-up now and in the future.

The Smithsonian Institution experiment aboard the OAO-2, with its seven photometric systems, has been designed to perform basically identification and mapping functions, whereas the University of Wisconsin experiment with four telescopes is capable of more intensive study of individual stars, planets and outer space phenomena.

During the first quarter of 1968, OGO-5 joined its sister geophysical observatories after its launch on 4 March into a long elliptical orbit around the Earth. It is concentrating on a study of energetic particles, electric and magnetic fields and other phenomena in Earth's vicinity, while OGO-4, in a low altitude polar orbit, studies principally the Earth's atmosphere and ionosphere, including auroral phenomena in the polar cap regions.

OSO-4, together with its cousin, OSO-3, continued to observe the Sun and its radiations from Earth orbit during the year. OSO-4 was launched in the last quarter of 1967.

GEOS-2, launched on 11 January, joined GEOS-1 in continuing measurements of the Earth's gravity field and in establishing more precisely the shape and size of the planet.

GEOS-2 carries a laser detector device which has permitted it to receive and analyse laser signals beamed at the satellite from Earth stations in a series of continuing experiments. In May for the first time, the spacecraft identified a laser beam directed to it while it was illuminated in sunlight.

Operating from a stationary orbit over the Equator at an altitude of 22 240 miles, NASA's ATS-3 continued its significant contributions to meteorology and communications. Its communications channels served to augment commercial circuitry in helping to bring the events of Olympic Games in Mexico City, the Apollo 7 and 8 spaceflights, and other world news to television viewers in Europe and North America.

Pioneer-9, launched on 8 November, added a new spacecraft to NASA's team of Sun-orbiting satellites assigned to study space continuously from widely separated positions. The spacecraft joined Pioneers 6, 7 and 8 in studying the nature and interrelationship of interplanetary magnetic fields, the solar wind and solar cosmic rays.

Major NASA *Launches*
1968

Date	Name	Launch vehicle	Launch site	Mission	Results: Vehicle	Results: Mission
1/7	Surveyor 7	Atlas-Centaur	KSC	Lunar Photos Lunar Surface Analyses	Success	Success
1/11	Explorer 36	Delta	WTR	Geodesy	Success	Success
1/22	Apollo 5	Saturn IB	KSC	Lunar Module Test	Success	Success
3/4	OGO-5	Atlas-Agena	KSC	Earth-Sun data	Success	Success
3/5	Explorer 37	Scout	WI	Solar radiation	Success	Success
4/4	Apollo 6	Saturn V	KSC	Launch Vehicle test	Unrated	Unrated
5/16	ESRO 2-B	Scout	WTR	Radiation Investigation	Success	Success*
5/18	Nimbus B	TAT-Agena	WTR	Meteorology	Failure	Failure
7/4	Explorer 38	Delta	WTR	Radio Astronomy	Success	Success
7/8	Explorer 39	Scout	WTR	Atmospheric Density data	Success	Success
	Explorer 40			Charged particle data	Success	Success
8/10	ATS-4	Atlas-Centaur	KSC	Spacecraft Technology	Failure	Failure
8/16	ESSA 7	Delta	WTR	Cloud cover photos	Success	Success*
9/18	Intelsat 3	Delta	KSC	Communications	Failure	Failure*
10/3	ESRO 1	Scout	WTR	Auroras	Success	Success*
10/11	Apollo 7	Saturn 1B	KSC	First manned Apollo	Success	Success
11/8	Pioneer 9	Delta	KSC	Solar radiation	Success	Success
	TETR-2			Tracking training	Success	Success
12/5	HEOS 1	Delta	KSC	Interplanetary physics	Success	Success
12/7	OAO 2	Atlas-Centaur	KSC	Astronomy	Success	Success
12/15	ESSA 8	Delta	WTR	Meteorology	Success	Success*
12/18	Intelsat 3	Delta	KSC	Communications	Success	Unrated*
12/21	Apollo 8	Saturn 5	KSC	First Manned Lunar Orbit	Success	Success

* Non-NASA mission.

These four Pioneers are contributing significantly to accuracy in forecasting solar flares. Their observations form part of the forecasting procedures used to decide whether radiation conditions in space at a given time will permit safe journeys for Apollo astronauts.

Riding piggy-back into orbit with Pioneer 9 was the 40 lb TETR-2 satellite. In its 200 by 500 mile Earth orbit, it has been used as an orbiting target for checking out equipment and training personnel of NASA's Manned Space Flight Network in preparation for Apollo moonflight operations.

Although no Mariner planetary flights were initiated during the year, scientists calculated that on 4 January, Mariner 5's orbit carried it within about 54 million miles of the Sun. This was closer than any other man-made object has approached to the centre of our Solar System. The spacecraft made its closest approach to Venus in October 1967.

Preparations continued during 1968 for Mariner flights to Mars in 1969, in 1971 and in 1973. NASA announced that the 1973 mission would be named Project Viking and would use the Titan III-D/Centaur as its launch vehicle.

Viking Mars 1973 science equipment will be finally determined after the 1969 mission to the planet. Two 6000 lb orbiting spacecraft will each send soft lander vehicles to the Martian surface. Mission objectives place special emphasis on returning information about life on the planet.

The orbiting of Air Density and Injun satellites (Explorers 39 and 40) on 8 August with a single Scout launcher extended studies of complex radiation-air density relations to regions above the Earth's polar caps.

Besides launches serving its own experiment programme, NASA successfully orbited seven other spacecraft for other agencies or governments during the year. They included the NRL Solar Explorer for the U.S. Navy, two weather satellites, ESSA 7 and 8, for the Environmental Science Services Administration and Atlantic 1 of the Intelsat III series for the Comsat Corporation.

International

For the European Space Research Organization, ESRO-I and II and HEOS-I were launched in NASA's International Co-operation Programme.

Also during this year, thirty-five investigators from eight foreign countries were selected to carry out experiments with the first lunar surface samples to be retrieved by NASA. Four foreign experiments were flown on NASA spacecraft, 122 sounding rockets were launched in scientific programmes with eight countries, geodetic satellite observations were carried out with thirty-four countries, and significant aeronautical research was conducted with Canada, France, Germany and the United Kingdom.

Manned Flight

In manned flight, the decision to boost Apollo 8 into orbital flight around the Moon on 21 December directly reflected the Apollo programme's overall maturity and operational readiness, progressively demonstrated by three flights and supporting ground test programme during 1968.

The precise re-entry and splashdown on 22 October, of the 11-day Apollo 7 flight ended what was called a 101% successful mission. Manned by astronauts Walter Schirra, Donn Eisele, and Walter Cunningham, Apollo 7 performed flawlessly for more than 260 hr in space, including firings of the spacecraft's primary propulsion system and the first live TV from a US manned vehicle.

Shortly after launch, with the Saturn IB rocket second stage still attached to the spacecraft, the astronauts exercised manual control of the combined vehicle from the spacecraft. Following space vehicle separation, they flew the spacecraft around the second stage and simulated a docking, using the lunar module adapter as the target. Later, with the second stage in a different orbit, the spacecraft "found" the vehicle and rendezvoused with it—demonstrating the ability of the command module to manoeuvre to the lunar module if the latter should become disabled on a manned lunar landing mission.

NASA Major Launch Record
October 1959 — December 1968

Year	No. of launches	Vehicle results		Mission results	
		Success	Failure	Success	Failure
1958	4	0	4	0	4
1959	14	8	6	8	6
1960	17	10	7	9	8
1961	23	16	7	15	8
1962	27	23	4	20	7
1963	13	12	1	11	2
1964	30	26	4	25	5
1965	31	27	4	26	5
1966	36	33	3	26	10
1967	27	25	2	25	2
1968	21	16†	3†	17*†	3†
10-Year Totals	243	196	45	182	60

* Includes two satellites launched on one vehicle.

† Figures do not include "unrated" items.

Most of the critical tests necessary to "wring out" the spacecraft equipment took place early in the flight. Crew performance, prime and back-up systems, and mission support facilities were checked.

The astronauts used hand-held movie and still cameras to photograph both Earth and stars. The astronauts had colds during the flight.

The flight not only accomplished all mission objectives, but also completed some tests not included in the original flight plan. Apollo 7 flew some 4·5 million miles on the first manned Apollo flight.

The 4 April flight of Apollo 6 was the second unmanned Saturn 5 mission to demonstrate launch vehicle and spacecraft systems performance. Two problems were experienced with the rocket systems: vertical oscillations or "POGO" effect in the first stage and rupture of small propellent lines in the upper stages.

As the result of a determined post-mission analysis and an aggressive ground testing and evaluation programme, these Saturn 5 problems were corrected.

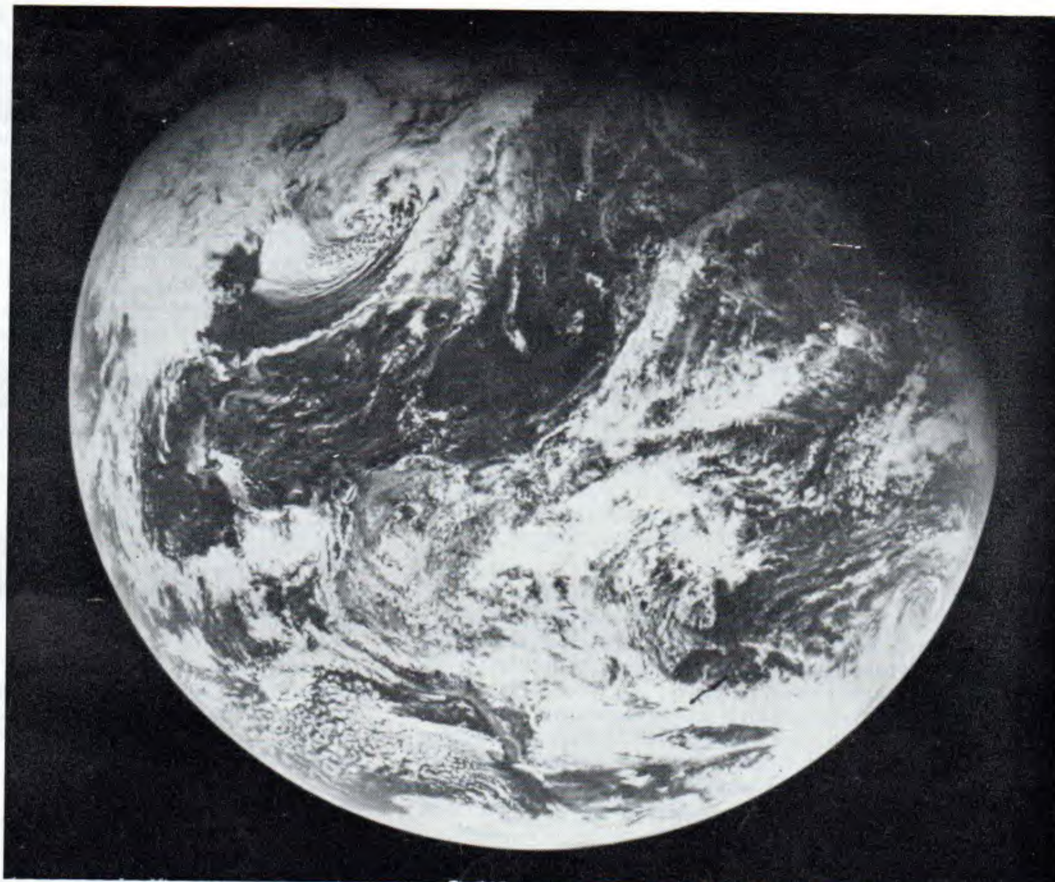
During the 22–23 January, Apollo 5 mission, lunar module systems and structural performance met all objectives, including two firings of both the ascent and descent propulsion systems.

The unmanned lunar module was boosted into Earth orbit by a Saturn IB. Post-flight analysis determined the lunar module ready for manned Earth orbital missions.

During 1968, Scientist-Astronauts John A. Llewellyn and Brian T. O'Leary withdrew from the training programme, Air Force Lt. Col. Michael Collins underwent surgery for removal of an arthritic bone growth, and Navy Lt. John S. Bull withdrew due to pulmonary disease. Astronaut James A. Lovell, Jr. replaced Collins in the Apollo 8 crew as command module pilot. The original Apollo 8 crew was redesignated for the Apollo 9 mission when the lunar module was deleted from Apollo 8.

Aeronautics

Among the continuing research and development projects in aeronautics are noise abatement, flight safety, the materials, propulsion and flight dynamics of supersonic and hypersonic aircraft, lifting bodies Vertical/Short Takeoff and Landing (VSTOL) craft.



America's triumphant Apollo 8 astronauts took this photograph of Earth as they returned from the Moon on 26 December. The North Pole is at about 11 o'clock. It is possible to identify parts of South America at the centre; the United States is at upper left. Along the sunset terminator at upper right can be seen a small portion of the bulge of West Africa.

Below, astronauts Frank Borman, James Lovell and William Anders await helicopter pickup as dawn breaks in the splashdown area south of Hawaii. They descended within 6000 yd of the aircraft carrier U.S.S. *Yorktown* after a journey of more than half a million miles.

Advanced Research

NASA scientists and engineers, working with university and industry groups, pushed ahead in the fields of space power, electric, nuclear and chemical propulsion to enhance the capability of already-proven launch vehicles.

Technology Utilization

NASA continued to transfer to industry, small business and the scientific community the new technology coming out of space-related research and development activity. Most of this technology comes from NASA field centres where specialists continuously review and develop projects for promising new ideas. In addition, NASA contractors are required to report inventions, discoveries, innovations and improved techniques they develop in work for NASA.

Tracking Nets

Three basic tracking networks keep tabs on NASA's orbiting satellites: Manned Space Flight Network (MSFN), Deep Space Network (DSN) and the Space Tracking and Data Acquisition Network (STADAN).

There are twenty-six sites in the three networks, some single, some of multiple purpose, located in fifteen countries around the world. Each network is designed to support specific types of missions, depending on whether it is near Earth, manned or probing deep space.

These networks are constantly being strengthened to handle the demands of the newer and increasingly sophisticated satellites. In 1969, NASA plans to add a 210-ft-diameter antenna in Spain and in Australia to enhance the DSN capability for future missions into deep space.

The 210's provide six-and-a-half times increased performance over existing 85-ft antennae, making it possible to return useful scientific data from 3500 million miles from Earth.

United States Information Service

SATELLITE SUPPORT FOR APOLLO MOONFLIGHT

Four major unmanned spacecraft, launched in the 40 days preceding Apollo 8's liftoff from Cape Kennedy, served to emphasize how much the safety and comfort of its three-man astronaut crew depended on a sophisticated, "support armada" of satellites deployed in space.

The split-second precision of the manned Moon-orbiting mission all but obscured the December achievements of three of these unmanned space launches in the busy 17 days before Apollo 8 roared into space.

Intelsat III F-2

Just three days before the astronauts' departure on 21 December, Intelsat III F-2 rode into an elliptical transfer orbit in space on its Delta launch vehicle and was promptly inserted into synchronous Earth orbit 22 300 miles above the Equator. Newest and most capable of Intelsat's growing family of commercial communication satellites, Intelsat III F-2 established its location at a point over the Atlantic Ocean and, by 24 December, joined its predecessors in handling its share of the commercial coverage of the Apollo 8 mission. NASA launched the satellite for Comsat corporation which acts as manager for the 63-nation Intelsat consortium.

ESSA VIII

Six days before the Apollo 8 launch on 15 December, ESSA VIII was sent up from the Western Test Range to join other Environmental Science Services Administration (ESSA, or Weather Bureau) satellites in compiling Earth weather reports for the launch and splashdown phases of the Apollo 8 mission. From its circular 885 mile, near-polar orbit, ESSA VIII furnished automatic picture transmission (APT) photographs used by NASA weathermen at Cape Kennedy and at Honolulu during the Apollo 8 mission.

HEOS I

The Highly Eccentric Orbit Satellite (HEOS), launched on 5 December from Cape Kennedy by NASA for the European Space Research Organization (ESRO), served as a backup for information about cosmic radiation and solar wind strengths in the region between the Earth and the Moon. Passing its 138 000-mile apogee every 11 days, HEOS reached out more than half the distance to the Moon to return information on radiation conditions in space.

Pioneer IX

An important year-end launch in terms of gathering "space meteorology" data for the Apollo 8 flight was the placing of Pioneer IX into orbit around the Sun on 8 November. Pioneer IX joined Pioneers VI, VII, and VIII in solar orbit.

Operating as a team, these widely-spaced satellites were able to offer daily reports about changes in radiation, flares and other conditions on the Sun's surface, including the side not visible from Earth. Their information formed a vital part of the space weather forecast, which predicted radiation levels within safe limits during the Apollo 8 mission.

Earth and Space "Weather"

The data returned from dozens of spacecraft and hundreds of Earth stations, aircraft and ships associated with reporting Earth and space "weather" for Apollo 8 were co-ordinated by two organizations established by ESSA for such tasks—the Spaceflight Meteorology Group (SMG), directed from Suitland, Md.; and the Space Disturbance Forecast Centre, with headquarters in Boulder, Colorado.

Space Conditions Monitored

Typical inputs to the Boulder forecast centre were those provided by NASA's Pioneer satellites. Boulder was able to furnish Pioneer data to the Houston Mission Control Centre on an almost "real time" basis, often within less than 30 min of the instant when new data were received from the solar satellites.

To visualize the relative positions of the four Pioneers during the Apollo 8 mission, imagine them together with the Earth, orbiting the Sun on the face of a huge clock. The Sun, at the clock's centre, rotates counter-clockwise on its axis once every 27 days. The orbital direction of Earth and the four Pioneers is also counter-clockwise.

During the time the astronauts were flying to the Moon and back, the Earth and Pioneer IX were at 6 o'clock. Pioneer VI was between 11 and 12 on the imaginary clock dial. Pioneer VII was between 8 and 9 o'clock and Pioneer VIII was at 7 o'clock.

Almost directly opposite the Sun from the Earth, Pioneer VI was nearly 170 million miles away during the Apollo 8 flight. Until NASA's Goldstone 210-ft antenna was diverted to handle Apollo 8 operational communications, Pioneers VI and VII were the only spacecraft able to furnish advance information about conditions on the Sun's far side, before these areas came into view around the Sun's left limb. Data from Pioneers VIII and IX in their locations closer to Earth were available during the entire Apollo 8 flight, via the 85-ft antennae in NASA's deep space communications network.

The Pioneers were joined by OSOs, OGOs, IMP-IV and other operational spacecraft carrying radiation and optical sensors in providing data for ESSA's Boulder forecast centre, which in turn made its daily inputs to the Apollo Mission Operations Centre in Houston.

Earth Weather Watch

Earth weather inputs preceding and during the Apollo 8 flight were co-ordinated by ESSA's Spaceflight Meteorology Group (SMG).

To meet the forecast and planning needs of the Apollo 8 mission, the SMG operated from five locations: at Kennedy Space Centre and at the Houston Manned Spacecraft Centre, with supporting operations at three key ESSA weather centres. These included the Suitland, Miami and Honolulu sections.

The Suitland section is co-located with the Weather Bureau's National Meteorological Centre and ESSA's National Environmental Satellite Centre, for ready access to daily worldwide weather data.

The SMG forecasters pondered the desirability of a brief launch delay due to low clouds at Cape Kennedy. But drier air arrived in time to provide good launch weather. The group made forecasts for a number of possible emergency landing areas and finally for the actual landing.

Forecasters made extensive use of ESSA satellite pictures showing cloud cover in remote areas. ESSA VII was especially useful in providing information from the emergency landing areas and in the actual landing zone.

In the Pacific landing area, ESSA VII photographs showed shower activity weakening during the last two days of the Apollo 8 flight so that conditions in the region were acceptable at splashdown. Weather photographs from NASA's versatile Applications Technology Satellites (ATS I and III) also contributed to Apollo mission forecasting.

Satellites Relay Apollo Communications, Telecasts

Perhaps few viewers in the worldwide television audience were aware of the extent to which satellite spacecraft were involved in Apollo 8 communications—both in operational exchanges between the astronauts and Houston Mission Control and in relaying commercial television broadcasts to many parts of the world.

Intelsat III F-2, launched on 18 December, just three days before Apollo 8, and capable of providing 1200 two-way voice circuits or four colour television channels, began carrying segments of commercial coverage to Europe the day before Christmas. Its large capacity was used to transmit Moon pictures from the crew capsule and to relay television coverage of the Pacific splashdown to Europe and Puerto Rico. The Comsat Earth station at Etam, West Virginia, and a terminal at Raisting, Germany, linked the spacecraft with Earth.

The Comsat-operated Series-II Intelsat satellites over the Atlantic and Pacific oceans each reserved about 100 of their 240 two-way voice circuits to handle NASA's support communications with the Apollo 8 capsule.

ATS I and III were used extensively to augment Comsat's commercial communications coverage of the manned Moon flight, as well as to back up regular NASCOM and DOD communications and transmit a limited number of weather photographs.

Because it had the only on-board equipment compatible with the special mobile terminal on the aircraft carrier U.S.S. *Yorktown*, ATS I initially relayed television coverage of splashdown events to an Earth station at Brewster Flat, Washington, from which it was transmitted via other satellites and ground lines to commercial television networks throughout the world.

Among the chores performed by ATS III were the relays of pre-launch and launch events to Raisting, Germany, and to Japan and return flight and splashdown details to Australia. Viewers in the United States saw a commercial television interview from the Jodrell Bank Observatory in England, received at Etam, West Virginia, via ATS III.

The "Five Kilometre Radio Telescope"

A new radio telescope, to be known as the Five Kilometre Radio Telescope, will be built at the Mullard Radio Astronomy Observatory of the Cavendish Laboratory, Cambridge, at a cost of about £2 million provided by the Science Research Council. It was this Observatory that discovered the remarkable pulsating radio sources which have become known as Pulsars. The striking regularity of the pulses from these objects has attracted world-wide interest and discussion amongst astronomers and physicists.

This decision is in implementation of the recommendations of the Fleck Report* and will provide at Cambridge the latest concept of the aperture synthesis type of instrument mentioned in that Report. The technique of aperture synthesis pioneered by Professor Sir Martin Ryle, F.R.S., and the Radio Astronomy Group at Cambridge and used in the present and proposed instruments, involves repeated scanning of the sky with the telescope aerials spaced at various positions along a rail in order to provide data which is progressively built up in a computer to form a map of the sky. For the new 5 km telescope the maps will be as detailed as if a huge radio telescope dish 5 km in diameter had been used.

The Five Kilometre telescope has been designed to extend one of the programmes now being carried out with the One-mile instrument which is aimed at understanding the physical mechanisms occurring within Quasi-stellar radio sources (Quasars) and radio galaxies. With the One-mile telescope it has been possible to obtain maps with a resolution of about 20 sec arc, but these maps have shown that many of the sources have considerable complexity in their structure which is below the present limits of resolution. A knowledge of the structure is the most important single requirement in establishing the nature of the physical processes occurring within sources; these physical processes, involving vast concentrations of energy, can only be studied by means of Radio Astronomy. Furthermore it seems possible that Quasars and radio galaxies represent different stages in the evolution of the same class of object, and to establish the role of radio sources in the evolution of the Universe it is important to refine the maps so as to reveal their small-scale features. The new instrument is intended to provide the increased resolution necessary to investigate structure as fine as 1–2 sec arc.

The possibility of constructing this large telescope adjacent to the present instruments was facilitated when British Rail announced the closure of the Cambridge to Bedford line which forms the northern boundary of the Observatory. A portion of this track runs almost due east-west for about 3 miles (5 km) and provides an excellent site for the new instrument which will consist of an array of eight paraboloid steerable aerials, four fixed and four movable on rails. The serials will be modified versions of the 42 ft dish developed by The Marconi Co. for the overseas satellite communications stations. The whole telescope array will be under the control of a Marconi Myriad computer.

The Engineering Group of the United Kingdom Atomic Energy Authority at Risley, have acted as agents for the SRC during the recent stage of design study on which some £10,000 has been spent. The UKAEA have been invited to act as agents during the construction period which is ecpected to last for about 3 years.

The construction work will involve laying at one end of the 3-mile stretch a very stable concrete beam three-quarters of a mile long which will support the rails on which the movable aerials will run. The fixed aerials will be spaced along the rest of the axis. The location of the aerials in position and height relative to each other and to the Earth's axis, calls for accuracies far in excess of those called for in normal civil engineering work. A special team of experts is to be called in to make the necessary precise measurements.

British astronomy relies almost exclusively on the Science Research Council for its finances and can only flourish if this sort of expensive "big science" equipment is provided by the Council. As with the present One-mile radio telescope which was first proposed in 1960 and completed at Lord's Bridge some 4 years later, it is intended that radio astronomers from other British universities will have access to the Five Kilometre telescope.

* *Radio Astronomy: Report of the Committee appointed by the Lord President of the Council under the Chairmanship of Lord Fleck. H.M.S.O.* 1965.

NEXT MONTH

Articles appearing in the June issue include developments in the Apollo programme and the 1969 Mariner mission to Mars. Photographs of the Moon obtained by the Apollo 8 astronauts are analysed, and a Soviet scientist reviews contemporary knowledge of the atmosphere of Venus prior to the arrival of the latest Soviet soft-landing probes. A major feature describes Britain's second terminal for satellite communications at the GPO Earth Station, Goonhilly Downs, Cornwall.

SPACE REPORT

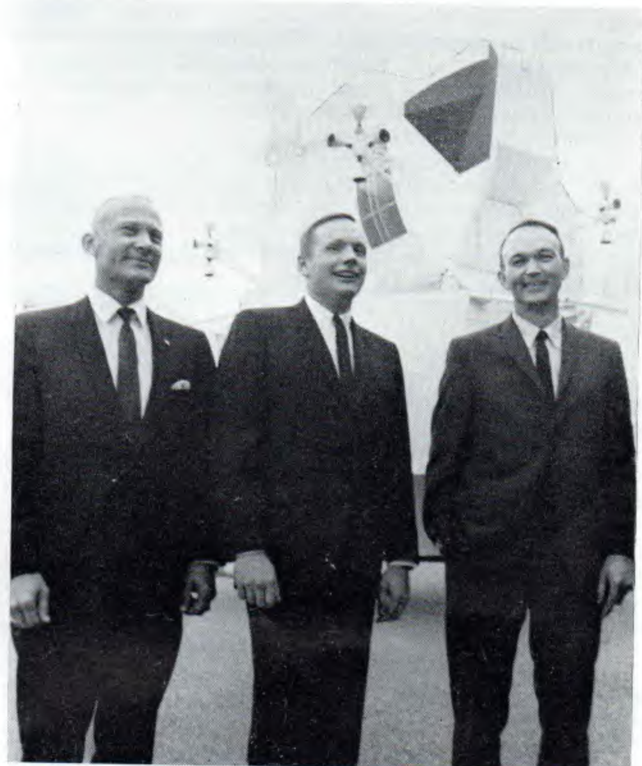
A regular monthly review of Space Events and Technical Trends

Moon Landing Mission

Astronauts Neil A. Armstrong, Michael Collins and Edwin E. Aldrin, Jr., will comprise the prime crew of the Apollo 11 Moon-landing mission scheduled to begin on 15 July. Armstrong, a civilian, will be commander; Collins, an Air Force Lieutenant Colonel, will be command module pilot; and Aldrin, an Air Force Colonel, will be lunar module pilot.

Backup crew for Apollo 11 will be Navy Capt. James A. Lovell, commander; Air Force Lt. Col. William A. Anders, command module pilot; and civilian Fred W. Haise, Jr., lunar module pilot.

Armstrong was command pilot of Gemini 8; Collins was pilot of Gemini 10; and Aldrin was pilot of Gemini 12, all 1966 missions. Lovell was pilot of Gemini 7, command pilot of Gemini 12, in 1966; and command module pilot on the Moon-circling Apollo 8 mission last December.



Men for the Moon. *Left to right*, Apollo 11 astronauts Edwin R. Aldrin, Jr, lunar module pilot; Neil A. Armstrong, commander, and Michael Collins, command module pilot. Behind them is a full size mock-up of the Apollo Lunar Module.

United States Information Service

Apollo TV Camera

Millions of people around the world have suddenly become personally involved in space exploration thanks to the invention of an astronaut television camera. The RCA camera, small enough to fit into the glove compartment of a car, brought the experience of orbiting the Moon to a world television audience last December; an alternative model built by Westinghouse will be used as American astronauts take their first steps on the lunar suface.

The Apollo 8 TV system consisted of the portable TV camera on board Apollo and electronic signal processing systems at Merritt Island, Florida; Corpus Christi, Texas; Goldstone, California and Madrid, Spain. Goldstone and Madrid are the stations receiving TV from Apollo lunar mission.

The TV camera and ground equipment at all locations except Corpus Christi were produced by RCA's Astro-Electronics Division of Princeton, New Jersey. The camera was built under contract to North American Rockwell Incorporated, prime contractor to NASA's Manned Spacecraft Centre for the Apollo Command Module.

The scan converters were built under contract to NASA's Goddard Space Flight Centre, which manages the Manned Space Flight Network. The converters at Goldstone, Madrid and Merritt Island allow NASA to provide live TV from the spacecraft for broadcast by the networks.

The tiny RCA space camera weighs less than 5 lb, including lens. It uses a 160° wide-angle lens for on-board monitoring of the three Apollo astronauts, and a 100 mm lens for viewing scenes outside the spacecraft.

The TV signal from the camera is fed into the spacecraft's communications system for transmission to Goldstone or Madrid, where it is received, processed and relayed to the NASA Manned Spacecraft Centre for world-wide distribution.

The use of miniaturized integrated circuits—specks of crystal that carry complete arrays of electronic components—enabled engineers at the RCA Space Centre to build a camera some thirty times lighter and eighty-five times smaller than a standard black-and-white TV broadcast camera. The Apollo camera requires only 6W of power to operate, compared with 500W for a studio camera.

The RCA Space Centre also developed the camera systems used aboard the Ranger satellites which took the first close-up photos of the Moon's surface, and the cameras on the TIROS, ESSA and Nimbus weather satellites.

"A forerunner of smaller TV cameras yet to come, the Apollo camera is the result of 2 years of intensive work to come up with a unit incorporating the compactness, ruggedness, portability and reliability demanded for manned space

Original hand-held TV camera developed for the Apollo programme.

Radio Corporation of America

operations," according to Richard P. Dunphy, camera programme manager for RCA. The space mission generally adds limitations of size, weight and electrical power requirements. In addition to these, the Apollo camera was built to meet the severe test levels that electronic equipment must pass for the Apollo programme.

Mr. Dunphy explained that because of the distance involved and the necessity to conserve size, weight and power, the Apollo TV system relies on different scanning standards than broadcast television. This means a ground-station scan converter must be used to make the Apollo TV signal compatible with home TV receivers.

Normally, commercial broadcast TV operates with a signal bandwidth of 4 500 000 cycles. However, because of spacecraft limitations, Apollo's TV system was designed to operate with a 500 000 cycle bandwidth. "This nine-to-one reduction in bandwidth results in a substantial saving of telecasting power," Mr. Dunphy said, "but it also makes necessary a reduction in TV frame and line rates. Apollo TV operates with a frame rate of 10 frames per sec, compared with 30 frames per sec for commercial TV. The space television system produces a TV picture with 320 scanning lines against 525 lines for broadcast TV." The RCA scan converter systems built for NASA electronically convert the signal from the Apollo scan standards to broadcast scan standards for proper display on commercial TV receivers.

As millions of armchair explorers watch the astronauts at work in the Apollo spacecraft, they will help to usher in a fascinating new aspect of space technology. Until now, most television camera systems for spacecraft have been designed to obtain scientific data. The Apollo system has the additional task of providing "live" and taped coverage for a world television audience.

A Year in Isolation

Three Soviet scientists have spent a year in a small airtight chamber linked with the outside world only by video telephone. The experiment, begun on 5 November 1967 and ending on 5 November 1968, is thought to be related to future Soviet space station activity.

The scientists—Herman Manovtsev, 31, a doctor, Andrei Bozhko, 29, a biologist, and Boris Ulybyshev, 24, a technician, withstood this difficult experiment extremely well. although at first they believed they would not be able to endure more than 5 months in the chamber.

The experiment was mainly intended to establish the possibility of spending a long time in isolation from the outside world, using water and oxygen regenerated from products of human vital activity (urine, evaporated moisture and exhaled carbon dioxide) and consuming food dehydrated by vacuum drying. It also tested new life-sustaining systems built in accordance with the programme of space exploration.

The chamber in which the scientists lived was crammed with all kinds of instruments. Its walls were painted in soothing colours. In a green-house adjoining the chamber, Bozhko grew such plants as fennel, watercress and borage—the only foods they ate in their natural state. All the rest was almost completely dehydrated.

The foodstuff had maximum calory content and retained its natural taste and even colour.

Although they were completely dehydrated, such foods can be kept for a long time in the most unusual conditions. The scientists ate, among other things, sublimed salmon, hard-melting chocolate and large tablets of a mixture of sublimed cottage-cheese and prune paste.

The scientists got up every day at 7 a.m. and went to bed at midnight. They had a full work schedule but took time off to watch TV and read books.

The experiment is stated to have produced important data not only of value to doctors and biologists. Life-sustaining systems and systems of regeneration of water and air were also tested. It has been established that the barrier of psychological incompatibility is not insurmountable for such a long stay in conditions close to those in space. The scientists learned to be tolerant of each other's mistakes although this was not always easy.

They could see daylight only on the TV screen and they saw their colleagues by video telephone only. While the experiment was in progress Herman Manovtsev's wife gave birth to a daughter.

In an interview after the experiment Andrei Bozhko said it was rather hard to be separated from the outside world. He had missed his relatives and friends, former students of the Department of Biology and Soils of Moscow University, from which he had recently graduated.

Herman Manovtsev said that on 25 February 1968 he had learned of the birth of his daughter and he had to wait 9 months before he could see her. He wanted his daughter to be named Svetlana. Manovtsev also said that he had a hankering to take a walk through Moscow on a rainy autumn evening.

Boris Ulybyshev missed his relatives and people close to him and he wanted very much to take a walk in a forest with his 18-months-old daughter Svetlana.

All three said that the last moments of the experiment caused them most irritation. They seemed to be the longest.

However, the scientists believe that the barrier of psychological incompatibility in conditions close to those of outer space can be surmounted. Manovtsev said that they had practically no acute conflicts. "We learned rather quickly to skirt acute angles, and now we have perhaps become more tolerant towards people around us. We learned to change from one task to another strictly according to plan. We worked in harmony throughout the year."

Immediately after the experiment the men were driven to a clinic where they spent several days acclimatizing themselves before going home.

ESRO's First Interplanetary Probe

The European Space Research Organization's first interplanetary physics research satellite, HEOS-A1 (Highly Eccentric Orbit Satellite), was successfully launched from Complex-17B at Cape Kennedy by a Thrust Augmented Improved Delta on 5 December 1968 Its scientific mission is to study interplanetary physics, especially magnetic fields, cosmic radiation and solar wind (outside the magnetosphere) and the Earth's shock-wave. The achieved initial orbit ranged between 424 and 223 428 km inclined at 28·28° to the equator.

Eight experiments are carried:

Experiment S-16. This involves the optical observation of a barium ion cloud created by the release of a capsule, from the spacecraft while in orbit, containing a barium/copper oxide mixture. When the capsule is some 25 miles from the spacecraft the mixture is ignited and the resulting cloud observed from ground stations in North and South America. It is hoped to obtain information on the magnetic field at the ignition point. Experimenters are Professor R. Lust and Dr. H. Gollnitz of the Max Planck Institute for Extraterrestrial Physics, Munich.

Experiment S-24*A*. This experiment will relay information on fields within the magnetosphere, transition and interplanetary regions on a continuous basis. It is designed to measure magnetic fields in the range ± 64-gamma with an accuracy of 0·5-gamma. Because of its high sensitivity the three-axis magnetosphere sensor is mounted at the end of a 1·6 metre boom. Prime investigators are Professor H. Elliot and Dr. P. Hedgecock of the Imperial College, University of London.

Experiment S-24B. Designed to observe high energy cosmic ray protons with energy greater than 350-MeV and to detect directional anisotropies which may be correlated with the interplanetary field configuration observed by experiment S-24A, the sensors consist of telescope arrangements of Cerenkov scintillation counters. Prime investigators are Professor H. Elliot and Dr. A. Engel of the Imperial College, University of London.

Experiment S-24C. This experiment will observe solar protons of low energy in the range 0·9 to 20 MeV and will detect directional anisotropies which, correlated with experiment S-24A, should yield fundamental information on the propagation mechanisms of solar protons. The sensors consist of four-element solid-state detector telescopes. Chief experimenters are Professor H. Elliot and Dr. R. Hynds of the Imperial College, University of London.

Experiments S-58 and S-73. These two experiments will measure both the energy distribution and angular distribution of the positive (proton) component of the solar wind. The sensor consists of a hemispherical electrostatic analyser to select protons of a given energy and a Faraday cup to collect and count the selected protons. By using the spacecraft's attitude control system the spin axis will be varied so that these two experiments will scan in the ecliptic plane, then perpendicular to this plane. Energy range is from 100 to 15 000 MeV. Experimenters are Professor Coutrez and Mr. W. Scholiers of the University of Brussels for S-58 and Professor A. Bonetti and Professor G. Pizzella of the University of Florence and Rome for S-73.

Experiment S-72. Consisting of a four-element, solid-state detector telescope it is designed to measure electrons, protons and alpha particles of solar and galactic origin. Energy ranges are 5 to 850 MeV (for protons), 150 to 1500 MeV (for alpha particles) and 1·5 to 15 MeV (for electrons). Investigators are Professor J. Labeyrie, Dr. J. Engelman and Mrs. L. Koch of the Centre D'Etudes Nucleaires De Saclay, France.

Experiment S-79. Measurement of the spectrum of high energy cosmic ray electrons in the range of 50 to 600 MeV is the purpose of this experiment. The sensor, a four-element telescope, embodies a gas Cerenkov detector to filter out effectively a large proportion of the greater proton flux at comparable energies. Experimenters are Professor C. Occhialini-Dilworth, Dr. C. Bland, Dr. Koechlin and Professor J. Labeyrie of the University of Milan and the Centre D'Etudes Nucleaires De Saclay, France.

The Thrust Augmented Improved Delta rocket used for the HEOS-A1 mission is the first launch vehicle (together with launch services) to be purchased from the US (NASA) by a foreign country. For this mission, ESRO is being charged $8·75 million for launch services and vehicle. Liftoff thrust of the TAID vehicle is 270 000 lb including strap-on solids.

Tracking of HEOS-A1 is the responsibility of ground stations of the ESTRACK network except for the injection phase when the spacecraft was followed by NASA stations and three French CNES stations located in Africa.

HEOS-A was prepared under the supervision of ESRO's European Space Technology Centre (ESTEC) at Noordwijk, Holland.

British Aircraft Corporation designed the attitude sensing and control system, and the associated electronics. It works as follows: A solar aspect sensor measures the attitude of sunlight striking the satellite, so enabling it to be aligned correctly with respect to the Sun. Following this, the satellite has to be aligned correctly to the Earth. As the orbit has

HEOS-A1 Spacecraft Details

Basic shape . .	Octagonal
Height	255 cm
Diameter	130 cm
Spin stabilization rate	10 rpm
Stabilization maintenance	Gas-jet system
Number solar cells . .	8576
Battery	One 5-amp-hr
Telemetry rate	12 bits/sec
Transmitter	136·65 MHz
Command receiver . .	148·25 MHz

such a vast range of distance from the Earth, two methods have to be employed. The first, for close-range alignment, depends on infra-red sensors to measure the Earth's horizon distances; the second, for long-range alignment, uses a unique sensor to measure sunlight reflected from Earth.

The sensors also determine the correct attitude of the satellite at all times with reference to the on-board experiments. All sensors have a determination of plus or minus 2°, the resolution factors being even more accurate.

From the sensors on board HEOS the solar aspect angle and Earth position are telemetered to ground stations. A computer at the European space operations centre, Darmstadt, Germany, then computes from this information the attitude of the satellite in space.

Unlike previous European satellites which have orbits relatively close to earth, HEOS has an orbit time of some 4·5 days in which it travels over half the distance to the moon.

This unusual orbit is essential to investigate the interplanetary magnetic field and the energy distribution of protons and electrons during the present period of expected great solar activity. Because it is essential for the satellite to be correctly aligned for these observations its attitude and spin rate must be known and controlled with great accuracy.

The consortium of companies involved in the design and construction of the satellite for the European Space Research Organization was led by Junkers Flugzeug- und Motorwerke AG of Germany. Other major sub-contractors in addition to BAC were ETCA, (Belgium) SNECMA (France) and Messerschmitt AG (Germany).

Astronaut Borman Promoted

Astronaut Frank Borman, Commander of Apollo 8, on 9 January was named Deputy Director, Flight Crew Operations, Manned Spacecraft Centre, Houston. His promotion to the division direction level includes responsibilities for activities of the Astronaut Office, the Aircraft Operations Office and the Flight Crew Support Division. Director of Flight Crew Operations is Donald K. Slayton. "Frank has a tremendous background in engineering, flight test and as an instructor," Slayton said. "He will be of enormous help to us in assuring proper pilot training in the critical months ahead."

Prior to the historic Apollo 8 flight around the Moon in December, Borman, a U.S.A.F. Colonel, performed a variety of special duties, including backup command pilot for the Gemini 4 flight and member of the Apollo 204 Review Board.

As command pilot of the National Aeronautics and Space Administration's Gemini 7 mission, launched on 4 December 1965, he participated in establishing a number of space "firsts," among them being the longest manned spaceflight (330 hr 35 min) and the first rendezvous of two manned manoeuvrable spacecraft as Gemini 7 was joined in orbit by Gemini 6. He was selected as an astronaut by NASA in September 1962.

The 1967 programme included fifteen Centaures, eleven Skylarks, four Dragons, two Beliers, carrying nineteen different payloads with fifty-three experiments provided by organizations in all the member countries.

2.3. *International Collaboration*

2.3.1. *Satellites*

Because of the paucity of national satellite programmes and the lack of concrete results from the ESRO programme, another useful outlet for Europe's space scientists during the last few years has been to obtain rides on American scientific satellites. The experiment is paid for by the national agency involved but the ride is free. Consequently the experiment has to be submitted to NASA and is only accepted if it is considered to be of scientific merit and worthy of inclusion in one of the NASA scientific satellites. To obtain a place in the payload the European scientists have to compete with the scientists of American universities and other scientific institutions.

To date eighteen such experiments have been allocated places in American satellites of which U.K. universities have provided eleven and France five, Italy one and the Netherlands one.

United Kingdom

The list of accepted projects covers a wide field and are being or will be carried in satellites of the Explorer, OAO, OSO, OGO and Nimbus series. They will study such subjects as:

Ion mass composition and temperature.

X-ray emission of stars and nebulae and the inter-stellar absorption of He and the heavier elements.

The total solar X-ray emission over a wide band.

Solar X-ray flux.

Electron density and temperature.

The direction of incidence of unchanged primary cosmic rays.

Emission from atmospheric carbon dioxide using a selective chopper radiometric temperature probe.

While all these experiments are important to increase our knowledge of the Earth's space environment, the last to be carried in Nimbus D is worth special mention because of its possible importance to operational meteorological satellites. At present the cloud pictures and radiation data from satellites currently provide a great deal of valuable information, but it is mainly qualitative in character and difficult to incorporate directly into numerical weather production models, which require data on atmospheric temperature, pressure, composition and winds.

The experiment proposed by Reading and Oxford Universities for Nimbus D offers the most promising instrument yet conceived for determining the vertical distribution of atmospheric temperature from measurements of the spectral distribution of infra-red radiation received from the carbon dioxide in the atmosphere. It has already been successfully tested on a balloon. With a viewing angle of 10° it will have a horizontal resolution of about 150 km. Absolute temperatures should be obtained to within about 1° K. Later it may be possible to install a more advanced instrument on a geostationary satellite and obtain continuous measurements with a horizontal resolution of about 500 km.

The results being obtained from the experiment in OSO D are impressive. The X-ray spectra have a better resolution than previous attempts showing the variation as the solar flares develop while OGO E is providing electron density and temperature information out to interplanetary plasma.

France

These experiments are being flown mainly in the OGO satellites and study subjects such as:

The airglow at 6300 Å, 5577 Å, 3914 Å and in the near ultra-violet region.

Determination of density and temperature of hydrogen in geocorona.

Measurement of the altitude distribution of nitrogen and oxygen in aurora.

Measurement of self-reversal of the solar Lyman-alpha spectrographic line.

Italy

In OSO G the monitoring of solar X-rays and gamma ray astronomy in the energy level 20–200 kev.

Netherlands

OGO E will carry a six counter telescope to measure absolute flux and energy spectrum of cosmic ray electrons.

In the execution of these experiments the universities are aided by a number of industrial companies thus providing industry with the opportunity to develop its space technology and bringing it into contact with the scientific work. This is most desirable and requires further encouragement. The fact that the experiments have been accepted by NASA and that a number have now operated successfully demonstrates the capability of European scientists and technologists to develop and engineer the equipment to operate successfully in the space environment.

The fact remains, however, that European scientists are unable to obtain sufficient opportunity on U.S. satellites. In fact the proportion of acceptances decreases each year. This is due to a number of factors.

(1) The limited expansion of the U.S. science programme.

(2) As more data is collected new experiments have to be more sophisticated in order to advance the state of knowledge and hence become more expensive. American universities with greater resources are able to make proposals for more comprehensive projects yielding more information at one go than European universities.

(3) Originally there is no doubt that proposals were assessed purely on scientific merit. Latterly there has been a suspicion of the "NIH" factor creeping in.

It would appear that in order to ensure adequate opportunities in U.S. satellites fewer but more expensive and sophisticated experiments will need to be mounted. One way to finance such projects would be for European universities to co-operate in joint projects which would be a good thing in itself.

However, when one considers the assistance provided by NASA to European space research by supplying launchers for such satellites as FR1, UK3, ESRO 1 and 2, and the free rides in U.S. satellites, Europe has no ground for complaint and one is forced to the conclusion that if European space scientists are to continue to make their mark in the world of Space Science, Europe must provide the opportunities either through ESRO or national programmes. The capability has been demonstrated; all that is required is the finance and efficient organization.

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