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HIGHLIGHTS OF 1976 ACTIVITIES

For the second time in its 19-year history, a perfect launch record was achieved in 1976 by the National Aeronautics and Space Administration.

NASA had 16 launch attempts during the year, all of them rated as successes.

Space agency highlights in 1976 included the successful landing of two Viking spacecraft on the surface of Mars, and the rollout of the first Space Shuttle Orbiter, the flagship of the new era of space transportation.

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SPACE FLIGHT

The key element in the United States' future Space Transportation System appeared on the scene in 1976 as the first Space Shuttle orbiter, the Enterprise, was rolled out of the NASA Rockwell International facility at Palmdale, Calif., Sept. 17, 1976.

After its brief debut, the spacecraft was checked and prepared for its January overland transfer to the NASA Dryden Flight Research Center, Edwards, Calif., where it will begin a series of approach and landing flight tests in 1977.

The past year marked the third calendar year since 1961 in which American astronauts did not spend time in space. Only the years 1964 and 1967 of the past 16 were without NASA manned space flights.

Also during 1976, NASA announced its eighth recruitment of astronauts to be crew members on Space Shuttle flights. The agency in July announced that it is accepting applications for two types of astronauts -- pilot astronauts and mission specialist astronauts. A minimum of 15 astronaut candidates in each category are expected to be selected by December 1977 and the successful candidates will enter a two-year evaluation program at the Johnson Space Center in July 1978. Women and minority candidates from the civilian sector as well as the military services are encouraged to apply. Applications will be accepted through June 30, 1977.

Along with the roll-out of the first Space Shuttle orbiter, other elements of the nation's future Space Transportation System continued to take shape.

In 1976, manufacturing and assembly of the Shuttle external tank test article was begun at the NASA Michoud Assembly Facility, New Orleans. The external tank supplies liquid hydrogen and oxygen to the orbiter's three main engines. All 11 case segments for the first solid rocket development motor were delivered to Thiokol, the prime contractor for the solid rockets, by the end of November. At Kennedy Space Center, Fla., primary launch and landing site for the Shuttle, construction of the Orbiter Processing Facility continues and modification of the existing Apollo Launch Pad 39 for Shuttle flights is well underway.

During the year, progress was made by the European Space Agency in the development of Spacelab, their versatile manned laboratory to be carried in the cargo bay of the Space Shuttle. Hardware has been assembled in Europe and major testing is being conducted.

The Boeing Company was selected by the U.S. Air Force to develop the Interim Upper Stage (IUS) for the Space Transportation System. The IUS, a joint NASA/USAF effort, will be used to place payloads into orbits beyond the capability of the Shuttle. Also, during 1976, NASA has been studying the possibility of developing Spinning Solid Upper Stages (SSUS) which would be used to place Delta and Centaur class payloads into high orbits.

SPACE SCIENCE

A decade of planning and work came to fruition in 1976 with the landing of a robot spacecraft on Mars to conduct a detailed scientific investigation of the planet, including the search for life.

America's Viking 1 made its historic touchdown after an 11-month journey, on a rocky, boulder-strewn Martian plain called Chryse on July 20 at 7:53:17 a.m. EDT, just 17 seconds later than flight engineers had predicted.

Within minutes after landing, two specially designed cameras on the bug-shaped craft began taking the world's first closeup pictures of the alien land. A miniature weather station aboard Viking monitored the thin Martian air. Other instruments noted magnetism, radiation -- all the data scientists sought.

Then eight days after landing, a slender 10-foot arm unrolled from the 780-kilogram (1,300-pound) spacecraft and its clawlike hand ripped into the Martian dirt. Small amounts of soil were dropped into three devices within the spacecraft's miniaturized biology laboratory. These instruments were designed to recognize the form of life most common on Earth -- microbes -- on the assumption that these would be the most common on Mars too.

The data that came back from the "life" experiments both delighted and puzzled scientists. The data indicated the presence of compounds which were conceivably of biological origin, but the organic analysis data did not support that conclusion.

The spacecraft's gas chromatograph-mass spectrometer instrument showed no evidence of organic molecules -- the building blocks of life (as we know it on Earth). How could there be any Earth-like form of life without organic compounds? Scientists do not know. It could be that there is no life on Mars, but that the planet's chemistry is unlike anything experienced before.

A chance to sample a different area of Mars came on Sept. 3, when a sister ship, Viking 2, touched down at Utopia, about 1,600 km (1,000 mi.) nearer to Mars' polar cap than Chryse. There's more moisture there, but the biology results were about the same as Viking 1's: puzzling.

In mid-November, transmissions between Earth and the Viking landers and orbiters were suspended. The motions of the planets had reached a point where the Sun was between Mars and Earth, an alignment known as solar conjunction that produces a blackout of Viking-to-Earth communications. This marks the end of the normal missions of Vikings 1 and 2, and the beginning of the "extended missions" that will permit scientific observations through an entire Martian year of 25 months. A return to full post-conjunction operations of the spacecraft was expected by mid-December. Experiments planned include taking more photographs of the Martian surface, monitoring for seismic events, observing the planet's daily and seasonable weather changes, and subjecting more soil samples to life-detection tests. In February, Viking 1 orbiter cameras are expected to take the most detailed pictures yet of Mars' tiny moon Phobos from a distance of 48 km (30 mi.).

At year's end, even as scientists were mulling the perplexing results of Viking, plans were moving ahead for the launch of NASA's heaviest unmanned spacecraft, the two-ton High Energy Astrophysics Observatory (HEAO) in April 1977, designed to return information on pulsars, quasars and black holes in space, and two Mariner-type spacecraft to Jupiter and Saturn in August and September respectively. Work also was continuing toward the late 1978 launch of Pioneer Venus, a multiprobe spacecraft designed to provide the clearest picture yet of the cloud-shrouded "sister planet" to the Earth.

SPACE APPLICATIONS

1976 may well be called the "Year of the Communications Satellite". Of NASA's 16 space launches during the past year 13 were communications satellites, nine of which were privately financed for commercial use.

On Jan. 17 NASA launched the Communications Technology Satellite (CTS), the second satellite designed to transmit high-quality color television to small, simple ground stations. (ATS-6 was the first such satellite.) The CTS is a joint United States/Canadian space communications technology project implemented by NASA and the Canadian Department of Communications.

CTS is a high-power communications satellite operating in a special frequency band allocated for broadcast satellites. It is stationed in a synchronous orbit about 36,00 kilometers (22,300 miles) at 116 degrees longitude, west of South America.

Currently, 18 U.S. experimenters are utilizing or planning to use CTS for a wide variety of demonstrations. Virtually all segments of society (industry, educational institutions, the scientific community and government) are participating in experiments typically categorized as follows:

Education

- Demonstration of classroom applications
- Sharing of curriculum, faculty and other resources
- Improvement of teaching skills

Health Care

- Exchange of information among hospitals
- Interchange of curriculum by medical schools
- Clinical and emergency medical treatment

Community and Special Services

- Two-way business conferences
- Disaster and emergency services
- Special event coverage

Technology Extension

- Demonstration of small terminal applications
- Investigation of digital video compression techniques
- Propagation characteristics determination

A satellite which looks like a giant golf ball was launched by NASA into a 5,900-km (3,600-mi.) high orbit from the Western Test Range in California on May 4. Lageos, an acronym for Laser Geodynamic Satellite, is a solid aluminum and brass space tool designed to obtain information on Earth's crustal movements, polar motion, solid Earth tides and precise locations of various spots on Earth.

The U.S. Geological Survey, the federal agency responsible for earthquake research and prediction, is using Lageos data to make minute measurements of movements of large land masses -- tectonic plates -- as well as observe long faults, such as the San Andreas fault in California.

The useful life of Lageos is estimated at up to 50 years, but it will remain in orbit for more than 8 million years.

NASA launched the seventh ITOS operational weather satellite, ITOS-H, for the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce on July 29 from the Western Test Range.

Designed and developed by NASA for NOAA, the 340-kilogram (749-pound) ITOS was designated NOAA-5 after it successfully entered a 1,450-km (790-mi.) circular near polar orbit.

Instruments aboard the satellite provide visible and infrared images of cloud cover, snow, ice, the sea surface and gather information on temperatures and moisture in the atmosphere.

Landsats 1 and 2 continued surveying the world every 18 days, 180 degrees apart.

The Landsat spacecraft are a part of a major research program conducted by NASA to demonstrate the feasibility of using remote sensing from space for the management of Earth resources.

Individual Landsat images cover an area 185 km (115 mi.) square, or slightly less than the combined territory of Massachusetts, Connecticut and Rhode Island. Such images and other data from the satellites are being used by scientists around the world for research projects ranging from crop inventory to hydrology and from geology to surveying strip mines.

On Aug. 1, ATS-6 completed a year's service to the Government of India transmitting instructional television to about 5,000 isolated villages, most of whose people had never seen TV pictures. The instructional material included family planning, health and hygiene, agricultural and other vocational information, child education and national development.

Immediately upon completing its India project, ATS-6 started with AIDSAT, a joint NASA/Agency for International Development project demonstrating to people in 27 developing nations how space and other advanced technologies can improve their way of life.

On Dec. 2, ATS-6 arrived back at its Western Hemisphere station at 140 degrees West longitude, where it was readied for its Third Year Experiments program starting in 1978.

AERONAUTICS AND SPACE TECHNOLOGY

Progress in a variety of areas marked NASA's research and technology development in support of advancing the nation's aviation and space flight capabilities.

Aimed at providing technology to enable future civil transports to reduce fuel consumption by 50 per cent, NASA began research efforts in the five technology areas of its Aircraft Energy Efficiency program.

Near-term applications include improved performance and less deterioration in existing turbofan engines; evolutionary aerodynamic improvements and the limited use of active controls; and lower-weight secondary aircraft structural components made of composite materials.

Elements with later-term applications include new engines with considerably higher cycle efficiencies; flight-critical, highly-reliable active control systems; laminar flow control for substantial drag reduction; and composites in primary aircraft structures.

A promising technique now being studied for reducing airport community noise exposure along the aircraft's approach path is based on delayed landing flap deployment. Flight tests and guest pilot evaluations of the Delayed Flap Approach in the NASA CV-990 aircraft has demonstrated significant fuel savings and noise benefits and the technique has received good pilot acceptance.

Design of the Quiet Short-Haul Research Aircraft (QSRA) was initiated this year with a major goal of limiting the noise footprint on the ground to an area less than one square mile. The QSRA also has the lift and control capability to investigate a wide range of low-speed flight conditions. The data obtained from the QSRA flight research program and other programs will provide propulsive-lift technology data for future quiet short-haul transport aircraft.

NASA's Quiet, Clean Short-Haul Experimental Engine (QCSEE) is currently under test. The primary objective of the QCSEE program is to demonstrate the major noise reduction technology along with other propulsion innovations for possible future jet transports.

The most significant advanced technology includes variable pitch fan blades, digital electronic engine control, and an advanced, acoustically designed, all-composite nacelle.

Significant progress has been made in supersonic cruise aircraft research studies. In aerodynamics, higher lift to drag ratios have been demonstrated. In structures and materials, weight savings with attendant lower costs may be possible through new titanium fabrication processes. In propulsion, NASA studies have narrowed the many options potentially available to a very few multicycle engines which not only should have reduced noise and emissions, but also have favorable fuel consumption characteristics.

Progress in the Highly Maneuvering Aircraft Technology (HiMAT) Program, a joint NASA/Air Force effort to integrate advanced technology concepts into a superior aircraft design, has resulted in a substantial contribution to advancing the state of the art of aircraft design methodology.

The joint NASA/Army Rotor Systems Research Aircraft (RSRA) has begun initial flight testing at the contractor's facility. A unique feature of the RSRA is the special load measurement capability built into the vehicle's primary structure. For the first time, a helicopter will be available that has been designed from the start with research capability in mind. The RSRA will reduce the costs and time-consuming trial-and-error experimentation now involved in rotorcraft development.

A new research aircraft, which combines features of both helicopters and conventional airplanes, was rolled out in October in a joint NASA/Army Tilt Rotor Research Aircraft Program.

The XV-15 is a proof-of-concept research aircraft. It is capable of developing and demonstrating tilt rotor concept technology, assessing its potential for noise reduction, reduced takeoff and landing area requirements and the effectiveness of combining helicopter utility with the longer range and higher speed characteristics of conventional airplanes.

Both military and civilian aircraft could benefit markedly from such a design. A two-year flight test program will begin early next year.

A study exploring the viability of a NASA role in technology development for aerial application has been completed. Results indicate that significant advances are needed for both short- and long-term improvements in the accuracy and efficiency of aerial applications of agricultural chemicals. NASA is now defining what it could and should do to help in this area.

NASA's research on techniques to minimize the wake vortex by changes to the vortex-generating aircraft included evaluation of such aerodynamic schemes as spoilers, vortex generators, trailing-edge drag devices, steady and pulsed mass injection, and span load variations.

Advanced composite rudders for use in passenger-carrying aircraft were ground tested early this year. The composite rudder, complete with fittings, hinges, etc., weighs 33 per cent less than the aluminum rudder it replaces. Flight service of these FAA-certified composite rudders began in June.

The NASA Aviation Safety Reporting System (ASRS) received nearly 1,500 reports during its initial three-month operational period ending in mid-July. Information contained in these reports prompted the submission of 130 alert bulletins to the Federal Aviation Administration (FAA).

A NASA study called "Outlook for Aeronautics" was recently published by the agency. NASA conducted the study to determine probable directions of civil and military aviation, the role that NASA should play in research and development, and the technical advances that may be needed.

The development of the Digital Fly-By-Wire (DFBW) control system capability for future aircraft would permit complete replacement of the mechanical/hydraulic linkages between the pilot's stick and the control surface actuators by an all-digital electronic system.

Such a system can augment the basic airframe stability to permit new and improved aircraft designs with increased performance and operational flexibility and allow considerable production and operational cost savings.

A 1,000-fold increase in information systems capability is a NASA space technology research goal. Work in solid-state imaging sensors could also be adopted for use in the civil sector for low light level surveillance systems, home security systems, and closed-circuit television applications.

A major component of a solid-state programmable data processor currently under development will perform high speed conversion of raw data into codes which satisfy user requests for specific information while reducing transmitted data requirements by at least 100 times. The programmable processor component is roughly 1/2 by 1/2 inch in size, but will perform functions now requiring large digital computers. This technology can reduce the cost of ground-based data processing and the delay between data acquisition and use.

NASA has initiated development of a low-power, high-speed memory using arrays of solid-state chips for storage. This technology is also attractive to hand-held calculator business and is being adopted for more sophisticated programmable calculators.

A new laser scanner has been developed which is the first such device to provide direct defect detection in circuit fabrication and is being evaluated as an on-line production screening tool.

TECHNOLOGY UTILIZATION

During 1976, the NASA Technology Utilization Program continued its efforts to speed the transfer of space and aeronautical technology into other areas of national life.

Since its inception 14 years ago, the program has helped spur a vast innovative effort that today reaches into virtually every scientific and technological discipline.

An insight into the scope of this effort during the past year may be gained from the following statistical highlights:

- Over 10,000 business and industrial clients--a new record--obtained technical data from NASA through its network of six Industrial Application Centers operated by academic and research institutions around the country.

- A comprehensive program of almost 60 engineering applications programs was continued in an on-going effort to apply aerospace know-how to the solution of public sector problems ranging from development of advanced medical instruments to transportation safety.

- More than 1,000 new items of technology were documented and over 600 of them were announced to the nation's business and industrial community through a new and successful quarterly publication called the Tech Brief Journal.

A highlight for the Technology Utilization Program was construction of a home at the Langley Research Center, Hampton, Va., that features innovative technology adapted from aerospace research. Called simply the Tech House, the one-story, 1,600-square-foot, three-bedroom, two-bath home incorporates solar heating and partial waste water reclimation systems as well as the latest construction, comfort and safety features, many of them derived from space research. Most importantly, it is an energy conservation house which will permit an average family to cut its fuel consumption by as much as two-thirds and its water use by one-half. Also, every item used to build and furnish the house is either available now or will be on the market within five years.

Tech House has created nation-wide interest among architects, home builders, other agencies and private citizens. It is open for inspection at the Langley Center.

Another major effort with potential national impact is the Johnson Space Center's food for the elderly program. Purpose of the program is to develop a series of balanced meals, easily prepared with long shelf life for elderly persons using food technology and packaging techiques developed to feed astronauts during space flight. The down-to-earth meals are designed to supplement existing national neutritional programs for the elderly. A basic meal consists of an entree, two side dishes, dessert and a beverage. The pilot program conducted during the year in cooperation with the University of Texas, the Texas Research Institute of Mental Sciences and United Action for the Elderly, has proved to be highly successful. Interest in adapting the program on a wider scale has been expressed by congressional groups and the Department of Health, Education and Welfare.

In May, the National Space Technology Laboratories, Bay St. Louis, Miss., demonstrated for the first time the transmission of medical data from a moving ambulance to a hospital by satellite. The system involves a special portable transmitter and antenna developed in cooperation with the General Electric Co. It permits continuous transmission of voice and medical data--including electrocardiograms--from the moving vehicle to the satellite and down to a hospital receiving station. The system could prove to be an important breakthrough in emergency medical care. Ultimately, it could lead to development of a special medical satellite which could relay emergency medical data not only from ambulances but also from remote hospitals, ships, off-shore oil platforms and other remote locations to major medical centers for medical consultation. The project was conducted in cooperation with the Southern Regional Medical Consortium.

INTERNATIONAL AFFAIRS

NASA's international partnerships in communications, stratospheric research, earth resources, scientific investigations and in the continuing development of the U.S. Space Transportation System, were highlights of 1976.

NASA also undertook a cooperative effort with the U.S. Agency for International Development to focus the attention of developing countries on new technologies now available to assist them.

On July 31, India successfully completed a one-year Satellite Instructional Television Experiment (SITE) using NASA's ATS-6 satellite to transmit educational TV programs to some 5,000 villages. The TV programs, ground transmitting station and village receivers were all funded and developed by India. Evaluation of the program is underway, but the experiment has already demonstrated the practicality of satellite-based instructional broadcasting for developing countries. The project has aroused interest throughout the world.

On Oct. 30, NASA and the Agency for International Development (AID) successfully completed their joint venture, AIDSAT. Beginning Aug. 1, when ATS-6 began its return passage to the Western Hemisphere, the two agencies conducted a three-month project using the satellite for demonstration broadcasts to and from 27 developing countries. The broadcasts included films on communications, remote sensing, and disaster prediction which were prepared especially for AID by NASA.

The live portion of the program was in two parts. The first, originating in the host country, featured decision-makers outlining current technological challenges facing their nation and efforts being made to meet them. The second was a two-way TV question and answer session between a panel of senior government officials in the host country and selected experts in Washington. The programs involved the active participation of a number of prime ministers, presidents and kings, and were viewed by high-level government officials. In addition, millions of persons in Asia, Africa and Latin America viewed the demonstration on their national networks.

Increasing emphasis was given in 1976 to future international use of the Shuttle-based Space Transportation System (STS). Potential users--government, industry and university--in Canada, Europe and Japan were briefed on STS capabilities, payload accomodations and probable terms and conditions of use. Four solicitations were distributed internationally for proposals for Shuttle experiments in the Orbital Flight Tests Phase; in the first two Spacelab missions; and in a planned free-flying Long Duration Exposure Facility. Preliminary studies for the first Spacelab payload, jointly planned by NASA and the European Space Agency, were completed, and final selection of the payload complement is expected in early 1977.

The development of Spacelab, the European contribution to STS, currently valued at $500 million, passed the midpoint in 1976. Completion of the Preliminary Design Review in December, was a major milestone toward the delivery of the first Spacelab Flight Unit to NASA in mid-1979, a year before its first mission.

Development was begun this year in Canada on the Remote Manipulator System for the Space Shuttle orbiter vehicle, at a cost estimated at more than $75 million.

NASA's intensified upper atmospheric research program has focused on the possible threat to the Earth's stratospheric ozone shield from fluorocarbon compounds widely used as refrigerants and aerosol propellants. Because of the global implications, NASA made special efforts in 1976 to inform the world scientific community generally and to pursue its stratospheric research activities cooperatively. To foster international coordination of stratospheric research and policy planning, NASA co-sponsored an International Conference on the Stratosphere and Related Problems at Utah State University, Sept. 15-17, 1976.

Of the 25 international satellites which have so far been launched by NASA on a cooperative (as distinguished from a reimbursable) basis, eight remained active and returning data in 1976. Most significant were the two German Helios solar probes which, in four perihelion passages in 1976, flew closer to the Sun than any other spacecraft, to within 30 million miles. Measurements by Helios of the solar atmosphere, magnetic fields and particle emissions have generated new data on solar-terrestrial interactions.

NASA concluded an agreement with the Aerospace Research Center of the University of Rome to develop the next generation of San Marco satellites for continued investigations of processes at the interface between space and the upper atmosphere. San Marco D is also expected to contribute importantly to the current study of the Earth's ozone layer.

International interest in contributing experiments to NASA spacecraft continues with agreements reached with Germany, the UK, the Netherlands and France on instrumentation for the NASA Solar Maximum Mission and the Pioneer Venus Orbiter and Probe spacecraft.

During 1976, NASA issued 14 Announcements of Opportunity for various forms of participation in future space missions and received over 173 proposals from nine European countries, the European Space Agency, Australia, Canada, India, Japan, and South Africa.

During the year NASA began to charge foreign Landsat station operators an initial token share of the annual cost of operating the Landsat satellites. Such stations, receiving data directly from the satellites, were operating in Canada, Brazil and Italy. The construction of others is planned by Zaire, Iran, Chile and Argentina under recent agreements.

The agreement between NASA and the Argentine space agency, Comision Nacional de Investigaciones Espaciales (CNIE), to build Latin America's second ground station was concluded in October. The new station, to be built by CNIE at Mar Chiquita on the Atlantic coast south of Buenos Aires, will be capable of receiving, processing and disseminating data covering all Argentina, and all or parts of Chile, Bolivia, Brazil, Uruguay and Paraguay.

This growing interest in direct reception stations is in part due to significant benefits reported by researchers in more than 100 countries currently using Landsat data. Bolivia, for example, has recently discovered deposits of lithium and potassium as a result of computer-assisted interpretation of Landsat data. A new iron ore deposit was discovered recently in Egypt using Landsat data as well.

Reimbursable launches during the year included INTELSAT IVA-2 (an international communications satellite); NATO IIIA (an operational communications satellite); and Palapa-A (the first Indonesian domestic communications satellite).

Contracts for reimbursable launches were signed with the UK, ESA, Brazil, Japan and Canada, as well as with FAA for two launches of the international aeronautical satellite, Aerosat, in 1979 and 1980.

Cooperative work between the US and USSR in space science and applications proceeded under the 1971 Bilateral Agreement. In planetary explorations, US and Soviet specialists exchanged information on the results of the Soviet Venera 9 and 10 missions, US radar observations of Venus, the US-planned 1978 Pioneer Venus missions and sharing of preliminary Viking results. The Space Biology and Medicine Joint Working Group met in Yerevan, USSR, in September and finalized plans for the flight of five US biological experiments on a Soviet biological satellite to be launched in the fall of 1977.

The cooperative study of the natural environment moved into the second phase in the spring of 1976 when the Soviets began providing ground truth data for the remote sensing of vegetation. These data will be useful in the US Large Area Crop Inventory Experiment (LACIE) aimed at developing a world wheat crop prediction capability.

ENERGY PROGRAMS

The broad goal of the Office of Energy Programs is to assure the effective use of NASA technologies and experience in support of national energy research and development activities. Nine primary areas of emphasis have been identified.

In support of ERDA's solar energy program, NASA is working in three areas; wind turbo-generators (wind mills), photovoltaics (solar cells), and solar heating and cooling.

The largest windmill in history will be built during the next two years. The windmill will have two slender fiberglass rotor blades spanning 200 feet in diameter, atop a 150-foot tower. At a site with average wind speeds of 22 mph, this machine could produce enough energy annually to supply more than 500 homes (1,500 kwe).

Cost-effective, reliable and efficient solar heating and cooling systems are being developed by NASA as a part of the ERDA Solar Heating and Cooling Program. Following development, improved system will be installed and demonstrated in over 60 residential and commercial structures in a wide range of geographic and climatic locations throughout the country.

NASA is also managing the commercial demonstration portion of ERDA's National Solar Heating and Cooling Program. The first group of 32 commercial solar systems have been placed under contract and all 32 sites should be in operation by about the end of 1977.

The first data collection system in a centralized nationwide network for monitoring efficiency and performance of solar heating and cooling demonstration projects began operation in October. Similar systems will be installed in several hundred sites over the next few years. Data are collected, stored, and analyzed at the Marshall Space Flight Center.

Photovotaics

Solar cells once used only to power satellities in space, are now beginning limited use for a variety of terrestrial applications.

The first devices studied under the ERDA/NASA Photovoltaic Test and Demonstration Project are intended for use in remote applications where commerical electric power is unavailable.

Solar cell systems are being used to power water pumps, lights, refrigerators, and radios used at the newly designed U.S. Forest Service lookout buildings on Antelope Peak in the Lassen National Forest and on Pilot Peak in the Plumas National Forest. In the past, water was pumped by hand, the lamps and refrigerators were powered by propane and radios were powered by batteries.

The complete power system for each lookout station consists of a 300-watt solar array, 3000 ampere-hours of battery storage capacity, a battery charge controller, and instrumentation to indicate the status of the power system.

Photovoltaic powered refrigerators have been developed to solve the problem of storing certain medicines and essential perishable foods at locations where there is no electrical power. Two remote sites have now been equipped with small refrigerators powered by solar cells.

Solar cells also have been used to provide power for electric vehicles. Two solar powered electric vehicles were demonstrated from July through September at the Festival of American Folk Life in Washington, D.C. During peak daylight hours the vehicle batteries were charged by the array of photovoltaic cells which converted the Sun's light directly into electrical energy.

In coordination with the ERDA, NASA has also initiated the many study, definition, and analysis activities needed to develop a comprehensive understanding of satellite power systems, a unique method of obtaining electrical energy from the Sun.

TRACKING AND DATA ACQUISITION

NASA's laser tracking system, the newest capability in tracking and ranging, began providing precision ranging data from the Lageos satellite in a study of continental drift and the processes that create earthquakes.

The stable Lageos orbit provides a reference point from which minute shifts in the Earth's crust can be determined. The laser range measuring capability is far more precise than conventional high frequency radio ranging techniques.

The landing of Viking on Mars was and continues to be the most exciting space event of the year. Through use of the Deep Space Network several firsts in the sphere of tracking and data acquisition were recorded. These firsts including the successful commanding, controlling and interrogation of a spacecraft on the surface of another planet, and the simultaneous support of four spacecraft at interplanetary distances. Aiding the operations of the Viking craft were the radar surveys by the 64 meter antennas of the Deep Space Network, which contributed significantly in selecting the landing site for Viking.

Implementation of Tracking and Data Relay Satellite System (TDRSS) services has taken another important step forward. Western Union Space Communications, Inc., a wholly owned subsidiary of Western Union Corp., Upper Saddle River, N.J. was awarded a contract to provide TDRSS services utilizing two satellites in synchronous orbit as relay stations between a single ground station and satellites in low Earth orbit. Through use of the TDRSS, many of the present tracking stations will close. The TDRSS can provide coverage for 85 to 100 per cent of each orbit as compared to an average of 15 per cent for today's world-wide ground-based systems.

LAUNCH RECORD

The space agency performed 16 successful launches in as many attempts during the year and all of the payloads are operating successfully. Two of the missions carried NASA payloads--Lageos I and Gravitational Probe I. Two were cooperative project--Helios II with Germany and Communications Technology Satellite (CTS) with Canada. The remaining launches were all in the reimbursable category in which the payload sponsor paid NASA for the launch and launch support operations costs.

The perfect 1976 launch record brings the percentage of launch successes since 1958 to 86 per cent. Of the 387 launches conducted since the agency was established, 332 were successes. The only previous 100 per cent year was 1972.

Nine of the launch vehicles were Deltas, three Atlas-Centaurs, three Scouts and one Titan-Centaur.