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HIGHLIGHTS OF 1981 ACTIVITIES

Two successful flights of the Space Shuttle Columbia, Voyager 2's flyby of Saturn and a perfect launch record were among the highlights of 1981 for the National Aeronautics and Space Administration.

Columbia's two missions, in April and November, marked a new era in space flight. It was the first time that a spacecraft has been launched from and returned to Earth and then reused for a second mission.

More spectacular photographs and new detail and scientific data resulted from the closest approach to the giant ringed planet of Saturn by NASA's Voyager 2 spacecraft late in August.

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The Voyager 2 mission added to information already gained about Saturn from Voyager 1 which flew past the planet in November 1980. Voyager 1 is moving out of the ecliptic plane of the solar system while Voyager 2 will travel several billion more miles to a Uranus encounter in January 1986, then on to a rendezvous with Neptune in August 1989.

In addition to the two Shuttle missions, there were 11 other successful launches by the agency. The year's perfect launch record is the fifth in the agency's 23-year history. The launches ranged from weather and communications satellites to environmental monitoring and Sun-Earth energy studies.

Space Transportation System

1981 was the year of the Shuttle. Two successful missions were conducted, in April and November, as the flight testing of the Space Shuttle, a key element in NASA's Space Transportation System, reached its halfway mark.

Astronauts John Young and Robert Crippen flew the Orbiter Columbia during its historic 54 1/2-hour initial mission. The second flight, STS-2, carrying the first payload and the remote manipulator arm was manned by astronauts Joe Engle and Richard Truly.

The new era in manned space flight began April 12 at 8:00 a.m. EST, when the Space Shuttle roared off the launch pad at the Kennedy Space Center, Fla. The two-million-kilogram (four-and-a-half-million-pound) revolutionary spacecraft was thrust into space by a combination of two solid rocket boosters and a trio of liquid fuel Space Shuttle main engines.

Young and Crippen, during their two days in orbit, carried out a wide ranging series of systems checks to prove the feasibility of the Space Shuttle system.

During the flight, television cameras detected minor damage to the Thermal Protection System (TPS) tiles located on the Orbital Maneuvering System pods. The damage was not deemed serious.

At 10:21 a.m. PST, on April 14, the Columbia landed safely on Rogers Dry Lake at Edwards Air Force Base, Calif. The first Space Shuttle mission was determined to be an unqualified success.

The Columbia was returned to the Kennedy Center in a less spectacular way -- piggybacked atop its 747 carrier aircraft.

STS-2, launched Nov. 12 from Kennedy Space Center, was significant in that it was the first time a spacecraft had been reused. Columbia, piloted by astronauts Joe Engle and Richard Truly, carried a space applications payload and a remote manipulator arm. It landed at Edwards on Nov. 14.

Despite a shortened mission, caused by a failed fuel cell, STS-2 was a success. Over 90 percent of the test objectives were completed by Engle and Truly and data from the OSTA-1 experiment package delighted investigators.

The Remote Manipulator System worked well and the Thermal Protection System again proved itself effective during the fiery entry through the Earth's atmosphere.

An investigation into the fuel cell failure began shortly after the orbiter was ferried back to the Kennedy Center from NASA's Dryden Flight Research Facility at Edwards.

Within two weeks after landing, work began on readying the Columbia for its third flight test scheduled for March 1982.

Meanwhile, construction continued on the second orbiter, Challenger, at Rockwell International's plant at Palmdale, Calif. The newest orbiter is to be delivered to the Kennedy Space Center in mid-1982.

As orbiter construction proceeded, main engine testing continued at full power level (109 percent of rated power level) and external tank production maintained a steady pace.

As the Space Shuttle began to prove itself, a new study began on an unmanned launch vehicle based on solid rocket booster technology. SRB-X would be capable of boosting a 29,490-kg (65,000-lb.) payload into low Earth orbit or 5,443 kg (12,000 lb.) in geosynchronous orbit.

Space Transportation Operations

The successful flights of the Space Shuttle Columbia conducted in April and November paved the way for targeting the first operational STS launch (STS-5) for November 1982. Two more test flights are planned for March and July 1982.

STS users conferences held after each of the year's test flights briefed users on the results of both flights and the impact of each on future Shuttle planning. A new manifest calls for operational flight rates to build to 24 annually by 1988. The breakdown by fiscal year: 1983, 5 flights; 1984, 10; 1985, 13; 1986, 17; and 1987, 21 for a total of 66 operational flights through fiscal year 1987.

Early in 1981, the Air Force announced that Shuttle launch and landing facilities at Vandenberg Air Force Base, Calif., will not be ready until October 1985, a slip of one year from the previous planned operational readiness date. First flight from those facilities is a Department of Defense mission scheduled for October 1985. Eight launches are planned from Vandenberg through September 1987.

Delivery of the second Shuttle orbiter, Challenger, is scheduled for June 1982 with its first flight planned for January 1983. The third orbiter, Discovery, is scheduled for its first flight in January 1984. Delivery of the fourth orbiter, Atlantis, could be delayed up to a year depending on the outcome of current budget processes.

Nineteen new astronauts completed training in August, bringing the total flight-status astronaut corps to 79, including eight women.

Highlights from 1981 for the Office of Space Transportation Operations include:

- In December the European Space Agency (ESA) delivered to the United States the Spacelab module and pallet scheduled to make the first Spacelab flight aboard Shuttle in September 1983.

- The STS-2 flight in November carried the first Shuttle science payload. Known as OSTA-1, it consisted of Earth resources experiments and the pallet on which it was mounted was the first use of ESA developed Spacelab hardware.

- Final integration of the OSS-1 payload with its Spacelab pallet was completed in December for installation aboard the orbiter in early 1982. The payload is scheduled to fly aboard the STS-3 mission in March 1982 and will study space plasma physics and astronomy.

- Companies that might be interested in bidding on a future contract to do all Shuttle turnaround processing for NASA were invited to watch, at the Kennedy Space Center, Fla., the complete cycle of preparation of the Shuttle for its third flight.

- NASA and the West German firm Messerschmitt-Boelkow-Blohm GmbH (MBB) signed a launch services agreement for the first flight of the Shuttle Pallet Satellite (SPAS-01) currently scheduled for STS-7 in April 1983.

- Tentative plans were formulated for a possible retrieval and repair of the Solar Maximum Mission on the STS-11 mission in December 1983.

- Vought Corp., aerospace subsidiary of LTV Corp., Dallas, won a contract to continue production and launching of the Scout launch vehicle. Nine Scout launches are planned during the duration of the contract which is in effect from Nov. 1, 1981, through Oct. 31, 1984.

- McDonnell Douglas Astronautics Co., Huntington Beach, Calif., received a contract to build and launch an estimated 13 Delta launch vehicles over a two-year period beginning Oct. 1, 1981.

- Eleven satellite launches were conducted using Atlas Centaur, Scout, Delta and Atlas launch vehicles (see attached NASA launch record).

- Twelve expendable launch vehicle flights are scheduled for 1982.

Space Science and Applications

The exploration of the solar system continued with the successful encounter in August by the Voyager 2 spacecraft of Saturn.

Building on the knowledge gained by the Voyager 1 encounter, the second Voyager provided information to resolve the ring structure in detail comparable to a street map. The rings appear to consist now of at least three discrete bands, the classical A, B and C rings.

The incredible structure, which at one point caused imaging chief Dr. Bradford Smith to insist that there were not just thousands, but thousands and thousands of ringlets, is now undergoing reexamination. The various Saturn moons, sizeable chunks of debris (the so-called shepherding satellites and others) and the enormous mass of Saturn itself are probably imprinting on the rings a harmonic wave-like feature representing gravitational influences among the various bodies.

This theory has outlasted the debris-sweeping satellite theory, which was favored prior to the second encounter.

The thickness of the rings was deduced to be considerably less than the length of a football field. In human terms, this makes the rings the equivalent of a phonograph disk 40 km (25 mi.) in diameter -- one of the strangest objects in the solar system still.

The atmosphere of Saturn was determined to operate dynamically different from Jupiter. There are no counter-cyclonic wind jets alternating within the cloud bands of Saturn, rather there is an equatorial jet stream of incredible speed -- more than 1,770 km/hr (1,100 mph). This led atmospheric physicists to postulate that the dynamics of Saturn's weather are much more profoundly related to internal structure within the planet itself. A series of barrel-like atmospheric cells, each nesting inside another, was conjectured to represent the model of Saturn. Jupiter, by contrast, consists of a series of upwelling and downwelling zones separated by rapidly changing slipstreams creating a literal maelstrom of eddies.

The new Saturn class of moons, the mostly icy satellites, were also examined in increased detail and the surfaces of nearly all the 17 moons mapped in detail. The extremely unusual moon, Hyperion was photographed for the first time. This moon -- perhaps a captured object -- is orbiting Saturn in a manner which cannot be explained by conventional accretionary disk models. This moon, incidentally, has been described as being "Campbell soup can-shaped."

Voyager 2 is now on a trajectory which will intersect Uranus in January 1986. Scan platform problems encountered during the Saturn encounter are now mostly cleared and there is high confidence that the Uranus encounter will occur with no additional hitches.

Pioneer 6, 15 years after its launch, continues to return interplanetary and solar science information. This is the longest mission ever achieved for an interplanetary spacecraft. All Pioneers from 6 through 11 continue to function well.

The Pioneer 10 spacecraft achieved a milestone -- of sorts -- it is now more than 25 thousand million miles from the Sun. Pioneers 10 and 11 are now providing first hand information about the nature and extent of the solar wind. This extended solar atmosphere gives way at some point, totally unknown, to the even more tenuous "atmosphere" of the Milky Way Galaxy. This limit, the heliopause, is the object of the extended Pioneer mission.

The Pioneer Venus mission continues to produce scientific results concerning the cloud-shrouded yellow neighbor of Earth. Long term studies now show that Venus has two different cloud states which alternate in dominance. The two patterns are a mid-latitude jet stream pattern which gives way over a period of several years to a cloud-and-wind pattern which behaves like a single air mass body.

The high altitude haze layer has also been shown to appear and disappear over periods of several years.

Other Venus findings include the relationship of the tremendous Venus surface temperatures, 482 degrees Celsius (980 degrees Fahrenheit), to the long-term effects of a carbon dioxide atmosphere.

Scientists working for NASA discovered a natural carbon dioxide laser operating within the atmosphere of Mars. The power of the Red Planet's natural laser is about five times the power production of the United States. This natural laser provides another clue to the influences working within atmospheres to heat them. Past theory was held that a thermodynamic balance exists within the whole atmosphere.

Researchers examining meteorites retrieved by NASA from the Antarctic have found miniscule diamonds within an iron-type sample. The diamonds are believed to have been formed in space during a great collision that probably took place in the asteroid belt many millions of years ago.

Other NASA researchers theorized that the pressure and temperature of methane on Uranus might be conducive to the natural creation of diamonds on that green ringed planet.

None of these diamonds, though, has any commercial value due to their incredibly small size and the extreme difficulty of retrieving them.

The High Energy Astronomy Observatory program came to the end of its successful mission with the HEAO-2 spacecraft depleting all of its attitude control gas in June and the HEAO-3 depleting all of its control gas in August. These spacecraft, along with HEAO-1, were pioneering X-ray astronomy observatories and built a tremendous baseline of information about the X-ray universe. This work was preceded by the Uhuru satellite which had proved that X-ray astronomy could be performed. The HEAO-3 was a mapper while the HEAO-2 was a fine pointing observatory. Among their many discoveries was the possibility of a black hole at the X-ray source Cygnus X-1.

The Johns Hopkins University was named to be the location of the Space Telescope Institute. The Association of Universities for Research in Astronomy, selected to operate the Institute for NASA, had chosen Hopkins as its partner in this venture. The Institute will operate as an observatory for scientists who use the Space Telescope, scheduled for launch aboard the Shuttle in 1985.

A new laser detecting and ranging device (LIDAR) was flown for the first time aboard a NASA aircraft. This new instrument uses light to sample atmospheric constituencies such as ozone and is intended for further testing aboard a Shuttle flight.

The Landsat-3 spacecraft's multispectral scanner was removed from operational service because of a malfunction. This leaves only the multispectral scanner from Landsat-2 to provide user information. The Landsat-3 television imaging system continues to operate.

The OSTA-1 payload successfully flew aboard the second Columbia flight in August. This payload, the first scientific payload to fly on the Space Transportation System, carried a synthetic aperture, Earth-looking radar, an advanced infrared radiometer, an experiment to automatically map the plankton concentrations in the world's oceans, a test instrument to determine if Landsat-type spacecraft can be further automated, and a carbon monoxide mapper. Inside the cabin the crew operated a lightning detection device and monitored the performance of a plant growth experiment.

Except for the plant growth experiment, which failed due to the shortened flight time of STS-2, the rest of the experiments were judged successfully by their investigators. The radar, in particular, was a spectacular success, showing Earth terrain features never before mapped from space. The entire payload was chosen to provide information and data to aid in designing a new generation of Earth resources orbiting satellites.

Aeronautics

As the U.S. agency primarily responsible for advancing aeronautical science and technology, NASA conducts the research to maintain U.S. leadership in the world air transport market and preeminence in military aeronautics. The main NASA aeronautics centers are: Ames Research Center, Mountain View, Calif.; Langley Research Center, Hampton, Va.; and Lewis Research Center, Cleveland.

In 1981, NASA continued development of advanced technologies that could reduce fuel consumption in future commercial transport aircraft by as much as 50 percent. Elements of the research effort included turbine-driven fan jets and advanced turbine-driven propellers, computerized flight control systems, stronger and lighter weight structures and materials, and more aerodynamically efficient configurations.

The Energy Efficient Engine program element highlighted these efforts in 1981. Performance goals were demonstrated with various engine components, with the technology developed providing fuel savings in advanced turbine-driven fan engines of up to 20 percent over today's most efficient engines.

Teamed with the Federal Aviation Administration and industry, NASA tested advanced technology to enhance safety and efficiency in the crowded airspace around airports and under adverse weather conditions. These continuing efforts include aircraft ice protection concepts, fire resistant materials, aircraft crash dynamics, anti-misting fuel, lightning research, and advanced technology flight management systems and flight procedures.

The NASA/Army tilt rotor research aircraft, a promising concept for future civil and military applications, completed the proof-of-concept flight research phase this year. The aircraft combines the vertical lift, hover and maneuverability advantages of the helicopter with the greater forward speed of the fixed-wing aircraft. It flew about twice as fast and twice as far as a helicopter on an equal amount of fuel, achieving a top speed of 557 kilometers (346 miles) per hour. Flight demonstrations of this concept are planned for potential military and civilian users.

Maneuverability of a high speed fighter aircraft is one of its most critical elements. NASA and the Air Force are demonstrating a number of advanced technologies in a single research aircraft called HiMAT -- for Highly Maneuverable Aircraft Technology -- which could double the maneuverability of future U.S. fighters. This year the research aircraft has expanded its flight testing to high transonic speeds, achieving over 7gs maneuver load factor.

NASA's swing-wing research aircraft completed its flight program, demonstrating aircraft handling qualities at subsonic speeds with its wing angled, fore and aft, up to 60 degrees to its fuselage. Aeronautical theory indicates that such an oblique wing aircraft could fly at low supersonic speeds using less fuel and with no sonic boom audible on the ground. The wing is returned to the conventional position for efficient, quiet, low speed flight and for takeoff and landing operations.

NASA's Quiet Short-Haul Research Aircraft, demonstrating advanced aeronautical technologies aimed at solutions to airport congestion and noise problems, completed a flight evaluation series this year. Government, military, airline and industry pilots flew the research aircraft to evaluate its propulsive-lift technology. The aircraft's engine exhaust is directed over the wing surfaces to substantially increase lift, permitting quiet takeoffs and landings from short runways of smaller, closer-to-city airports.

NASA intentionally guided a modified F-106B jet fighter through severe southwest thunderstorms this year to study how lightning affects aircraft in flight. This and other basic knowledge about lightning is important to help safeguard future aircraft against a lightning strike. These efforts are a part of NASA storm hazard research, which includes studies of air turbulence, wind shear and storm hazards correlation.

Safety, energy efficiency and utilization of general aviation and commuter aircraft were emphasized in NASA research and technology efforts this year.

Acceptance flight tests of an advanced concept in aircraft flight control, navigation and flight management were completed. The system uses modern digital electronics, shared displays and modular concepts to achieve fault tolerance and increased reliability at potentially low cost. This system is being demonstrated in a NASA Cessna 402B aircraft.

Winglets, small structures attached almost perpendicular to wingtip surfaces, were developed by NASA as a means to reduce fuel consumption by lessening the effect of drag-producing vortices, the swirls of air that form at the aircraft wingtips. Similar winglets were tested on an agricultural aircraft in an attempt to make these vortices aid agricultural aerial applications.

NASA and the FAA are studying the crash dynamics of light planes, including the energy-absorbing characteristics of aircraft subflooring. By redesigning the interior floor, researchers are attempting to reduce the crash forces that can be transmitted to people inside the plane. Other research is aimed at improving the energy-absorption characteristics of aircraft seats and restraint systems.

This research on crash dynamics is being expanded to jet transports and will complement current NASA/FAA research aimed at enhancing occupant survivability in post-crash fires.

In aerodynamics research, important strides were made in the use of high-speed computers to predict aircraft aerodynamic behavior. An algorithm was discovered that permits a 10-fold increase in computational speed and in calculating forces and flow velocities over aircraft wings and bodies. The method introduces a procedure permitting time steps in the computations that would normally produce instability and lack of convergence in the computation. The new procedure has been independently checked and is being adopted by researchers all over the world.

In propulsion, research on alternate hydrocarbon gas turbine fuels for aviation focused on fuel property characterization and combustor concepts for engines typical of commercial transport and commuter applications that minimize the impact of operating with poorer quality fuels that might be expected from oil shale or coal derived fuels in the future. Research results have shown that poorer quality fuels, lower in hydrogen content, result in significant increases in engine combustor liner temperatures and moderate increases in exhaust emission levels for current production combustor configurations. The advanced concepts, such as multistage combustion, have demonstrated a much lower sensitivity to fuel quality changes.

In aviation electronics, modern flight control system designs employing digital computers incorporate an independent backup computer system to preclude the simultaneous loss of all control channels. This approach increases the overall system complexity and cost. Recent research in controls has focused on the development of a technique of embedding backup software within the primary control system computers, thus eliminating the need for any additional hardware. Such software would be independently generated and called upon when a generic software anomaly occurred. Laboratory tests have demonstrated the effectiveness of this technique in reducing the cost and complexity of future digital flight control systems.

Energy Research and Development

NASA energy research, development and demonstration efforts, sponsored by the Department of Energy and other agencies, made significant contributions during the year toward advancing technologies to meet national energy needs.

A first generation, experimental, advanced gas turbine automobile engine was assembled to verify turbine aerodynamic efficiency advances and to continue development of ceramic components, the key technology needed to raise engine operating temperatures to engine efficiency goals.

Test of the first, intermediate temperature experimental Stirling engine demonstrated efficiencies equal to automotive diesel engines and emissions less than Environmental Protection Agency research goals.

First experimental ac electric vehicle propulsion system tests demonstrated an overall efficiency of 82 percent, equaling dc systems. With further development, both systems hold promise for improved performance and lower initial cost of an electric car.

Solar cell electric system technology advancements, this year, included improved methods for purifying silicon and for producing thin silicon sheets by ribbon crystal growth processes. Encapsulation system designs were developed and automation in assembly of cells into encapsulated modules was demonstrated. This process is consistent with program goals of providing technologies for cost-effective solar-cell electric systems in this decade.

Three large wind turbine electric generators began operation in 1981, bringing the total constructed to nine since program initiation in 1973. These latest machines are advanced designs installed at Goodnoe Hills, Wash., each providing 2.5 million watts to the power grid. Each of the three units in this first U.S. "wind farm" has 91-meter (300-foot) diameter blades. It is estimated that production versions of these machines could provide electric power for about 5 cents per kilowatt-hour, a price competitive with conventional power in many U.S. areas. Conceptual designs were completed on larger wind turbines that could produce power for about 3 cents per kilowatt-hour. These designs have rotor blades 122 m (400 ft.) in diameter and would produce 5 to 7 million watts.

Over 7,000 test hours have been accumulated on the first multi-kilowatt phosphoric acid fuel cell power plant being developed for on-site commercial/residential applications. An improved short cell stack configuration was tested for more than 5,000 hours at an operating pressure and temperature required for multi-megawatt utility applications. The latter configuration promises reduced overall system cost by at least 20 percent and an extended electrolyte inventory of 40,000 hours. An alternative air-cooled cell stack concept is also being investigated which holds the potential for system design simplicity and enhanced reliability.

Space Tracking and Data Acquisition

The Office of Space Tracking and Data Acquisition provides the vital electronic link between Earth and space for NASA's flight programs, including the Space Shuttle.

Its job is to keep track of where spacecraft are in orbit, tell them what to do, get information from them and process that information into a meaningful form. It does this primarily through two worldwide networks -- one for deep space missions operated by the Jet Propulsion Laboratory, Pasadena, Calif., and the other for Earth-orbiting missions operated by the Goddard Space Flight Center, Greenbelt, Md. A global communications system called NASCOM ties the networks and various control centers together.

During the year, the networks supported an average of 25 flight missions daily. NASA's annual operating budget for its tracking and data acquisition functions is more than \$400 million.

Highlights for 1981 included support of the first two orbital flight tests of the Space Shuttle Columbia in April and November, and the historic Voyager 2 flyby of Saturn in August. Space Shuttle mission support, among other things, enabled the world to see spectacular live television pictures from the Columbia in orbit.

Because of gaps in coverage during early Space Shuttle flights, temporary stations, primarily for voice communications, have been established at Dakar, Senegal; Gaborone, Botswana; Mahe, Seychelles Islands in the Indian Ocean; and Yarragadee in Western Australia. These stations will not be needed when the Tracking and Data Relay Satellite System is in place.

Work on integration and testing of the first Tracking and Data Relay Satellite continued at the TRW Systems Group, Redondo Beach, Calif. It is now scheduled for launch from the Space Shuttle in January 1983.

When this two-satellite, geosynchronous orbit system is in full operation, with its single ground terminal at White Sands, N.M., it will be the primary tracking and data acquisition system for the Space Shuttle as well as low Earth-orbiting satellites, eventually replacing ground stations of the Spaceflight Tracking and Data Network. Two stations of that network -- Rosman, N.C., and Quito, Ecuador -- were shut down during the year.

Finally, because of reductions in NASA's operating budget and the modestly declining workload of the three-station Deep Space Network, the 26-m (85-ft.) tracking antennas at Goldstone, Calif.; Madrid, Spain; and Canberra, Australia, ceased operations on Dec. 1. The stations will continue to operate 64-m (210-ft.) and 34-m (112-ft.) deep space tracking antennas as in the past.

Space Research and Technology

NASA research and technology developments this year continued to expand the U.S. technology reservoir supporting national space capabilities.

An image processor designed for robotic vision applications was successfully demonstrated at NASA's Jet Propulsion Laboratory, Pasadena, Calif., for the first time. Vision capability is the most valuable sensor for robotic control during automated satellite servicing and in-space structure assembly and construction. The image processor could visually track objects at a 15 video-frames-per-second rate. The laboratory demonstration is an early step towards control-oriented computer vision system development for space robotics.

A mobile work station concept from which space-suited astronauts could assemble large structures in space was developed and tested at NASA's Langley Research Center, Hampton, Va., and Marshall Space Flight Center, Huntsville, Ala., under simulated space conditions this year. The station is designed for operations attached to the Space Shuttle or as a free flyer. The astronauts would be attached by foot restraints to the station, freeing their hands for the assembly tasks.

Concepts were developed for assembly, without tools, of large structures in the weightless environment of space using lightweight composite columns and unique, specialized joints. Assembly of a 38-element structure in both a 1 g laboratory environment and in a neutral buoyancy tank simulating the weightlessness of space has shown the structural concepts to be practical.

An experimental computer program for automatically planning and scheduling spacecraft action sequences was designed and developed at the Jet Propulsion Laboratory. The program combines artificial intelligence technology with operations research and techniques to automatically perform tasks which typically require support from a number of mission operations specialists. The experimental computer program was successfully demonstrated on realistic Voyager-like spacecraft sequences spanning a six-hour operational period involving dozens of spacecraft actions and events.

The orbital flight tests of the U.S. Space Shuttle also began a unique flight research program supporting NASA's advanced (21st Century) space transportation program. Flight research experiments onboard measure orbiter performance, providing precise engineering data for the timely and evolutionary development of future space transportation concepts.

International Affairs

A milestone in European-American space cooperation occurred Dec. 4, 1981, when the European Space Agency Spacelab unit was accepted by NASA at a rollout ceremony in Bremen, West Germany.

Spacelab is a major element in the NASA Space Transportation System with facilities and equipment similar to laboratories on Earth but adapted for zero gravity.

The first Spacelab mission is currently scheduled for September 1983.

The second test flight of the Space Shuttle (STS-2) in November carried for the first time the Canadian-developed Remote Manipulator System (RMS) and the first European-developed Spacelab hardware, a pallet, into space.

The Remote Manipulator System, or arm, is designed to place payloads into orbit and retrieve them, as well as for other freight-handling activities in space. Astronauts Joe Engle and Richard Truly operated the arm in all of its modes, ranging from fully automatic, in which it is programmed in advanced by computer to perform a series of operations, to fully manual in which it is operated directly from a control panel that bypasses the computer.

The five OSTA-1 experiments on STS-2 that were flown in the orbiter's payload bay were carried on a special "U"-shaped structure called an orbital flight test pallet. The 3-by-4-m (10-by-13-ft.) aluminum frame and panel structure weighing 1,218 kg (2,685 lb.), is an element of Spacelab, a reusable, modular research facility being developed for the Space Transportation System by ESA in cooperation with NASA.

The Spacelab pallet carried on STS-2 was an engineering model of the flight version pallet. This engineering unit was certified for flight and was adapted for use with special subsystems which provide interfaces between the payload and orbiter systems. The subsystems were developed by NASA using, for the most part, off-the-shelf hardware.

The pallet, developed for ESA, is built by the British Aerospace Dynamics Group under subcontract to ERNO Raumfahrttechnik GmbH, the prime contractor for ESA.

NASA and the West German firm Messerschmitt-Boelkow-Blohm GmbH (MBB) signed a launch services agreement in June for the first flight of the Shuttle Pallet Satellite (SPAS-01) which will be carried into orbit on the third Space Shuttle operational flight, STS-7, now scheduled for February 1983. It will be the first payload to be deployed and retrieved by the Canadian-built arm.

MBB's objective is to conduct materials processing research experiments while SPAS is in the Shuttle payload bay. After these experiments are finished, NASA will use the payload in a test of the Remote Manipulator System's deployment and retrieval capabilities during the five-day mission. A 70mm camera mounted on SPAS will provide photo coverage during deployment, free flight, retrieval and reberthing on the Shuttle.

MBB is the fifth international user to sign a Shuttle launch service agreement with NASA, joining India, Indonesia, Telesat Canada and Intelsat. The agreements signed with India, Telesat Canada and Intelsat also provide for launches aboard NASA expendable launch vehicles -- Delta or Atlas Centaur -- prior to the Shuttle becoming operational. In addition, the Arab Satellite Communications Organization (Arabsat), Australia, Colombia, the Federal Republic of Germany, Italy, Japan and Luxembourg have reserved launches aboard the Shuttle or NASA expendable launch vehicles, and a number of other countries are expressing interest.

On May 23 and Nov. 15, 1981, NASA launched Intelsat V spacecraft aboard Atlas Centaur launch vehicles. The launch service agreement with Intelsat, which was signed in 1980, provides for launch and associated services for six Intelsat V spacecraft. The next two satellites in the series also will be launched aboard Atlas Centaurs, while the fifth and sixth satellites are scheduled to be launched from the Space Shuttle. In addition, NASA and the Italian National Research Council (CNR) signed a Memorandum of Understanding in July 1981 that provides for a launch and associated services for the Italian Research Interim Stage (IRIS) payload on the Space Shuttle.

In 1980 NASA agreed to include two European scientists in the mission specialist astronaut training program in recognition of the substantial contribution ESA is making to the Space Transportation System by funding development of Spacelab. ESA is reimbursing NASA for the costs of this training. The two European scientists completed the first phase of their training at the Johnson Space Center in Houston during August 1981.

ESA decided in September, that one of the mission specialist trainees, Dr. Wubbo Ockels, would transfer to NASA's Marshall Space Flight Center in Huntsville, Ala., to resume payload specialist training in preparation for the first Spacelab flight. Dr. Claude Nicollier, the other trainee, will continue as an ESA astronaut at Johnson for possible selection as a mission specialist for flight on board the Shuttle with the planned German "D-1" Spacelab mission in 1985.

The Infrared Astronomical Satellite (IRAS), which is to carry out an all-sky survey of discrete infrared sources, is a cooperative project involving the United States, the Netherlands and the United Kingdom. The United States is producing the cryogenically-cooled infrared telescope system; the Netherlands is furnishing the satellite; and a mission control center will be established in the United Kingdom. Spacecraft testing of IRAS was completed in September 1981 in the Netherlands. The spacecraft was then shipped to the United States where it is going through its final development and test phase leading to a launch in August 1982.

The Active Magnetospheric Particle Tracer Explorer (AMPTE) mission will study the interaction between the solar wind and the Earth's magnetosphere through release of chemical tracer elements. AMPTE is a dual spacecraft mission with NASA providing the Charge Composition Explorer and West Germany, the Ion Release Module. NASA will launch the two spacecraft on the same Delta vehicle in 1984. The development phase of the project began in 1981. A Memorandum of Understanding between NASA and the Ministry for Research and Technology of the Federal Republic of Germany was signed Oct. 15, 1981, outlining the responsibilities for each side.

Development continued during 1981 on Galileo, a cooperative project with the Federal Republic of Germany which will continue the exploration of Jupiter and its environment. The Federal Republic of Germany is contributing a Retro Propulsion Module to inject the Galileo spacecraft into Jovian orbit, as well as other mission hardware. Critical design reviews of the mission hardware and systems requirements reviews have been completed. Several components are nearing completion and the development model for the probe's heat shield recently passed tests at NASA's Ames Research Center, Mountain View, Calif. Launch of the Galileo orbiter and atmospheric probe is now planned for 1985.

Development also continued on the Space Telescope, a cooperative project with the European Space Agency, which is scheduled for launch on the Space Shuttle in 1985.

Announcements of opportunities were issued worldwide for participation in further scientific analysis of data acquired in a variety of NASA missions ranging from Viking-Mars data and Apollo lunar samples to astrophysics observations from the High Energy Astronomy Observatories. As a result of previous such announcements, scientists were selected for definition studies of scientific instruments for possible flight on the Solar Optical Telescope, the Upper Atmospheric Research Satellite and the Origin of Plasma in the Earth's Neighborhood program.

During 1981, planning proceeded on the multilateral Search and Rescue (SARSAT) program. In addition to the United States, Canadian, French and Soviet participation previously agreed upon, Norway has been added as an investigator on the project.

NASA and the Indonesian National Institute of Aeronautics and Space signed a Memorandum of Understanding for the establishment of a Landsat ground station at Pekayon, near Jakarta, Indonesia.

Ten foreign Landsat ground stations are already in operation outside the United States: Prince Albert, Saskatchewan and Shoe Cove, Newfoundland, Canada; Cuiba, Brazil; Fucino, Italy; Kiruna, Sweden; Tokyo, Japan; Hyderabad, India; Alice Springs, Australia; Mar Chiquita, Argentina; and Harkbeesthoek, South Africa.

A ground station in Thailand is receiving test signals and a number of other ground stations are in the planning stages.

In 1981 NASA negotiated a 10-year renewal of the Interagency Agreement for the Operation of Tracking Facilities in Australia.

Agreements were also concluded for the establishment of a Shuttle Support Communications Facility in Gaborone, Botswana, and the upgrading of the Shuttle support facility in Dakar, Senegal.

NASA provided, through its Spacecraft Tracking and Data Network (STDN), reimbursable tracking support for ESA's Ariane launchings and the Meteosat II satellite.

Reimbursable tracking support was also provided to Japan for its Astro-A and GMS-II satellites.

Mutually beneficial cooperation between the United States and Soviet Union in the area of planetary research was developed further during 1980. In October, the U.S./U.S.S.R. Joint Working Group on Near-Earth Space, the Moon and Planets met in San Francisco to review the status of collaborative efforts in process, exchange information on future plans for lunar and planetary exploration and identify potential areas of mutual interest for future bilateral cooperation. Scientists from both countries exchanged the results of the U.S. Pioneer Venus and Soviet Venera 11 and 12 missions which encountered the planet in December 1978, and agreed to continue their joint analyses of data from these missions.

U.S./Soviet cooperation in space biology and medicine continued as well. The United States is preparing for participation in the Soviet Cosmos 82 biosatellite mission with primates. Experimenters in the United States will be involved in studies of primate biorhythm and cardiovascular activity, and in biological studies using rats. A new program of collaboration in studies of calcium metabolism and bone mineral loss resulting from manned spaceflight yielded important data which will aid in the understanding of the effects of weightlessness on humans. In November, a Symposium on Cardiovascular Changes Resulting from Spaceflight was held in conjunction with the Twelfth meeting of the U.S./U.S.S.R. Joint Working Group Meeting on Space Biology and Medicine, in Washington, D.C. The symposium brought together over 50 specialists from both countries to exchange information and present the results of ground-based and inflight research in this area.

A letter agreement was concluded in May 1981 between NASA and the Italian National Research Council for an advanced development study of a Tethered Satellite System. The project involves a data-gathering satellite suspended from the Shuttle on a tether up to 97 km (60 mi.) long.

Should the Tethered Satellite System receive budgetary approval, the Italians will be responsible for the satellite and NASA for the tether and deployer mechanism, as well as for overall systems integration.

Significant progress is continuing with implementation of a series of cooperative studies and projects with Japan. These projects were reviewed in September 1981 in Tokyo at the first meeting of the Joint Committee on U.S./Japan Cooperation in Research and Development in Science and Technology.

Development of the reusable space plasma physics experiments facility (SEPAC) in Japan is near completion at the end of 1981 and will be delivered to the United States in 1982 for integration for the Spacelab 1 mission.

Proposals were selected for participation in the Crustal Dynamics Program using space geodetic data for application to Earth movement measurements and earthquake modeling. Over 20 foreign investigators from Germany, France, the Netherlands, Canada, China, Chile, Peru, Venezuela, Spain, Switzerland, Australia and New Zealand were chosen. Negotiations continued with other countries including Italy, England and France for other cooperative geodynamics studies activities.

1981 NASA LAUNCH RECORD

Date	Payload	Launch Vehicle	Launch Site	Mission Remarks
February 21	COMSTAR-D	Atlas Centaur	ESMC*	Comsat General Corp. communications.
April 12	Space Shuttle	STS-1	KSC**	First Space Shuttle flight.
May 15	Navy 20 (NOVA 1)	Scout	WSMC***	DOD transit.
May 22	GOES-E	Delta	ESMC	NOAA weather.
May 23	Intelsat V-B	Atlas Centaur	ESMC	Intelsat communications.
June 23	NOAA-C	Atlas-F	WSMC	NOAA weather.
August 3	Dynamics Explorer	Delta	WSMC	NASA scientific.
August 6	FLTSATCOM-E	Atlas Centaur	ESMC	DOD communications.
September 24	SBS-B	Delta	ESMC	SBS communications.
October 6	Solar Mesosphere Explorer	Delta	WSMC	NASA scientific.
November 12	Space Shuttle	STS-2	KSC	Second Shuttle flight. First reuse of a spacecraft.
November 19	RCA-D	Delta	ESMC	RCA communications.
December 15	Intelsat V-C	Atlas Centaur	ESMC	Intelsat communications.

* ESMC - Eastern Space and Missile Center, Cape Canaveral, Fla.

** KSC - Kennedy Space Center, Fla.

*** WSMC - Western Space and Missile Center, Vandenberg Air Force Base, Calif.

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