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ABSTRACT

In this document, a historical development of the space exploration activities of the United States and of the Soviet Union is provided. In particular, communications leading to the cooperative space agreement developed in 1972 are described. The article describes in detail the flight plan for the Apollo-Soyuz space flight. (CP)

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RENDEZVOUS IN SPACE: APOLLO-SOYUZ

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As many Americans awaken on July 15, Soviet technicians will be completing an afternoon countdown for a Soyuz rocket booster to be launched from the Baykonur complex near Tyuratam in Central Asia, some 2,000 miles southeast of Moscow.

Meanwhile, NASA technicians at Kennedy Space Center will clear the area around an Apollo launch pad and begin loading liquid hydrogen and liquid oxygen into the 224-foot Saturn IB. Seven and a half hours after Soyuz has begun its journey around the Earth, at 3:50 p.m. EDT, Apollo will roar over the Atlantic Ocean in pursuit.

The dual launch of Apollo and Soyuz, beginning the first manned spaceflight to be conducted jointly by the United States and the Soviet Union, is the result of years of negotiating, careful planning, and extensive testing. The flight itself, though it symbolizes a new era in U.S.-Soviet relations, is only the last in a series of tests for a new docking system—a system designed jointly by engineers of the two nations to give future astronauts of both nations a common mechanism for locking their spacecraft together. For those who have had dreams of Earth-orbiting space stations supplied and manned by spacecraft from many nations, such a standardized docking system is an essential first step. Without a compatible docking system, each nation would be limited to its own independent activity during a period when research and practical applications in Earth orbit are steadily increasing in value. For others, who have watched the independent progress of the two great spacefaring nations, the fact that such a mechanism could be designed and tested jointly will be evidence in itself of a far greater accomplishment—a significant increase in understanding between superpowers that once waged an ideological war that seemed to threaten the safety and security of the entire globe.

Beginnings in space. On October 4, 1957, the Soviet Union launched the first artificial earth satellite. In retrospect, the accomplishment seems a modest one—Sputnik I operated for three weeks and stayed in orbit only three months. During this period, its radio beep and movements revealed information about the density of the upper atmosphere, temperatures experienced in the new environment, and the effectiveness of radio transmission from space.

But the dawn of the space age had a tremendous impact on world public opinion. For more than two years, the United States had been publicizing its plans for launching an artificial satellite as part of the 1957 International Geophysical Year. Now, with virtually no advance publicity, the Soviet Union appeared to have surpassed the United States in a single giant leap.

Soviet representatives had, in fact, made passing mention that their government was pursuing investigations to this end, but such information sounded no alarms in the United States. Now, the resulting political effects in the United States and in other countries were remarkable. Although the Soviet Union had made substantial progress since the 1917 Revolution, the argument that the Soviet system was better able than the American to provide developing nations with economic and technological growth had proved unconvincing to much of the world. Now, in an era of Cold War, the Soviets had scored a propaganda coup of major proportions.

For people all over the world, the space successes of the Soviet Union were viewed as symbolic of the overall technical and scientific level of the Soviet society. During the first few years, the Soviet accomplishments greatly enhanced their prestige and influence in the world. Their new image convinced many that they had at the very least equalled the United States. The military implications of the successful launches of great payloads into Earth orbit were lost on few. The scientific equipment, animals, and finally cosmonauts that orbited the Earth all rode into space on missiles capable of carrying nuclear weapons.

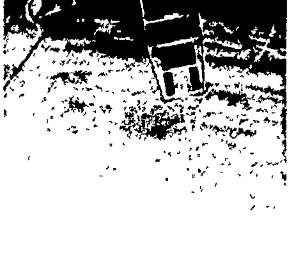
In the United States, the Sputnik launch and the following explosion of our own Vanguard rocket on the launch pad brought a flurry of activity. Within a year, Congress had created a new agency, the National Aeronautics and Space Administration, to lead the civilian space effort.

Following Yuri Gagarin's successful orbital flight on April 12, 1961, President John Kennedy asked his advisors to present him with a space program that would demonstrate American technological leadership and regain our international prestige. Vice-President Lyndon Johnson, chairman of the National Space Council, passed the desired recommendations to the President, who announced on May 25, 1961, an urgent national priority: to land a man on the Moon and to return him safely to Earth before the end of the decade.

International cooperation. During the first years of space activity, international cooperation in space was endorsed by both the United States and the Soviet Union. Because of the military implications of the advanced propulsion and guidance technology, some areas—booster development, for example—were clearly not suited for intimate cooperation between the superpowers.

In the realm of scientific research, however, NASA quickly advertised its willingness to engage in cooperative projects with other nations, and a number of programs to launch sounding rockets and small satellites were agreed to in the early 1960s. The first international satellites, the United Kingdom's Ariel and Canada's Alouette, were launched in 1962 atop U S rockets.

Left, Explosion of the U.S. Vanguard on the launch pad in 1957. Below, Britain's Aerial satellite, launched by the U.S. in an early example of cooperation.



Despite a number of formal and informal approaches to Soviet officials in the first years of the space age, no agreement on the nature of specific cooperative projects acceptable to both sides was reached until 1962, after the first orbital flight by John Glenn. Chairman Nikita Khrushchev's congratulatory telegram included a statement concerning the desirability of cooperative effort by our two nations in the exploration of outer space.

In response, NASA and other U.S. agencies provided specific proposals for concrete space projects that might be undertaken by the U.S. and USSR. President Kennedy's letter to Khrushchev outlined these as (1) establishment of an operational world weather satellite system through coordinated satellite launchings and global data exchange, (2) exchange of spacecraft tracking services; (3) mapping of Earth's magnetic field with each nation launching its own satellites equipped to share this task, (4) an invitation to the Soviet Union to provide a ground terminal as part of an international program using U.S. communications satellites.

In view of the extensive cooperation already underway between the United States and many other nations, the agreement signed by Anatoliy Blagonravov of the Soviet Academy of Sciences and Hugh L. Dryden, Deputy Administrator of NASA, in June 1962 represented a very small step toward cooperation between the two nations that were most active in space.

This first agreement on space cooperation between the United States and the Soviet Union provided for mutual exchange of data from weather satellites, mapping of the Earth's magnetic field through an exchange of results from independent satellite launches, and a communications experiment using the U.S. satellite Echo II.

In 1965, stimulated by a Soviet suggestion, negotiators agreed on a plan to prepare a joint review of space biology and medicine, the first U.S.-Soviet cooperative effort in an area directly related to manned spaceflight. After a decade of compilation and review, the U.S.-U.S.S.R. editorial board has approved this impressive joint work for publication in the coming months.

Although U.S. space cooperation with dozens of nations flourished in the 1960s, joint efforts with the Soviet Union were limited to a very modest exchange of results and some small attempts at coordinating the two vigorous independent national programs.

From the launch of Sputnik in 1957 through the 1960s, the Soviet space program recorded a number of firsts. In 1959, the first spacecraft to escape Earth's gravity, Luna I; also in 1959, the first pictures of the far side of the Moon, by Luna 3; in 1960, the first recovery of orbited animals; in 1961, the first manned orbital flight, with Yuri Gagarin in Vostok 1, in 1962, the first spacecraft to fly past Mars, Mars 1, in 1964, the first multi-manned flight with a crew of three in Voskhod 2, in 1965, the first walk in space, by Aleksey Leonov, now commander of the Soviet prime crew for the Apollo-Soyuz mission, in 1966, the first spacecraft to impact Venus, Venera 3, and in 1969, the first circumlunar flight to be returned to Earth.

Meanwhile, the United States national space program also made significant advances. The first global weather photo, the first communications satellites, the first photograph of the Earth from space, the first docking of manned spacecraft in orbit, the first photographs of Mars, the first orbiting solar observatory—all were U.S. accomplishments in the 1960s. The crowning achievements—the first manned flight around the Moon, the first docking in lunar orbit, and finally the first manned landing on the Moon—significantly extended man's reach into space.

Growing U.S.-Soviet communication. In the latter half of the 1960s, as the United States moved toward the successful landing on the Moon, American space officials repeatedly offered to undertake additional cooperative efforts with the Soviet Union, but none of these overtures brought an affirmative response from the USSR.

During this period, however, the United States and the Soviet Union were among the dozens of nations signing the Outer Space Treaty in 1967. These nations, and the others signing in succeeding years, agreed that space is free for exploration and use by all countries, that space exploration shall be carried out for the benefit of all humanity, and that the Moon and other celestial bodies shall be used exclusively for peaceful purposes. This was followed in 1968 by a supplemental treaty concerning assistance by nations to astronauts in distress.

The rapid progress of NASA's lunar program was accompanied by steady growth in U.S. cooperative space activities with other nations. From 1965 through 1969, a dozen separate U.S. launches carried satellites from Canada, the United Kingdom, France, Germany, Italy and the ten-nation European Space Research Organization. Foreign scientists also provided experiments to be included in U S spacecraft and shared the responsibility for analyzing data gathered by U.S. instruments.

But even in early 1969, when new NASA Administrator Thomas Paine embarked on another campaign to elicit Soviet cooperation in defining mutually desirable space projects, the results were disappointing. Despite the great potential for space cooperation between the two nations most actively exploring the cosmos, no new joint effort had been undertaken for several years.

Until July 20, 1969, when American astronauts landed their lunar module on the dusty surface of the Moon, the pursuit of a more extensive program of space cooperation between the United States and the Soviet Union produced no hint of success.

If the landing on the Moon awakened mankind to both the needs of Earth and the potential of the human species, the accomplishment also stimulated a new interest in international space activity. Congressional resolutions endorsed an increased effort to bring about cooperation with all nations and to share the benefits of the Apollo success with the entire world. An advisory panel created by President Nixon recommended steps to involve other nations in a wide range of future space activities; a second panel, composed of representatives of several government agencies, began reviewing the possibilities for U.S.-Soviet cooperation in space. The enthusiasm of NASA Administrator Paine for seeking new joint projects was now bolstered by supporting statements from many quarters.

On the other side of the globe, Soviet officials began opening their doors. Congratulatory telegrams and informal expressions of Soviet support for increased space cooperation flowed from Soviet officials to their U.S. counterparts within days of the Apollo 11 landing.

Assured of the President's personal support for a broad initiative, Paine sent Mstislav V. Keldysh, President of the Academy of Sciences of the USSR, a copy of two reports on long-range U.S. goals in space and expressed the hope that they would suggest to Keldysh, as they did to him, possibilities for moving beyond the current, limited cooperation in space between their two countries. In the closing days of 1969 Keldysh replied that he agreed on the need to develop U.S.-USSR cooperation further. He suggested that in three or four months they return to the subject and agree on the time and place for a meeting.

In the succeeding months, the movement toward U.S.-Soviet space cooperation broadened and gathered momentum. In correspondence, at an informal dinner in New York, at private meetings, at an international space meeting in Leningrad, officials from NASA and other interested organizations suggested possible opportunities for cooperative effort.

During these months, several U.S. officials suggested that the two nations work together to develop a common docking mechanism for use on future spacecraft. In July 1970, a year after the first landing on the Moon, the Embassy of the USSR in Washington conveyed a message from Academician Keldysh. Soviet officials were ready to begin discussions leading to the development of common docking mechanisms for space stations.

Agreement is reached. In October, U.S. and Soviet officials met in Moscow for preliminary technical discussions. This first joint session led to basic agreements in several areas. Three joint working groups were formed, each with responsibility for a portion of the effort necessary to create a new docking system. These working teams would adapt procedures and systems developed independently by the two nations so that future vessels would be able to dock in space. This first meeting not only produced a formal agreement to design compatible rendezvous and docking systems for future manned spacecraft, it also led to a plan of action for their development.

The success of the rendezvous and docking meeting in October was followed by an agreement to substantially expand U.S.-Soviet space cooperation by establishing five new joint working groups. NASA Deputy Administrator George Low and Academician Keldysh met in January 1971 and agreed to the formation of new working groups to further cooperation in programs for weather satel-

On May 24, 1972, Richard M. Nixon and Alexei Kosygin signed a cooperative Space Agreement.

lites, atmospheric sounding rockets space sciences, the environment, and space biology and medicine Two of the projects to grow from the Low-Keldysh meeting were an exchange of lunar samples and a joint study of the Bering Sea using satellites, research ships and specially equipped aircraft.

At the January meeting, Low suggested to Keldysh that Apollo and Soyuz spacecraft be considered for a test flight of the new docking system the two nations would be developing. Then, in March, Low reported the recent developments in U.S.-Soviet cooperation to the Congressional committees that oversee the U.S. space program. NASA officials held regular discussions with senators, representatives, and staff members from Senate and House committees throughout the negotiations with the Soviet Academy of Sciences.

NASA and Soviet officials met again June 21-25, 1971, in Houston to discuss the technical requirements for compatible docking systems. Among the areas considered were radio and visual systems necessary for rendezvous and docking, differences in the communications and environmental control systems used by the two nations' spacecraft, and the basic functions and design of the proposed docking system. The two groups also agreed to study the costs and technical feasibility of testing the new docking sysem with existing spacecraft.

The technical feasibility of a test flight using existing spacecraft was confirmed in the succeeding meeting, held November 29-December 6 in Moscow, then at the Low-Keldysh meeting the following April, U.S. and Soviet delegations agreed that a test flight using U.S. Apollo and a Soviet Soyuz would be desirable

During the April session, both sides carefully and completely reviewed the work of the previous eighteen months. Before a formal agreement could be signed by the chief executives of the two nations, every major element in the proposed Apollo-Soyuz Test Project had to be outlined to the satisfaction of both sides. Before advising the President of the United States to formally approve such a test mission, NASA officials sought and obtained firm commitments from their counterparts in the Soviet Union on the methods and schedules to be followed in the coming three years. The two sides carefully detailed the objectives of the joint flight; they agreed on hardware tests, training exercises, and mission simulations to be conducted before the flight; they formulated mutually acceptable policies for handling various situations that might arise in space; and they established general guidelines for the exchange and public release of information concerning the joint flight Although each of these areas would be more extensively negotiated during future meetings, the basic plan was firmly established when the session concluded on April 6, 1972.

On May 24, 1972, President Richard Nixon and Aleksey Kosygin, Chairman of the USSR Council of Ministers, signed an agreement "concerning cooperation in the exploration and use of outer space for peaceful purposes." The leaders formally endorsed the arrangements previously agreed to at a lower level and established the two nations' determination to test the compatible docking system with an experimental Apollo-Soyuz flight in 1975.

The purpose of the new standardized system being designed for spacecraft and space stations was, in the words of the Nixon-Kosygin agreement, "to enhance the safety of manned flight in space and to provide the opportunity for conducting joint scientific missions in the future." The new docking system would provide the two nations with a steppingstone to cooperation in space.

ASTP development. Subject to continuing budget approval from the Congress, the Apollo-Soyuz Test Project was underway. During the three years to follow, well over a hundred U.S. engineers, astronauts, and project officials have traveled to the Soviet Union to meet with their counterparts, and a similar number of Soviet personnel have visited the United States. At these joint working group meetings, every aspect of the proposed mission that required coordinated effort was discussed Astronauts and cosmonauts began receiving language instruction in preparation for the flight. Engineers agreed on a design for the docking system, then each nation set about building its own hardware to meet the joint requirements. As a result, the docking systems are internally different, but the parts connect perfectly.

The Apollo and Soyuz spacecraft selected to test the new docking system are different in many important respects. The orbiting Apollo weighs about sixteen tons, more than twice as much as Soyuz. Designed for lengthy missions to the Moon, Apollo has a larger fuel supply for maneuvering, Apollo also has more spacious interior quarters. During the joint flight, the two Soyuz crewmembers will remain in space for just under six days; with a larger supply of fuel, oxygen, water, and food, the three Apollo astronauts will be able to stay in orbit for nine days, permitting additional scientific experiments to be completed.

To be certain that no surprises occur when the two spacecraft dock 140 miles above the Earth, numerous tests were conducted in the U.S and the Soviet Union The docking system was subjected to extremes of heat and cold and to other stresses that will be encountered in the vacuum of space. Soviet training teams familiarized

U.S. astronauts with the Soyuz spacecraft in exercises at the cosmonaut facility known as Star City, just outside Moscow. The Soviet crew members practiced in an Apollo training device in Houston. The teams that will be in the U.S. and Soviet mission control centers during the joint flight also exchanged visits and were trained in control center operations.

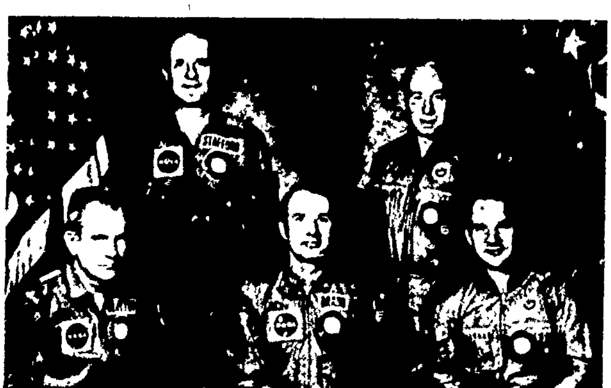
A total of nine astronauts and eight cosmonauts have received extensive training in all aspects of the joint flight. The Apollo prime crew is commanded by Thomas P. Stafford, 45, a brigadier general in the U.S. Air Force, a veteran of three spaceflights, and an astronaut for more than a dozen years. Stafford flew to within eight miles of the surface of the Moon on Apollo 10, the last test flight to precede the lunar landing in 1969. In 1965, Stafford participated in the first rendezvous in space when he and Walter Schirra brought the Gemini 6 to within a half-dozen feet of Gemini 7. In 1966, Stafford commanded Gemini 9 during a three-day flight in Earth orbit.

Donald K. "Deke" Slayton, Apollo docking module pilot, has called himself the world's oldest space rookie. Slayton, 51, was one of the first seven U.S. astronauts selected in April 1959 and was to have piloted the second U S. spacecraft to orbit the Earth, until a very slight heart irregularity was discovered. A comprehensive medical review in 1972 found Slayton physically qualified for spaceflight, and he will make his first trip into space on July 15.

The third U.S. prime crewmember is Vance D. Brand, 44. An astronaut for eight years, Brand trained as a backup crewmember for the Apollo 15 lunar landing mission and for the last two missions to use the Skylab space station. Brand has been named Apollo command module pilot for his first spaceflight.

The two-man Soyuz is commanded by Aleksey Leonov, one of the first group of Soviet cosmonauts to be chosen, and now a colonel in the Soviet Air Force. In 1965, Leonov was the first person to walk in space when he spent 12 minutes outside Voskhod 2. Flight engineer for the Soyuz will be Valeriy Kubasov, who flew aboard Soyuz 6 in a 1969 flight that included a rendezvous with two similar spacecraft, Soyuz 7 and 8.

The men who will fly the Apollo-Soyuz Test Project in July, from left to right: astronauts Slayton, Stafford, and Brand; cosmonauts Leonov and Kubazov.

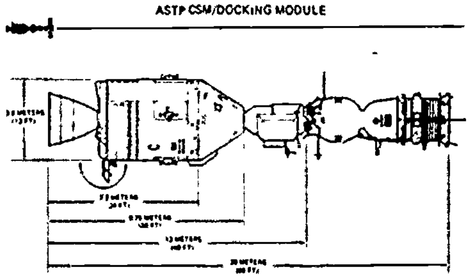


Above, Joint crew training at Johnson Space Center during a "walk-through" of the first day. Below, Soviet flight controllers during a briefing at Houston.

The spacecraft. The equipment for the Apollo-Soyuz Test Project includes both standard systems and new hardware developed specifically for the upcoming flight. The U.S. will use an Apollo spacecraft left in storage when the number of lunar landing flights was reduced in a cost-cutting effort. Because the Apollo command module was built with a docking system designed to work only with U.S. spacecraft like the Apollo lunar module or the Skylab space station, some method of incorporating the new compatible docking system designed by American and Soviet engineers had to be found.

A second important problem required solution before a joint flight could be made. The Apollo uses a pure oxygen atmosphere at about one-third the atmospheric pressure found on the surface of Earth; Soyuz, on the other hand, uses a nitrogen-oxygen mix like the air we breath on the ground, and at normal atmospheric pressure—14.7 pounds per square inch. To permit crewmembers to pass from Soyuz to Apollo, engineers had to include an airlock to equalize the pressure. A direct transfer from the Soyuz atmosphere to the low-pressure oxygen of Apollo would cause the "bends," a condition experienced by deep-sea divers when they come back to the surface too quickly and nitrogen gas bubbles form in their body fluids.

ASTP CSM/DOCKING MODULE



Fortunately, the problem presented by differences in the two spacecraft atmospheres and the need to adapt the Apollo to use the new docking system were resolved by combined action: the U.S. built a new piece of equipment and the Soviets made a modification to the Soyuz. Since the existing Apollo could not be changed to accommodate the new docking system without considerable work and expense, the U.S. decided to build a small docking module—an airlock ten feet long and five feet in diameter with the new docking system on one end and a system compatible with the Apollo on the other. The Saturn IB rocket used to launch Apollo will also carry the 4,400-pound docking module, and the astronauts will turn the Apollo around and connect it to the docking module after they are in Earth orbit.

To eliminate the need for a lengthy adaptation period for crewmembers passing from Soyuz to Apollo, Soviet engineers will reduce the atmospheric pressure aboard Soyuz by about one-third—to 10 pounds per square inch —while the two spacecraft are linked. The smaller difference in pressures allowed the United States to simplify and reduce the cost of the docking module, since crewmembers will not be required to spend long periods in the airlock. The change also will make enough time available to permit all crewmembers to participate in the exchange of visits.

The docking module includes virtually everything necessary to meet the compatibility requirements for Apollo. Only minor changes were necessary in the Apollo command module itself, for example the installation of controls for the docking module.

The Soviet side built new, modified Soyuz spacecraft specifically for the planned joint mission—each with the new compatible docking system included as an integral part of the Soyuz design. Two unmanned test flights were made with the new configuration, and in December 1974 Soviet back-up crewmembers for the joint flight rehearsed the entire mission independently during the six-day flight of Soyuz 16.

Two of the new Soyuz spacecraft will be prepared for launch from the Baykonur launch complex near Tyuratam, east of the Aral Sea. If one of the Soyuz launches is unsuccessful, or if the Apollo is unable to follow within a few days of the Soyuz launch, the second Soyuz will be available for the joint flight

By the time the flight itself begins, every procedure will have been worked out in detail, and many of the possible problems will also have been carefully reviewed. As the Soyuz stands ready on the launch pad in the Soviet Union, television pictures of the crew and rocket will be relayed to the U.S. mission control center in Houston from the Soviet mission control center at Kaliningrad, outside Moscow. Throughout the flight, communications between the spacecraft and the global tracking networks of the two nations will be relayed to flight controllers on both sides of the Earth. The control centers will be linked by lines for telephone, teleprinter, and television to permit rapid communication between all of the participants as the flight progresses.

The ASTP mission. The Soyuz will be launched first to take advantage of the fact that Apollo has a greater fuel capacity and is better able to close the gap with Soyuz once the two spacecraft are in orbit. Apollo will follow in 7½ hours, with subsequent launch opportunities on each of the five succeeding days.

About an hour after Apollo is launched, the command module will turn around in orbit, connect with the docking module, and begin moving away from the second stage of the rocket that placed Apollo in orbit.

During the succeeding 42 hours, from Tuesday evening (July 15) to just after noon on Thursday, the Apollo and Soyuz crews will slowly and carefully guide their spacecraft to dock some 137 miles above the Earth Seven or more Apollo maneuvers will be required to dock with Soyuz—each changing the Apollo's initial velocity—about 17,500 miles an hour—by less than fifty miles an hour to bring it closer and closer to Soyuz.

After docking is completed and a check is made of the new system, Apollo astronauts Stafford and Slayton will open the hatch from the command module to the docking module, leaving Vance Brand behind in Apollo. At 3:26 p.m. EDT Thursday afternoon, the two U.S. crewmembers will open the hatch to Soyuz and greet the Soviet crew. Three more crew transfers will be made on Friday, assuring that all of the U.S. and Soviet crewmembers will crawl through the airlock for at least one visit in the other's spacecraft, an important part of the test of procedures and equipment developed for future cooperative work.

At 8:02 a.m. Saturday morning, the Apollo and Soyuz will undock and Apollo will move about 650 feet away from Soyuz to provide an artificial solar eclipse for Leonov and Kubasov to observe. The cosmonauts will photograph the outer atmosphere of the Sun and will also record the effects of the Apollo steering rockets as they fire their gases into the vacuum around the U.S. spacecraft. Then Apollo will fly around Soyuz, beaming special lights to a mirror or "retroreflector" on Soyuz and back to a spectrometer on the Apollo. The amount of light absorbed as the beam travels between the two spacecraft will reveal the quantity of atomic nitrogen and atomic oxygen to be found in the region 135 miles above the Earth.

Following the joint experiments, Soyuz will dock with Apollo in a further test of the new docking system. Later on Saturday, following undocking, Apollo will fire its engines briefly and begin moving away from Soyuz. Soyuz will descend from orbit and land in the south central USSR near Karaganda early Monday morning.

The Apollo spacecraft will continue in orbit, with astronauts Stafford, Slayton, and Brand conducting several scientific experiments and making science demonstrations before they splash into the Pacific Ocean southwest of Hawaii at 5:18 p.m. EDT, Thursday, July 24.

U.S. experiments. Because this will be the last U.S. manned spaceflight in Earth orbit until the first Space Shuttle launch in 1979, NASA officials are taking advantage of the joint mission to carry on several scientific research projects during the nine-day flight. In addition to the two experiments mentioned above, which require the participation of both the U.S. and Soviet spacecraft, three other joint experiments and 22 independent U.S. experiments are planned for the flight.

Many of these experiments will explore areas investigated by the crews of the Skylab space station, which completed its work in February 1974. Inside the docking module, an electric furnace will be used to experiment on the processing of materials in space, a field that may someday return great dividends in the form of new materials that cannot be produced on Earth because of the distorting effect of the planet's gravitational forces. A Soviet scientist has prepared one of the samples to be inserted into the furnace. Other joint studies concern the effects of cosmic rays on bacteria, and the movement of microbes between crewmembers and the interior surfaces of the two spacecraft.

The U.S. crew will conduct several independent astronomy projects to record various forms of radiation from within our galaxy—the Milky Way—and from the universe beyond. Two other experiments will measure the relative movement of the Apollo command module in relation to an advanced communications satellite launched last year and in relation to the docking module, which will be sent spinning away by the crew after the docking experiments are concluded. By detecting small changes in the relative motions of the spacecraft, scientists can map areas where the Earth's gravity is slightly greater because of concentrations of mass beneath the surface. Tracking of satellites from the ground has revealed larger concentrations, while smaller differences can be detected by instruments here on the surface. The Apollo experiments will fill the gap between these two.

In two medical experiments, an electric field will be used to separate blood samples into their constituents. In another form of space cooperation, Germany provided the equipment for one of these two electrophoresis experiments. The investigations will help to determine

SCIENCE DEMONSTRATIONS FROM SPACE

During the flight of Apollo-Soyuz, the astronauts will conduct some science demonstrations that will utilize the unique conditions of the spaceflight environment in a way not possible on Earth. These demonstrations, which are in addition to the 27 experiments to be conducted, should be of great interest to science teachers and their students. They will be recorded on motion picture film and made available later for showing in high school science classes. The demonstrations are:

The "book" gyroscope—will show that a book-shaped object can rotate very stably about two of its symmetry axes (those of least and greatest moments of inertia), but no matter how carefully it is started rotating about the third symmetry axis the book soon undergoes an interesting flip-flopping motion which will be visible with the object rotating slowly and unsupported in zero g.

Planetary orbits--two metal spheres tethered together by fine thread will be launched with rotation but no translation about their center of mass, so as to orbit about each other in a plane. A pair with both masses equal will be a double-star model. A pair with one heavy and one light sphere will model a sun-planet or planet-moon or black-hole-star-system. No matter how the spheres are launched, they must always rotate in a plane.

Chemical reactions in foams—will involve the mixing of chemicals in zero g by shaking them to a foam. After a certain delay, a chemical reaction will occur, turning the colorless foam to a deep red. The stability of the foam, as well as the time of reaction, will be noted and compared to ground-based studies.

Capillary wicking—on Earth, the action of wicks is always the result of two forces, adhesion and gravity. Even when the wicking proceeds horizontally, some influence of gravity exists. In orbit, the wicking action should proceed without the disturbing influence of gravity. The rate of capillary action in different wicks placed in a low surface-tension fluid will be observed and compared with rates on Earth.

Liquid spreading-liquids, when brought in contact with solid surfaces, have a tendency to spread over the entire surface, provided that cohesive forces between molecules of the liquid are smaller than adhesive forces between molecules of liquid and molecules of the solid. Under Earth gravity, this wetting action takes place only when the flow of the liquid along the surface proceeds in a horizontal or downward direction. However, under the zero-g conditions, a wetting liquid will spread evenly over a surface irrespective of its orientation.

whether the unique space environment may offer a better means of isolating viruses, enzymes, and other small particles for analysis and whether this space technique may someday play an important role in helping to combat diseases here on Earth.

One of the more interesting Apollo experiments continues a study conducted during the Skylab flights. The U.S. astronauts will focus their eyes and cameras on the Earth, studying such features as snow cover in the Himalayan Mountains, the Great Salt Lake, deserts in both hemispheres, developing weather patterns, and conditions in the oceans.

Although the Soviet crew may also conduct scientific experiments during their flight no similarly extensive program of research has been planned for Soyuz. Soviet cosmonauts completed their most recent scientific mission aboard a Salyut space station early this year.

Despite the many scientific experiments added to the first flight test of the new international docking system, the Apollo-Soyuz Test Project will cost the United States only a little more than the Applications Technology Satellite which will be used to relay communications from the Apollo to a ground station in Spain. With the Soviet Union contributing a significant portion of the total costs, and the U.S. using a left-over Apollo, the overall expense of the project to the average American will be just a little more than one dollar.

The new compatible docking system is now a reality. All that remains to accomplish is the final flight test to prove its effectiveness in space. Two nations with great differences have shown during the intervening years that they can work together to their mutual benefit. The new system developed by the United States and the Soviet Union may be used on future space stations and on the shuttles that will carry crews to and from space.

During the designing of the new docking system, U.S. and Soviet representatives have, on occasion, disagreed as they struggled with the difficult technological problems to be solved. In the end, however, they resolved each of these conflicts to the satisfaction of both sides. When American engineers and managers required information about the Soviet spacecraft to assure the safety of the American crew and the success of the joint flight, Soviet officials provided the necessary assistance. Still, to protect certain technological innovations used in each nation's spacecraft, information about manufacturing techniques and the internal workings of advanced space equipment has not been exchanged.

This first international manned spaceflight is a dramatic climax to years of quiet effort on both sides, a significant step that may lead to a truly international era in space—an era in which all nations share the work and the reward of space exploration. Although the Apollo-Soyuz flight offers no guarantee of future cooperation between the great spacefaring nations, it does illustrate the potential for joint work in space—work that nations may do together despite their ideological differences.

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U.S.-SOVIET QUIZ (answers on p. 11)

1. In 1974, the Soviet Union launched how many spacecraft in comparison to the number launched by the U.S.?
   a. an equal number c. twice as many
   b. half as many d. four times as many
2. How many men have walked on the Moon?
   a. 2 c. 10
   b. 6 d. 12
3. A total of how many U.S. and Soviet manned space flights had been conducted by April 1?
   a. 20 c. 54
   b. 36 d. 61
4. What portion of the U.S. federal budget is set aside for space research?
   a. 1% c. 10%
   b. 5% d. 18%
5. After Apollo-Soyuz, when is the next U.S. manned spaceflight scheduled to take place?
   a. 1976 c. 1979
   b. 1977 d. 1981
6. What is the record for the longest duration manned space mission?
   a. 13 days c. 4 weeks
   b. 17 days d. 12 weeks

NASA WINNERS OF INTERNATIONAL SCIENCE AND ENGINEERING FAIR

Seven students were selected for NASA awards at the 26th International Science and Engineering Fair in Oklahoma City, May 12-17. Each was presented a certificate of merit and will receive an expenses-paid trip with a teacher of his choice to the Apollo launch of the Apollo-Soyuz Test Project in July. The seven winners of awards given for creative scientific endeavor in aerospace research were:

Randy C. Elliott, Duncan Junior High School, Duncan, Oklahoma; "The Sun in the Service of Mankind"

Joan Carol Heuchert, St. Thomas Public School, St. Thomas, North Dakota; "The Relationship between Hormones and Plant Growth under Influence of Centripetal Force"

Kenneth Walter Holappa, Roosevelt Senior High School, Virginia, Minnesota; "Application of Aerodynamics to Semi-Trucks"

John C. Holmes, Nicolet High School, Glendale, Wisconsin: "Constellation Structure Shifts Produced by Parallax with an Interstellar Baseline"

Mark Lacas, Wawasee High School, Syracuse, Indiana; "Systems Monitor"

William Rojas, Mainland Senior High School, Daytona Beach, Florida; "Arithmetic Logic Unit"

Sheldon R. Tieszen, Bonneville High School, Ogden, Utah; "Aerodynamic Characteristics of Airfoils"

Ten additional students were cited for honorable mention, including two of the 1974 winners, Richard Foch and Gothard Grey. Each received a mounted photograph of Robert McCall's painting of the Apollo-Soyuz signed by Dr. James C. Fletcher, NASA Administrator, and the Apollo crew of the ASTP. The honorable mention winners were Bradley Gene Burgess, Castleberry High School, Fort Worth, Texas; Derek L. Davis, Central High School, Davenport, Iowa; David M. Eslinger, C. D. Donart High School, Stillwater, Oklahoma; David I. Feinstein, Menlo Atherton High School, Atherton, California; Richard James Foch, Astronaut High School, Titusville, Florida; John Arlin Gorlee, Permian High School, Odessa, Texas; Gothard Carson Grey, Olympus High School, Salt Lake City, Utah; Scott Hoenig, Red Bank High School, Chattanooga, Tennessee; Frank M. Hopkins, Episcopal High School, Baton Rouge, Louisiana; and Siegfried A. Zehentbauer, Jr., A. N. Myer Secondary School, Niagara Falls, Ontario, Canada.

AIR AND SPACE SEMINAR HELD IN NORTH CAROLINA

An informational seminar, designated as "NASA Symposium '75," was held at Shaw University, Raleigh, North Carolina, April 21 to 25. It consisted of workshops, exhibits and lectures designed to disseminate information on the aerospace industry and space program to the state's minority community.

Upper elementary, junior high and high school students from schools within a 75-mile radius of Raleigh were brought into the city by bus to view the exhibits and attend lectures. Dr. Harriett G. Jenkins, Assistant Administrator for Equal Opportunity Programs, directed the program, which was co-sponsored by NASA Langley Research Center. Dr. Jenkins said that the objectives of the symposium were: (1) to provide the minority college student with a wide exposure to and a greater appreciation of the potential that lies within the career fields of science, engineering and technology; (2) to assist minority institutions in recognizing and understanding the opportunities for participation in various institutional assistance programs operated by NASA; (3) to stimulate the interest of the upper elementary, middle school and high school student in these career fields; and (4) to share with the community the various ways in which space-age technology has contributed to the improvement of the quality of life on spaceship Earth.

MORE "READ UP ON MARS"

The launches in August of two Viking spacecraft to investigate the evidence for life on Mars will start a year-long period of intense interest in the red planet. Following, from NASA Headquarters Library, are more publications which, added to those described in the February 1975 **NASA Report to Educators,** will build your background knowledge.

Bracewell, Ronald N. **The Galactic Club: Intelligent Life in Outer Space.** 141 p., illus., W. H. Freeman and Co., distributed by Charles Scribner's Sons, 1974. $3.95 paperback. The author, a professor at Stanford University, covers the current theories about extraterrestrial life. He details the enormous problems of direct radio communication with other worlds, and suggests that more advanced civilizations may, instead, contact Earth by use of interstellar probes which will establish the basis for later radio communication. The book is indexed, and includes bibliographic notes for each chapter.

National Aeronautics and Space Administration. **Mars as Viewed by Mariner 9.** NASA SP 329. Stock =3300-0052. 225 p., illus., U.S. Government Printing Office, 1974. $8.15. Photographs of the surface of the planet Mars which were obtained by the Mariner 9 space probe are presented. Areas of investigation during the Mariner 9 flight involved television coverage, ultraviolet spectroscopy, infrared radiometry, S-band occultation, and celestial mechanics. Descriptions of the photos further identify surface features and the coordinates of each area photographed are included. Photos of cloud formations and dust storms are analyzed.

Ponnamperuma, Cyril, and A. G. W. Cameron, editors. **Interstellar Communication. Scientific Perspectives** 226 p., illus., Houghton Mifflin Co., 1974. $5.95 paperback. A collection of lectures given at the NASA Ames Research Center in 1970 by specialists in fields involved in the study of extraterrestrial life. A general view of the interstellar communication problem is followed by considerations of the most likely locations of other life in the universe, the forms it might take, and the technical aspects of communication to and from other planets. An extensive bibliography, arranged by subject, is appended.

REQUIREMENTS MAY EASE FOR SCIENTISTS TO FLY THE SPACE SHUTTLE

Nonpilot members of Space Shuttle crews flying in the 1980s will probably qualify under much less stringent physical requirements than those demanded for today's astronauts. Thus as many as 1,000 scientists, engineers, and technicians—both men and women—may have the opportunity to carry out investigations aboard the Space Shuttle on missions ranging from 7 to 30 days. The relaxation of standards is possible because of smaller forces of acceleration during launch and re-entry than on previous flights and because scientists will not have the major responsibility for mission safety that the pilots have.

INTERDISCIPLINARY MEETING AT CAPE KENNEDY

On April 10-13, 1975, representatives of the NASA Educational Programs Division met with representatives of the National Science Teachers Association and the National Council for the Social Studies in an interdisciplinary conference at Kennedy Space Center in Florida. The purpose of this educational conference was to determine what relevant aerospace educational material can be developed that could be used by both science teachers and social studies teachers in separate and combined programs and how it can best be presented. The conference offered an opportunity for interaction between the two disciplines concerning the impact of space technology on educational curriculums.

Previous conferences were held with each of the groups separately. The NSTA group met at the Johnson Space Center in Houston, Texas, in May 1974, and the NCSS group met at the Marshall Space Flight Center in Huntsville, Alabama, in June 1974.

The conference was co-chaired by Dr. Stanley P. Wronski, Professor of Education and Social Science at Michigan State University, and Dr. Lee R. Summerlin, Professor of Natural Sciences and Mathematics at the University of Alabama. Classroom teachers, curriculum specialists, and department heads were represented at the conference.

A report with recommendations will be submitted to NASA late this summer.

NASA PLANS URANUS MISSION

NASA is inviting scientists to propose experiments for a 1979 mission to Uranus, third farthest planet from the Sun, using a Mariner-type spacecraft to fly past Jupiter and then continue on to Uranus and the far reaches of the solar system. The flyby would provide man with his first closeup look at the distant planet—a mammoth ball of poisonous gases, spinning on its side (tilted about 90 degrees to the ecliptic plane), one of the most bizarre planets of the solar system.

SPACE PICTURES GUIDED SHIP THROUGH ANTARCTIC ICE FIELD

A NASA satellite, Navy weathermen, and an experimental Coast Guard ship and crew teamed up to aid the National Science Foundation in a recent investigation of a marine route to a remote part of Anarctica previously inaccessible by sea. The problem was one of navigating CG cutter **Burton Island**, with a maximum speed of three knots, through the 80 to 180 miles of 4- to 15-feet-thick sea ice present in the waters to be traversed. Landsat-2, the earth resources satellite launched in January, was used because its instruments detect objects 300 feet in diameter or smaller, a resolution that makes possible the detection of cracks in the icepack wide enough for ship's passage. The route of the **Burton Island** was laid out in advance. In 1973, Landsat-1 was used in NASA's successful attempt to guide Jacques Cousteau's injured oceanographic ship, **Calypso**, through sea ice to safety.

MARS IS NOT THE ONLY TARGET IN THE SEARCH FOR LIFE

A NASA satellite is observing three nearby Sun-like stars for signs that other civilizations may be tryng to contact us wth ultraviolet laser beams. The Orbiting Astronomical Observaory called Copernicus is direcing its telescope at the stars epsilon Eridani, tau Ceti, and epsilon Indi at the direction of Herbert F. Wischnia, a guest investigator. He says, "lasers in the vacuum ultraviolet part of the optical spectrum represent an efficient and logical electromagnetic radiation source which could be used by an extraterrestrial community to announce their presence to us."

LUNAR SAMPLES AVAILABLE TO U.S. COLLEGES AND UNIVERSITIES

Under a new NASA program, samples of materials collected from the Moon during the Apollo missions are now available on a loan basis to colleges and universities in the U.S. offering undergraduate or graduate work in geosciences. There is no cost to the institutions, and the only equipment needed is a standard petrographic microscope. The aim of the program is to broaden the use of the lunar sample collection for scientific and educational purposes and to provide the samples as an educational tool.

The packages of material, which may be used for teaching purposes for up to several months, contain thin sections of three general types of rock found on the Moon—plutonic, volcanic, and breccias—as well as samples of lunar soil, which consists of ground-up rock and various glasses formed by fusion and rapid meteoric heating. Each sample is fully identified. The thin slices of moon rock allow light to be shone through them so that the detailed structure is visible.

Application should be made to the Lunar Sample Curator, Code TL, Johnson Space Center, Houston, Texas 77058. Qualifying schools must enter into a cooperative agreement with NASA which outlines security conditions for the safekeeping of the lunar material.

U.S.-SOVIET QUIZ ANSWERS

1. d: the Soviet Union launched 95 spacecraft in 1974, about four times as many as the U.S. which launched 24.

2. d: six two-man U.S Apollo teams landed on the Moon between July 20, 1969, and December 14, 1972 A third Apollo crewmember remained in lunar orbit aboard the command module for each flight.

3. c: the U.S. has conducted 30 manned spaceflights: 6 with the one-man Mercury, 10 with the two-man Gemini, and 14 with the Apollo (3 visited Skylab): the U.S.S.R has launched 6 one-man Vostok, 2 Voskhod, and 16 Soyuz spacecraft (3 visited Salyut space stations)

4. a: the proposed NASA budget for the coming year is $3.5 billion, a little less than one percent of the total federal budget.

5. c: the first test flight of the new Space Shuttle, a reusable spacecraft that will return from Earth orbit to land like an airplane, will be made in 1979. It will become fully operational in 1980.

6. d: the third crew to visit the Skylab space station spent a total of 84 days in space: Gerald Carr, Edward Gibson, and William Pogue returned to Earth on February 8, 1974, after surpassing the 59-day record of the second Skylab crew

RECENT NASA FILMS

Rediscovery is a new series of 14-minute, color films covering disaster phenomena (created by the elements or by man) and NASA's contribution to providing data to reduce casualties and property loss through observations from space: **Hurricane Below—HQ-233; Tornado Below—HQ-246; Pollution Below—HQ-247; Earthquake Below—HQ-248; Flood Below—HQ-249.**

The Time of Apollo—HQ 229—Color—Sound—28 Mins. Burgess Meredith narrates a poetic view of why the Apollo missions went to the Moon and what the discoveries mean to us.

4 Rooms Earth View—HQ-239—Color—Sound—28 Mins. The three missions of the Skylab space stations gave men their best and most prolonged view of Earth. E. G. Marshall takes viewers through the complete Skylab story.

Apollo-Soyuz—HQ-242—Color—Sound—28 Mins. This is a fast-paced trip from Sputnik to a Soviet-American handshake in space, capturing the flavor and significance of what promises to be an historic demonstration of how well two large world powers can work together for mutual benefit. Yul Brynner's narration sequences the fiery failures and dramatic successes of the U.S. and U.S.S.R. space competition, leading to agreement to work together.

NASA films may be borrowed for group showings from the NASA center serving your area, except for the states below:

National Audiovisual Center (GSA)
Washington, D.C. 20409
Connecticut Maine Massachusetts New Hampshire New York Rhode Island Vermont

WHERE TO WRITE FOR SERVICES

NASA publications should be ordered from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Publication lists, film lists, and information about other services are available from the Educational Office at the NASA center serving your state. See the list below.

NASA Ames Research Center
Moffett Field, California 94035
Alaska Arizona California Hawaii Idaho Montana Nevada Oregon Utah Washington Wyoming

NASA George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812
Alabama Arkansas Iowa Louisiana Mississippi Missouri Tennessee

NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Connecticut Delaware District of Columbia Maine Maryland Massachusetts New Hampshire New Jersey New York Pennsylvania Rhode Island Vermont

NASA John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
Florida Georgia Puerto Rico Virgin Islands

NASA Langley Research Center
Langley Station, Hampton, Virginia 23365
Kentucky N. Carolina S Carolina Virginia West Virginia

NASA Lewis Research Center
21000 Brookpark Road, Cleveland, Ohio 44135
Illinois Indiana Michigan Minnesota Ohio Wisconsin

NASA Lyndon B Johnson Space Center
Houston, Texas 77058
Colorado Kansas Nebraska New Mexico N Dakota Oklahoma S. Dakota Texas

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