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WORKING TOGETHER

INTERNATIONAL COLLABORATION AND DIPLOMACY IN AEROSPACE

↗ The laboratory module in the cargo bay of the Space Shuttle Columbia was photographed during the Spacelab Life Science-1 (SLS-1) mission. SLS-1 was the first Spacelab mission dedicated solely to life sciences. (Photo credit: NASA)

NASA HISTORY OFFICE
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From the Chief Historian

↑ President John F. Kennedy speaks of his hope that the United States and Soviet Union could work together in space on 23 March 1962, during the University of California, Berkeley's 94th Charter Day Ceremony. (Photo credit: Robert Knudsen, White House Photographs; John F. Kennedy Presidential Library and Museum, Boston)

> The Administration, under the foreign policy guidance of the President, may engage in a program of international cooperation in work done pursuant to the Act, and in the peaceful application of the results thereof, pursuant to agreements made by the President with the advice and consent of the Senate.
>
> —Section 205 of the National Aeronautics and Space Act of 1958

The expectation of international collaboration is written into NASA's founding charter. And even at the very darkest moments of the space race with the Soviet Union, President John F. Kennedy held out the olive branch of collaboration in space to America's existential threat and Apollo's seeming reason to exist.

In March 1962, during the Charter Day Address at the University of California, President Kennedy spoke of his hope that the Soviets would accept his offer earlier that week of mutual collaboration in space. For Kennedy, the importance of mutual action went beyond merely the "scientific gains" from the venture. It was the "gains for world peace" that held the most promise. Cooperative efforts in space sciences and exploration would "emphasize the interests that must unite us, rather than those that divide us." Space offered both parties "an area in which the stale and sterile dogmas of the Cold War could be literally left a quarter of a million miles behind," and such a partnership could

> [r]emind us on both sides that knowledge, not hate, is the passkey to the future—that knowledge transcends national antagonisms—that it speaks a universal language—that it is the possession, not of a single class, or of a single nation or a single ideology, but of all mankind.[1]

While President Kennedy's goal of collaboration came to little beyond the exchange of weather satellite data, presidents afterward would continue to see the value of international collaboration in space. The Apollo-Soyuz Test Project—the handshake in space—in July 1975 was the first major achievement. There would be many more.

On 6 December 2023, NASA and the international community celebrated the 25-year anniversary of the first major step in constructing the International Space Station (ISS)—the mating of the U.S.-built Unity node with the Zarya module in low-Earth orbit. Over those 25 years, the ISS has been a true model for international collaboration. Partners across the world have contributed hardware, participated in missions to the facility, and conducted scientific experiments.

But it is not just the more celebrated programs within the field of human spaceflight that mark NASA's collaborations with the world. Scientific discovery has also seen its share of space diplomacy and cooperation. The James Webb Space Telescope provides a more recent example: the European Space Agency contributed the Near-Infrared Spectrograph, Mid-Infrared Instrument Optics Assembly, and Ariane 5 launch vehicle, while the Canadian Space Agency provided the Fine Guidance Sensor (FGS) and the Near-Infrared Imager and Slitless Spectrograph (NIRISS). Additionally, the international community of scientists will use their observing time to unlock the secrets of the universe. Smaller projects like NASA's Imaging X-ray Polarimetry Explorer (IXPE), a collaboration with the Italian Space Agency, also benefit from international partnerships. The absence of these partnerships would diminish the Agency's ability to make astonishing scientific breakthroughs.

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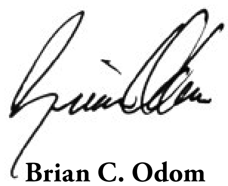
Widely available scientific data is at the heart of NASA's international collaboration. One notable example is NASA's Applied Sciences Program, which, through projects and initiatives such as SERVIR and DEVELOP, utilizes the vantage point of space to bring critical data to bear on global and village-level issues such as climate change, capacity building, and responses to natural disasters. This level of international collaboration works to empower global communities, ensure food security, and strengthen local ecosystems.

As historian John Krige has written, "there is an inherent contradiction in NASA's twin missions to maintain leadership *and* to foster international collaboration." As he points out, "By helping others acquire space capabilities NASA at once enhances the capacity, visibility and reach of the US space program, and contributes to the efforts of those who may eventually compete with it."[2] This was the dichotomy President Kennedy faced in his conversations with Soviet Premier Nikita Khrushchev—a choice of either gaining international prestige for the United States or maximizing the benefits of scientific discovery for all. Over the decades since the close of the Apollo program, NASA has made great strides in favor of the latter. Successes resulting from collaborative missions, the free sharing of data, and innovations in space law frameworks have expanded our sense of shared destiny in exploration and science.

Today, the Artemis Accords offer a new framework for international collaboration. This framework builds upon the Outer Space Treaty of 1967 and underscores the willingness of the signatories to recognize "their mutual interest in the exploration and use of outer space for peaceful purposes" and an understanding that peaceful collaboration in space is for the "benefit of all humankind."[3] As we continue to probe the secrets of the universe and return to the Moon, we do so with a much better model than Apollo. This time, we go back upon a foundation of new international collaboration and partnership.

The articles in this issue of *News & Notes* explore many important milestones in international collaboration and space diplomacy. From more well-known ventures like Spacelab and the Satellite Instructional Television Experiment (SITE) to lesser-known demonstration projects in the village of Tangaye in Burkina Faso, these essays highlight the rich history of cooperation at the core of NASA's portfolio. Understanding how deeply international collaboration is embedded in the Agency's DNA helps us consider how the international cooperation paradigm is a much more useful model for the future of space exploration than the anomalous model that was the Apollo paradigm. ■



Brian C. Odom
Chief Historian

Endnotes

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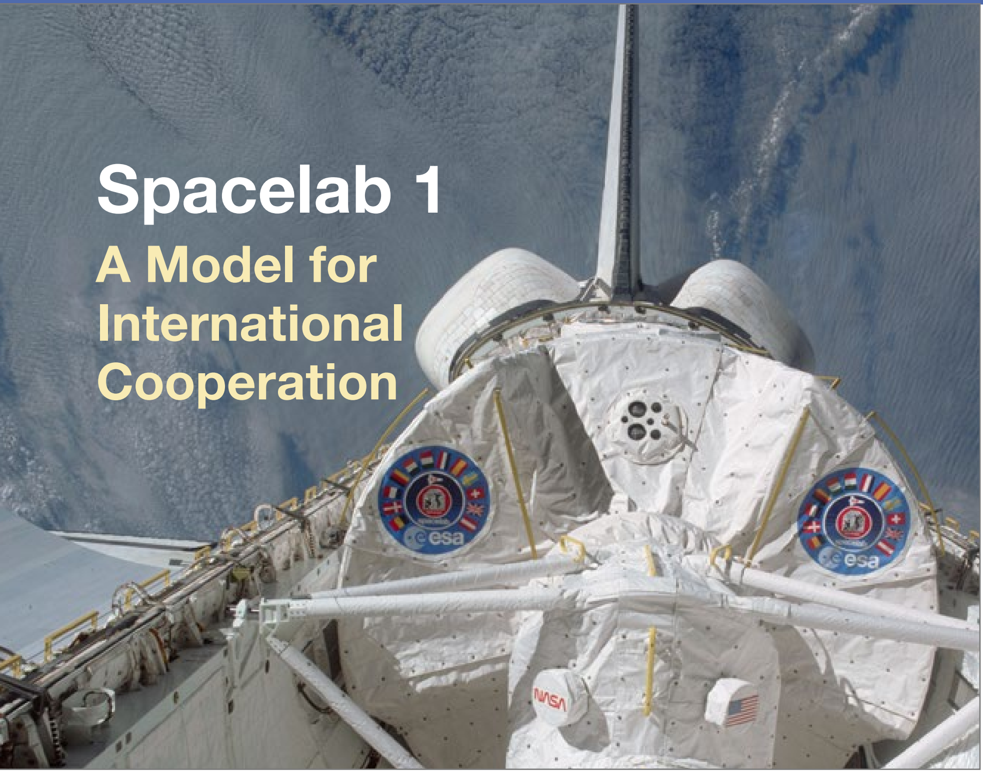

Spacelab 1

A Model for International Cooperation

← View of the Spacelab module in the payload bay of Space Shuttle Columbia during STS-9. (Photo credit: NASA)

» By **Jennifer Ross-Nazzal**, NASA Historian

FORTY YEARS AGO, in 1983, Space Shuttle Columbia flew its first international spaceflight, STS-9. The mission included—for the first time—the European Space Agency's (ESA's) Spacelab pressurized module and featured more than 70 experiments from American, Canadian, European, and Japanese scientists. Europeans were particularly proud of this "remarkable step" because "NASA, the most famous space agency on the globe," included the laboratory on an early Shuttle mission. NASA was equally thrilled with the Spacelab and called the effort "history's largest and most comprehensive multinational space project." The Spacelab became a unifying force for all the participating nations, scientists, and astronauts. As explained by one of the mission's payload specialists, Ulf Merbold, while the principal investigators for the on-board experiments might be British or French, "there is no French science, and no British science [on this flight]. Science in itself is international." Scientists flying on the mission, and those who had experiments on board, were working cooperatively for the benefit of humanity. As then–Vice President George H. W. Bush explained, "The knowledge Spacelab will bring back from its many missions will belong to all mankind."[1]

Training for the flight required international cooperation on an entirely new scale for the American space program. Today it is not unusual to hear about an astronaut training for spaceflight at many different locations and facilities across the globe. NASA's astronauts have grown accustomed to training outside the United States for months at a time before flying on board the International Space Station, but that was not the experience for most of NASA's flight crews in the Agency's early spaceflight programs. Mission training mainly took place in Houston at the Manned Spacecraft Center (now Johnson Space Center) and in Florida at Kennedy Space Center. The Apollo era featured only one international flight, the Apollo-Soyuz Test Project (ASTP), with astronauts training in the two participating nations: the USSR and the United States.

It also rarely makes news these days when someone who is not a professional astronaut or cosmonaut flies in space. In the past, flying in space was a professional occupation. This all changed with the development of the Space Shuttle and Spacelab, which birthed a new space traveler: the payload specialist. The individuals selected for these positions were not career astronauts. The payload specialists were experts on a specific payload or an experiment, and during the early years of the Space Shuttle Program, came from a wide variety of backgrounds: the Air Force, Congress, industry, and even the field of education. The principal investigators for this science-based mission selected the payload specialists who flew in space and operated their experiments. Spacelab 1 was unique in providing the first opportunity for a non-American, a European, to fly on board a NASA spacecraft.

In the summer of 1978, NASA chose scientist-astronauts Owen K. Garriott

> **The knowledge Spacelab will bring back from its many missions will belong to all mankind.**
>
> —George H. W. Bush

and Robert A. R. Parker as mission specialists for the Spacelab 1 crew. Garriott, who had been selected as an astronaut in 1965, had flown on America's first space station as a member of the Skylab 3 crew, a team that exceeded all expectations of flight planners and principal investigators. Parker had also applied to be a scientist-astronaut and was selected in 1967. His class jokingly called themselves the "XS-11" (pronounced "excess-eleven"), because they had been told there was no room for them in the corps and they would not fly in space—not immediately, anyway. Parker worked on Skylab as the program scientist, but once the program ended, he accepted a new title: chief of the Astronaut Office Science and Applications Directorate, where he spent the next few years working on Spacelab matters. It was perfect timing for the astronaut to turn his attention to this international program. Once Skylab ended in 1974, representatives of the European Space Research Organisation (ESRO) and members of ERNO, the Spacelab contractor, started traveling to Houston and Huntsville to give the two NASA Centers updates on the development of the Spacelab and to hold discussions on the module. In a 1974 press conference, ESRO's Heinz Stoewer emphasized the "very intense cooperation" he witnessed "with our friends here in the United States in making this program come true."[2]

Around the same time, as Spacelab was being built, the European Space Agency began considering who might fly on that first flight. Three days before Christmas in 1977, ESA released the names of their four payload specialist candidates: Wubbo Ockels, Ulf Merbold, Franco Malerba, and Claude Nicollier. Two Americans, Byron K. Lichtenberg and Michael L. Lampton, were selected in the summer of 1978 as potential payload specialists.[3]

The Spacelab 1 payload crew, which operated the module and the mission's experiments in the payload bay of the orbiter, included two mission specialists, Garriott and Parker, and two payload specialists, one from the United States and another from ESA. The payload crew and their backups began training many years before the Space Shuttle Columbia launched into space on STS-9. (The original launch date of December 1980 kept slipping, so the crew ended up training for five years.)[4] Training in Europe began in earnest in 1978, while training in the United States and Canada began in 1979.[5] Merbold was eventually selected to fly on the mission, along with Lichtenberg. The entire payload crew spent so much of their time traveling to Europe that John W. Young, who was then chief of the Astronaut Office, called their flight assignment and European training, which involved travel to exotic locations like Rome, Italy, "a magnificent boondoggle. In my next life," he declared, "I'll be an MS [mission specialist] on S Lab [Spacelab]."[6]

↓ Spacelab 1 prime and backup science crewmembers (left to right): Mission Specialists Robert Parker and Owen Garriott, with Payload Specialist-1 Ulf Merbold, backup Payload Specialist-2 Michael Lampton, backup Payload Specialist-1 Wubbo Ockels, and Payload Specialist-2 Byron Lichtenberg. (Photo credit: NASA)

Pictured from the left are astronaut Owen K. Garriott, Vice President George Bush, and Ulf Merbold of West Germany inside Spacelab in the Operations and Checkout Building at Kennedy Space Center. This European-built orbital laboratory was formally dedicated on 5 February 1982. (Photo credit: NASA)

Lichtenberg recalled that the science crew—the prime and backup payload specialists and mission specialists—traveled the globe "like itinerant graduate students…to study at the laboratories of the principal investigators and their colleagues." In these laboratories, universities, and at research centers across Europe, Canada, and Japan, they learned about the equipment and experiments, including how to repair the hardware if something broke or failed in flight. Lichtenberg felt like he was earning multiple advanced degrees in the fields of astronomy and solar physics, space plasma physics, atmospheric physics, Earth observations, life sciences, and materials science. The benefits of training were numerous, but perhaps the most important were the personal and professional relationships that were built with the investigators from across the world and with his crewmates.[7]

For the payload specialists, building relationships within the astronaut corps proved to be more complicated. Merbold recalled traveling to the Marshall Space Flight Center in Alabama and receiving a warm welcome. "But in Houston you could feel that not everyone was happy that Europe was involved. Some also resented the new concept of the payload specialist 'astronaut scientist,' who was not under their control like the pilots. We were perceived to be intruders in an area that was reserved for 'real' astronauts." As an example, the European astronauts could not use the astronaut gym or take part in T-38 flight training. Over time, attitudes changed, and Garriott credited STS-9 Mission Commander John Young with the shift, and so did Merbold. As the crew was preparing to fly, the former moonwalker took Merbold on a T-38 ride, and when the payload specialist asked if he could fly the plane, Young willingly offered him the opportunity. After that flight, Merbold recalled that he "enjoyed John Young's unqualified support."[8]

Friendships blossomed on the six-man crew. Parker called Pilot Brewster H. Shaw and Commander Young "two of [his] best friends to this day."[9] For Merbold, the flight cemented a significant bond among the STS-9 astronauts. He had "no brothers, no sisters"; he was an only child, but the Columbia crew

Astronaut John W. Young (left), STS-9 crew commander, and Ulf Merbold, payload specialist, enjoy a meal in the middeck of the Earth-orbiting Space Shuttle Columbia. Merbold, a physicist from the Federal Republic of Germany, represented ESA on this 10-day flight. (Photo credit: NASA)

Spacelab 1 (continued)

became his family. "My brothers are those guys with whom I trained and flew," he said.[10] Young and Merbold had an especially close bond. Garriott saw that relationship up close on the Shuttle and later told an oral historian, "Young had no better friend on board our flight than Ulf Merbold." The two remained close until Young's death.[11]

Following landing, Flight Crew Operations Directorate Chief George W. S. Abbey told the crew that the science community was "very pleased."[12] The first international spaceflight since ASTP brought scientists, astronauts, and space agencies from across the globe together, laying the foundation for bringing Europe into human spaceflight operations and kicking off a different approach to training and performing science in space. As Spacelab 1 Mission Manager Henry G. Craft and Richard A. Marmann explained, the program "exemplified what can be accomplished when scientists and engineers from all over the world join forces, communicating and cooperating to further advance scientific intelligence."[13] Eventually, the international cooperation Craft and Marmann witnessed led to today's highly successful International Space Station Program. ■

↑ Four of the STS-9 crewmembers enjoy a rare moment of collective fun inside the Spacelab module aboard Columbia. From left to right are Byron K. Lichtenberg, Ulf Merbold, Robert A. R. Parker, and Owen K. Garriott. The "card table" here is the scientific airlock hatch, and the "cards" are the targets used in the Awareness of Position experiment. (Photo credit: NASA)

Endnotes

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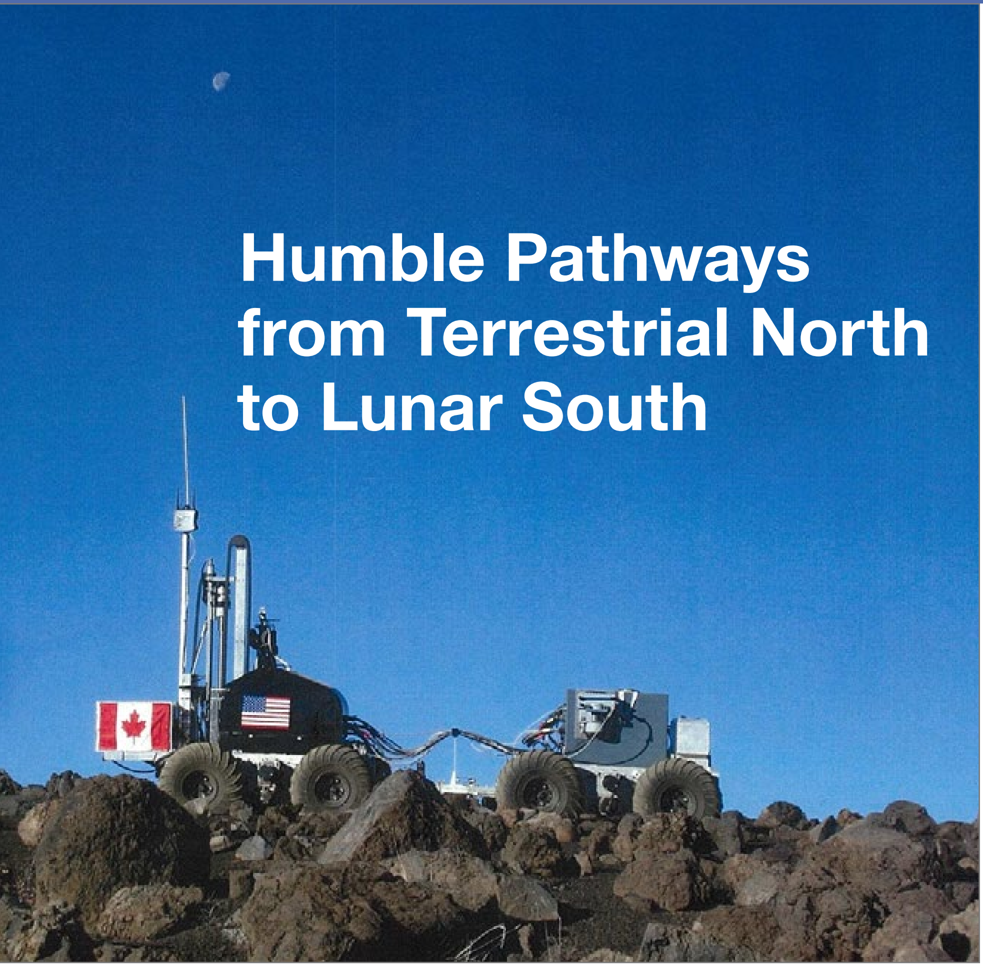
Humble Pathways from Terrestrial North to Lunar South



Canada's Juno tandem rover and drill during a 2010 deployment with NASA to an analog site in Hawai'i. (Photo credit: NASA)

» By **James Anderson**, NASA Historian

FROM MANITOBA TO THE MOON, Canada and the United States have worked together on space-related research since before either country had established a civilian space program. This collaboration is long-standing and multifaceted, offering examples of projects that have varied in size, complexity, duration, and visibility. Every project, naturally, has been subject to the particular domestic and international political contexts of their time. Two examples are considered here: a collaboration between Canada and the United States during the International Geophysical Year (1957–58) and a more recent collaboration involving the development of robotic rovers. Both efforts were rather low-profile, never commanding many of the space-related headlines during their development. In addition to reflecting the typical dynamics that influence space projects of any size, these humbler collaborations reveal the extent to which international partnerships remain an integral part of scientific exploration.

Some of the higher-profile examples of the Canada-U.S. partnership worth mentioning include Canada's first satellite, the decades of use and continuing development of the robotic Canadarms, and the flights of Canadian astronauts. Lower-profile collaborations, meanwhile, offer their own unique insights. They highlight the fact that space-related science, like exploration, does not begin simply at launch or when data are returned. As processes that involve the coordination of teams and institutions, science and exploration—in spite of whatever grand images they may conjure—require rather ordinary tasks, planning, and persistence to succeed. Indeed, the ability to "pick up the pieces" from underfunded or stalled work and reconstitute core groups of teams, mature designs, and build meaningfully upon previous work is so common that it often receives little attention, yet the vast majority of spaceflight mission proposals from recent history proceeded in this manner.

In the mid-1950s, selecting a location for Canada's participation in the International Geophysical Year (IGY) did not proceed from a blank slate, nor did it require extraordinary efforts. In

The Shuttle Remote Manipulator System, or Canadarm, was installed on all five orbiters and was a crucial component of the Shuttle Program. The second-generation Canadarm2 helped build the International Space Station, and a third generation is under development for the Gateway. In this photo from STS-100, Canadarm2 is included in the payload bay prior to its installation on the Destiny Laboratory of the International Space Station. (Photo credit: NASA)

The Churchill Rocket Research Range operated from 1956 to 1985 and is now a National Historic Site of Canada. It is located just east of the town of Churchill, Manitoba, on the shores of Hudson Bay. The range was the only facility in Canada for launching sounding rockets, and the first Black Brant was launched there in 1959. (Photo credit: Parks Canada Agency/ Agence Parcs Canada)

1954, the Canadian Army had already begun launching rockets from Fort Churchill in Manitoba, a remote outpost along the Hudson Bay in northern Manitoba. With preparation for the IGY beginning shortly after that, a group of Canadian and American scientists chose Fort Churchill as a convenient location to conduct their IGY-related launches.[1] In 1956, with the approval of Canada's Defence Research Board, the U.S. Army built the Churchill Rocket Research Range, which remained operational until 1985.[2] This early space-related research, strictly speaking, was really upper atmosphere research that relied on sounding rockets to collect data about the ionosphere. That research built upon many decades of international coordination related to the earlier International Polar Years, and Canada's geography made it a natural location for the research.

After the IGY launches, it was not clear that there would be sustained, scientific rocket launches from the Churchill range. The U.S. Air Force soon took over funding and management from the U.S. Army, reflecting the Air Force's growing interest in further developing radio communications and guidance techniques for missiles over the polar regions. Some of the factors that were pulling U.S. support away from Churchill included Alaska's (still a relatively recent state) lobbying for more U.S. military arctic research to be based there, as well as a shifting of attention and resources toward Vietnam. Concurrently, increased domestic support in Canada for continuing scientific research through the country's National Research Council in the mid-1960s kept the site active, and a joint coordinating group between the United States and Canada oversaw the operations. Canada also developed a civilian sounding rocket program to complement its own satellite development.[3] Free of the pressure to compete directly at a scale comparable to the competition between the United States and the Soviet Union, one of the many enduring smaller-scale successes that emerged was the ongoing development of the Black Brant family of Canadian sounding rockets, which have become one of the most widely used types of sounding rockets. From the aftermath of the IGY and the Space Race, the Black Brant remains a humble cornerstone that sustains suborbital scientific exploration to this day.

More recently, the Moon has become much more of an international destination for robotic exploration, including attempted commercial missions, and planned human missions. As part of this overall effort, both Canada and the United States are developing robotic lunar rovers. At least two of those rovers—NASA's Volatiles Investigating Polar Exploration Rover (VIPER) and a Canadian rover that Canadensys Aerospace Corporation and its partners are developing—are slated for delivery to the Moon via NASA's Commercial Lunar Payload Services initiative. Both rovers are distinct projects today, but their deeper development histories are intertwined.

A Black Brant IX sounding rocket launches from the Poker Flat Research Range in Alaska. The Canadian-designed family of sounding rockets remains one of the most widely used in suborbital research. (Photo credit: NASA)

Canadian astronaut Jeremy Hansen test-drives one of Canada's rovers in 2013. Hansen is one of the four crewmembers for the Artemis II mission, which will send humans around the Moon for the first time since Apollo. Working remotely with rovers in analog test sites is a key part of science and mission planning. (Photo credit: Canadian Space Agency)

When a team at NASA's Kennedy Space Center began designing and testing an instrument package for prospecting lunar resources, it was the Canadian Space Agency (CSA) that brought the rover. Beginning in 2008, NASA's Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction (RESOLVE) mission team and the CSA collaborated on multiple field deployments over about four years. The CSA has developed more than 10 different rover prototypes for lunar, Martian, and terrestrial environments, with the consortium Space Resources Canada leading the rover equipment development on behalf of the CSA. In addition to hardware development in support of international collaboration in space, the technology development efforts have included software for autonomous operation and the opportunity to rehearse the coordination of scientific teams across the globe, since their field deployment simulations mimic the conditions that scientists and rover operators will experience with nearly real-time communication to rovers on the Moon. The instruments included in the RESOLVE package evolved and were later incorporated into the Resource Prospector mission, for which NASA developed a rover in house. After Resource Prospector's cancellation, Ames Research Center led the effort to bring many of the team members and the instruments back together as the VIPER mission. The VIPER rover is currently being assembled at Johnson Space Center.

Following the 2010 Juno deployment, the subsequent iteration of the lunar rover, called Artemis Jr., is seen at Kennedy Space Center with NASA's RESOLVE instrument suite integrated, prior to another deployment to Hawai'i in 2012. (Photo credit: NASA)

Science and exploration have been international and collaborative pursuits since long before the Space Age. From developing sounding rockets to testing resource mapping tools and techniques in analog environments, these lower-profile pursuits not only reflect that reality, but they quite literally lay much of the groundwork for the higher-profile missions of Artemis, as robots are already being sent to the lunar South Pole and beginning to explore in regions where the next astronauts to walk on the Moon will venture.

Endnotes

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2. The Army soon transferred its control to the U.S. Air Force, and in 1964, the National Research Council of Canada assumed control of the facility. According to Parks Canada, this was the only facility in the country for launching sounding rockets. See "Churchill Rocket Research Range National Historic Site of Canada," Parks Canada Directory of Federal Heritage Designations, https://www.pc.gc.ca/apps/dfhd/page_nhs_eng.aspx?id=115 (accessed 27 November 2023).
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ORAL HISTORY

Fear of War, Hope for Peace

Creating the United Nations Committee on the Peaceful Uses of Outer Space

» By **Sandra Johnson**, NASA Oral History Lead

Legislative Reference Service analyst Eilene M. Galloway. (Photo credit: Library of Congress, Prints and Photographs Division, photograph by Harris & Ewing)

EILENE M. GALLOWAY began her career with the Library of Congress Legislative Reference Service (later known as the Congressional Research Service) in 1941. As an editor for public affairs abstracts, which she described as a "Reader's Digest of all the issues that were before the Congress," she was in a position to assign herself the articles on international relations and national defense. Galloway continued, "…[T]hat was the area that I was mostly interested in. I gradually accumulated experience in the different types of legislation." Later promoted to the role of national defense analyst, she worked on the budget, manpower, and organization for the Department of Defense and the Atomic Energy Commission.

In April 1957, Galloway wrote a report for the Senate Committee on Armed Services titled "Guided Missiles in Foreign Countries"[1] that served as a survey of the missile and rocket programs in other countries, their status, and how far they had progressed in advanced weaponry. In the fall of that same year, the world looked toward the sky with trepidation. On 4 October 1957, the Soviet Union successfully launched Sputnik, intensifying Cold War tensions and setting into motion a rush to understand the implications of the orbiting satellite and organize an appropriate response. Galloway's recent publication on guided missiles and experience in government organization made her the perfect choice for the task at hand. In her NASA oral history interviews, she described what happened next and how her efforts helped lead to international cooperation and the creation of the permanent United Nations Committee on the Peaceful Uses of Outer Space.[2]

"It was an extreme shock, on Capitol Hill, especially. It was almost as if a bomb had fallen there because we were so surprised that the Soviet Union was first…. So, it came to us as a problem in national defense, especially when a second Sputnik… was orbited on November 3, 1957. It showed that they had the capability of launching intercontinental ballistic missiles. There was fear throughout the world for that reason because the satellite was going around and every ninety minutes it circled the Earth. Everyone was really frightened. So because it appeared as a problem in national defense, the first people who looked after it in the Senate were members of the Senate Armed Services Committee.

Senator Richard Russell [Chairman of the Senate Armed Services Committee], for whom I had been working on other subjects as a military analyst, telephoned me and asked me to write a report on the impact on the United States of the Soviet Union being first to orbit the Sputnik. Then he told Lyndon Johnson that I could help him with hearings, and at that time Lyndon Johnson was chairman of the

Fear of War, Hope for Peace (continued)

President Dwight D. Eisenhower (center left) stands with Senate Majority Leader Lyndon B. Johnson (center) and other guests, during a bipartisan luncheon at the White House on 31 March 1955. (Photo credit: *U.S. News & World Report*/Thomas J. O'Halloran)

Senate Preparedness Investigating Subcommittee. So we set about immediately setting up the questions and getting the witnesses for those hearings for Senator Johnson.

That was really our problem, how were we going to organize the government so that the United States would become preeminent in outer space. That meant that we had to organize the executive branch and we had to organize the Congress, because this was a subject that cut across a great many different committee jurisdictions.

Senator Johnson asked me to figure out how to organize the Congress, so I was working on all aspects of organization...against the background of national defense. First, we had to select witnesses, and then we had to select the questions that we were going to ask the witnesses before we could set up the hearings. Everything had to be done in a hurry. If you were working for Lyndon Johnson, everything had to be done in a hurry. He never asked the head of my organization, Legislative Reference Service... whether I was available to do this. He simply...took me over to his committee to work on this subject, and we were working on it from morning to night.

We had all the scientists and engineers and all the people from industry and people from the government and people from academic life to testify as to how well we were prepared to deal with a missile satellite situation. This was an investigating committee.

A curious thing came about. Instead of it being a problem that was solely national defense where we were really afraid for our security, it became a problem of maintaining peace. It became a problem where the scientists and the engineers...told us of all the benefits that we could derive from using outer space. They told us about communications, increasing the benefits of meteorology, navigation, remote sensing, all the information to solve problems on the Earth.

So it was not only then fear of war, but hope for peace. At that time... the scientific community that had been working on the International Geophysical Year (studying the whole Earth including outer space), the nation states, and the United Nations were three forces that combined to make it possible for us to emphasize peace rather than war. We would be prepared for national defense, but we were also going to use outer space for peaceful purposes.

...The next step was to have legislative committees. There was no committee in the Congress that was prepared to undertake this, so they set up two special committees, the House Select Committee on Astronautics and Space Exploration and the Senate Special Committee on Space and Astronautics, to create NASA. These were legislative

A curious thing came about. Instead of it being a problem that was solely national defense where we were really afraid for our security, it became a problem of maintaining peace. It became a problem where the scientists and the engineers...told us of all the benefits that we could derive from using outer space.

Fear of War, Hope for Peace (continued)

committees that began in the spring of 1958.

Congressman [John W.] McCormack, who was Majority Leader of the House, became chairman of that committee. Lyndon Johnson, of course, was chairman of the Senate committee. The hearings began in the House, and Congressman McCormack asked me to write a paper on the issues before Congress in connection with outer space.

So I wrote that report, and he opened his hearings with the [President Dwight D.] Eisenhower proposal and my report on the issues before Congress because we had to decide on creating NASA.[3] Everybody had agreed that we should have a civilian agency.... We had to set up a civilian agency and then decide what the relationship would be between the civilian and the military.... I set up four options: we could either give space to the Joint Committee on Atomic Energy, we could set up a new Joint Committee on Outer Space, we could assign legislation to the...standing committees, or we could have separate committees in the House and Senate.

...So, by the end of July we had finished all the hearings and we created NASA by the end of July of 1958.... Then in November...President Eisenhower called Lyndon Johnson and asked him to go to the United Nations and forward our foreign policy to set up an ad hoc Committee on the Peaceful Uses of Outer Space, because one of the main points of U.S. foreign policy was to maintain peace and try not to have any war in outer space.... The whole world wanted peace in outer space. They

Eilene Galloway seated in her Washington, DC, home on 7 August 2000 and surrounded by a selection of her publications and written contributions to international space law. (Photo credit: Sandra Johnson)

Eilene Galloway (1906–2009)

Born in 1906, less than three years after the Wright brothers' first flight, Eilene Galloway lived to 103, continuing to work in her field of expertise long after she retired from the Congressional Research Service. Throughout her life, she remained passionate about preventing the weaponization of outer space and represented the United States in many of the annual meetings for the committee that she helped create: the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).[4] She continued to help draft treaties overseeing the uses of outer space as the U.S. delegate for the International Astronautical Federation to UNCOPUOS, including the Outer Space Treaty (1967),[5] which she referred to as "the Magna Carta treaty, and...the very basis of space law," a field in which she was globally recognized as a leading expert.

Galloway was instrumental in creating the International Institute of Space Law and presented the first of her numerous papers for the institute titled "The Community of Law and Science" at the request of Senator Lyndon B. Johnson at the First Colloquium on the Law of Outer Space at The Hague in 1958.[6] According to Galloway: "There were a number of Senators who wanted to go, but Lyndon Johnson [who was then majority leader] said that he needed their votes in the Senate. I didn't vote in the Senate, so he said, 'Eilene is expendable; we will send her.'" The institute continues to honor her contributions to space law annually with the Eilene M. Galloway Symposium on Critical Issues of Space Law.

ONLINE RESOURCES

Bibliography of Galloway's personal collection and non-congressional published papers, as well as a list of her numerous awards, honors, and memberships, held at the Center for Air and Space Law at the University of Mississippi

Her collection donated to the National Air and Space Museum

Oral Histories: Learn about Galloway's work on the creation of NASA 65 years ago (and why the acronym stands for "National Aeronautics and Space *Administration*"—not "Agency"), the National Aeronautics and Space Act of 1958, and the NASA Space Council. 1 2 didn't want a war in the air or directed to the Earth.

Lyndon Johnson...took me and [Senate staffer] Glen Wilson and some other people to the ranch to work on the speech that he was going to give in the United Nations.[7] That was a real experience. There was a telephone strung every few feet all through the house and all around the swimming pool and all through the ranch, apparently.

Then a group of us met in Austin, and we went over the first draft. Two or three people read the draft, and I was appalled by this draft so I didn't say anything, I just stared at Senator Johnson. He said, "Eilene, you get out from under the table and tell me what you think of this." I said, "Well, I think it won't do because if you're giving a speech at the United Nations it has to be of very high quality, very high on foreign affairs, and we have to have a message, we have to say something in it." When I said that, I thought I'd probably made an enemy of everybody else here, but he said, "All right, we'll go back and do it over."

So back to the ranch we went, and we did it over. Then President Eisenhower sent the plane to Texas and flew Lady Bird and Lyndon Johnson, the staff, and some other people, to LaGuardia. We were met by Henry Cabot Lodge, who was our Ambassador to the United Nations. Lyndon Johnson gave this speech that said that outer space is free and it must remain that way and we must maintain peace. At that time, he was talking about the United Nations voting for an ad hoc Committee on the Peaceful Uses of Outer Space.[8]

I thought I'd probably made an enemy of everybody else here, but he said, "All right, we'll go back and do it over."

The Soviet Union and Czechoslovakia and Poland would not [vote] with us. We got nineteen other countries [to agree], and the resolution passed by twenty votes. Those three countries would not accept membership because we were going to have majority voting.[9] Well, naturally, the Soviet Union didn't want to be outvoted by Mongolia, Uruguay, the Philippines for example.

We worked on that for a year and finally came up with [the idea of] consensus voting. With consensus… you can abstain or not vote. So as soon as we decided to do everything by consensus, the Soviet Union joined, and we set up a permanent Committee on the Peaceful Uses of Outer Space. ■

Endnotes

1 Eilene Marie Slack Galloway, Guided Missiles in Foreign Countries, prepared for the Committee on Armed Services, United States Senate, 85th Cong., 1st sess., (Washington, DC: U.S. Government Printing Office [GPO], 1957).

2 "Committee on the Peaceful Uses of Outer Space," https://www.unoosa.org/oosa/en/ourwork/copuos/index.html (accessed 27 November 2023).

3 Eilene Galloway, "The Problems of Congress in Formulating Outer-space Legislation" (Washington, DC: GPO, March 1958).

4 "Committee on the Peaceful Uses of Outer Space."

5 "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," United Nations Office for Outer Space Affairs, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html (accessed 13 December 2023).

6 "The Community of Law and Science," 1st Colloquium on the Law of Outer Space, the Hague, the Netherlands, 1958, pp. 59–62.

7 As his political career flourished, Johnson spent much of his time in Washington, DC, but returned to Texas as often as he could. In 1951, he bought a 1,500-acre ranch, 15 miles west of Johnson City, near Stonewall, TX, from his widowed aunt. The ranch and its comfortable house were his home until his death 22 years later. https://www.nps.gov/nr/travel/presidents/lyndon_b_johnson_nhp.html (accessed 13 December 2023).

8 Lyndon B. Johnson, "Special Message to the Senate on Transmitting the Treaty on Outer Space," https://www.presidency.ucsb.edu/documents/special-message-the-senate-transmitting-the-treaty-outer-space (accessed 27 November 2023).

9 All United Nations (UN) Member States are represented in the General Assembly. Each Member State has one vote. Decisions on such key issues as international peace and security, the admission of new members and the UN budget are decided by a two-thirds majority. Other matters are decided by simple majority. Many decisions are reached by consensus without a formal vote. See "General Assembly," https://www.un.org/en/model-united-nations/general-assembly (accessed 27 November 2023).

A solar panel is installed in the village of Tangaye in present-day Burkina Faso. (Photo credit: NASA)

NASA's Demonstration of Photovoltaic Systems in Developing Nations

» By **Robert Arrighi**, NASA Historian

AS THE APOLLO PROGRAM ended in the early 1970s, a national energy crisis and a growing environmental movement emerged. In response, NASA began emphasizing the application of a wide range of aerospace technologies to improving life on Earth. These benefits ranged from pollution reduction to the design of medical devices and alternative sources of energy. A major component of the renewable-energy effort was reducing its cost and demonstrating its practicality.

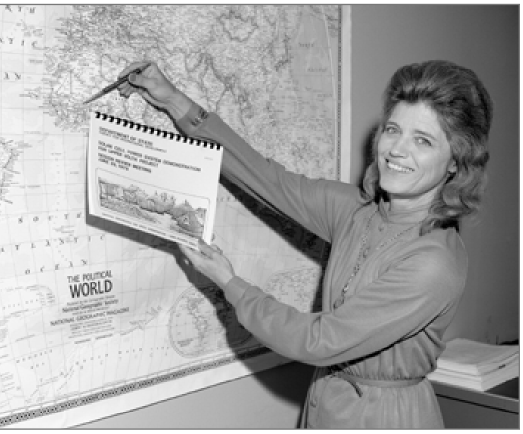
The Sun's ability to generate heat was recognized in ancient times, but it was not until 1839 that the photovoltaic effect—the process of generating an electric current or voltage by exposing a material to direct sunlight—was discovered. The first solar cell, created in 1883, only converted one percent of the solar energy to electricity. Although efficiency increased incrementally over the years, solar cells remained too inefficient to compete with fossil-fuel–based electricity. In 1954, Bell Laboratories produced a major advance with the development of a solar cell capable of operating small electrical equipment. Still, the cost remained prohibitive for general applications.

The Navy's launch of the Vanguard 1 rocket in March 1958 provided the first significant demonstration of the potential of photovoltaic systems. Vanguard's solar-powered communications system operated in orbit for seven years, while the traditional batteries on board lasted only weeks. Solar arrays soon became an essential component of nearly all satellite designs where their price was marginal compared to the overall mission cost.

In 1961, Joseph Mandelkorn and several colleagues who designed the Vanguard system joined NASA's Lewis Research Center (today Glenn Research Center) to form a Photovoltaic Branch. Their efforts in the 1960s steadily improved solar-cell efficiency for space applications, but the technology remained too expensive for everyday applications on Earth.

A major breakthrough took place in the early 1970s with the determination that imperfect silicon wafers discarded by semiconductor manufacturers could be repurposed to construct solar cells.

Lewis staff oversees the shipment of photovoltaic equipment to the African village of Tangaye in September 1978. Robert Didelot (far left), William Bifano (second from left), and Patricia O'Donnell (second from right), are pictured with two unidentified men. (Photo credit: NASA)



Patricia O'Donnell points out the solar cell demonstration site in Tangaye in what was then (1978) the Upper Volta. (Photo credit: NASA)

The use of solar energy for remote communications, instrumentation, and navigation began to spread across the globe.

With the establishment of the Department of Energy (DOE) in early 1975 came the creation of a National Photovoltaic Energy Conversion Program. The program sought to increase the performance of affordable solar-power systems and spur a viable photovoltaic industry. The extensive effort included contributions from NASA, which saw it as an opportunity to not only benefit people on Earth, but also improve the Agency's technological capabilities for future aerospace endeavors.

The extensive effort included contributions from NASA, which saw it as an opportunity to not only benefit people on Earth, but also improve the Agency's technological capabilities for future aerospace endeavors.

Marshall Space Flight Center worked on solar heating and cooling systems for residential and commercial buildings, while the Jet Propulsion Laboratory sponsored a program to analyze the performance of commercially available solar cells. Lewis managed the Photovoltaic Tests and Applications Project. This project sought to identify near-term solar-energy applications and users, design and manage demonstration projects, and develop standards and procedures.

In 1977, the Center's 10-person Terrestrial Photovoltaic Projects Branch managed the installation of automatic solar-powered weather stations and remote sensing equipment in various inaccessible locations across the country. These systems could operate for years without maintenance. In 1978, the Center supplied the Papago Reservation in Arizona with a photovoltaic system to operate a communal water pump and appliances and provide interior light for the 16-home village. It was the first validation of a large stand-alone solar-powered system.

Because of the nation's extensive existing power infrastructure, engineers had difficulty finding domestic locations where these stand-alone power systems would be beneficial. It became apparent that this technology would be most useful to developing nations.

NASA and DOE partnered with the U.S. Agency for International Development (USAID) to identify potential sites

A solar panel is installed in the village of Tangaye in present-day Burkina Faso. (Photo credit: NASA)

to install solar-power systems in Africa and South America. Lewis managed the technical aspects, while USAID studied the social and economic effects. Private companies were contracted to install the hardware. The projects were not designed to electrify the entire area, but to provide targeted applications to improve everyday life and demonstrate the potential of solar-based power systems for both local governments and the U.S. manufacturing base.

Most of these projects were not as large as the Arizona endeavor but instead provided power for small medical clinics, vaccine refrigeration units, and well pumps. Patricia O'Donnell, project manager for the Gabon project, explained, "Our goal was to not interrupt their lifestyle, just make it a better quality."

The U.S. agencies employed anthropologists and other experts in the local society to facilitate the preliminary negotiations to determine the specific needs. NASA personnel also worked with local officials to determine power loads and site locations. Communication often added a layer of complexity to the projects. Even with interpreters, there could be different languages, dialects, and norms at different locations within a country.

The first large demonstration project was in village of Tangaye in what is today the West African nation of Burkina Faso. NASA staff spent six weeks in Tangaye to oversee the installation of the arrays, batteries, control equipment, and instrumentation for a water pump and grinding mill. The country's prime minister and other African dignitaries were on hand for the dedication in late March.

↑ A collection of solar arrays installed in Hamman Biadah, Tunisia. (Photo credit: NASA)

In early 1980, NASA and DOE entered into an agreement with Gabon to provide solar electricity to four remote villages. NASA's manager for the project, O'Donnell, worked with government officials to get approvals and work out the logistics. She did not think it would be much trouble to fulfill the Gabonese request for solar-powered water wells until she realized it would require not only the solar pump, but digging the actual wells. She later recalled, "I guess it never entered my mind that there would be a country without a single water well." The project, which began operation in 1982, included 17 power systems in four rural villages that provided medical stations, classroom lighting, streetlights, and the new wells.

Instruments were installed on all the systems to provide daily analysis of their performance. Although minor operational problems were not uncommon, the systems generally performed well. Lewis engineers continued to provide technical support after the demonstration phase was completed and the systems were turned over to local entities.

By the early 1980s, NASA had increased its efforts in traditional aerospace fields and begun phasing out its Earth-based technology programs to concentrate its energy work on projects with aerospace applications, such as the space station power system. Lewis's terrestrial photovoltaic group disbanded in early 1983, and the final project in Tunisia concluded in 1984.

Between 1978 and 1984, Lewis designed, fabricated, and installed 57 photovoltaic systems in 27 countries. Although there is no clear line between these projects and the larger standalone solar power systems employed today, the demonstrations contributed to the step-by-step progression toward today's solar industry.

X-31: The First International X-Plane

The Rockwell-MBB X-31 was equipped with three vectoring paddles that provided control and lift at low speeds and high angles of attack. (Photo credit: U.S. Marine Corps/Major Cody Allee)

» By **Christian Gelzer**, NASA Historian

An airplane flies because the movement of air around its wings creates enough lift to raise it into the air. If, at any point in flight, a wing cannot make enough lift to keep flying, the plane stalls—literally stops flying and starts falling, hopefully with style. Some of the dangerous unpredictability of a stall has been designed out of newer aircraft, but even these can stall, and a spin can develop before the pilot is able to prevent it. (Some airplanes carry "helpful" placards warning that they are not to be spun.) The danger of a stall is greatest during slow flight and nose-up flight (including maneuvering at high angles of attack, also called AOA or "alpha") because both happen at takeoff and landing on every flight. One way to delay a stall is to have the massive thrust of a military fighter, yet even they stall at some point.

In the 1970s, Wolfgang Herbst, an aerodynamicist with the West German firm Messerschmitt-Bölkow-Blohm, GmbH (MBB), began arguing that maintaining control of an aircraft at 70 degrees AOA or higher, in the "post-stall" region (beyond aerodynamic control), would give a fighter an enormous advantage. At that time, the McDonnell Douglas F/A-18 was a modern U.S. carrier-based, twin-engine fighter-attack aircraft, and it stalled at 35 degrees AOA. (The F-22, the current premier U.S. fighter, can maintain control at more than 60 degrees AOA, well after stalling.) Herbst proposed using the fighter's engine exhaust to compensate for the loss of aerodynamic control. Vectoring thrust dates at least to 1912, when a British dirigible used swiveling propellers to maneuver. At least one airplane flown in World War II tilted its engines up slightly to redirect thrust on takeoff; a rocket flew with vectored thrust in 1948; and the British flew the P.1127, precursor to the Harrier "jump jet," in 1960.[1] Of course, every time an aircraft changes propeller pitch or opens thrust diverters to decelerate on landing, it is vectoring engine thrust (and post-stall, no less). Herbst wanted to vector the exhaust coming out the engine's back end, not another point along the way.

Germany became interested in "post-stall" flight, or controlled flight well after the wing has lost lift aerodynamic control, because researchers expected that air combat with the Soviet Union/Eastern Bloc would be at close quarters.

In contrast, the United States planned for combat with missiles launched from beyond visual range of the opponent and saw thrust vectoring often as the Navy did, in terms of carrier operations.[2] Herbst used flight simulation to demonstrate his idea, but critics pointed out that as this region of flight had no precedent, the simulator was untrustworthy: he needed an airplane. But airplanes are expensive, research airplanes especially so, and the German Ministry of Defense would not foot this bill alone. Communication between parties in the United States and Germany determined mutual interest in this field, resulting in the X-31 in 1986. The first international X-plane was a beneficiary of the congressional passage of the Nunn-Quayle amendment to that year's Defense Authorization Act, which made international cooperation like this possible.

↑ The F/A-18 HARV is tied down for a thrust-vectoring demonstration using the afterburner to illustrate the engine's redirected exhaust. (Photo credit: NASA)

The United States (through the Defense Advanced Research Projects Agency, or DARPA) funded 80 percent of the project and designated the Navy as its supervising authority (the Navy had begun exploring 2D thrust vectoring in the 1970s). The Germans brought to the table 20 percent of the budget and their experience, an apparent gross imbalance. Said a DARPA X-31 manager about this: "[W]e did things we knew how to do. The Germans did things that had never been done before."[3] The commercial partners (MBB and Rockwell International) cooperatively designed two identical single-seat fighter concepts (which MBB built) that used a "cranked wing" (double-delta), canards, and a single GE F404 turbofan with afterburner. Around the exhaust nozzle were three carbon fiber paddles that could be deflected into the plume to direct the flow three-dimensionally for post-stall maneuvering.

NASA, too, was interested in this region of flight. Lewis Research Center (now Glenn Research Center) and Langley Research Center explored 3D (multi-axis) thrust vectoring using models of U.S. fighters, and then the Agency began a multi-Center project to investigate post-stall flight using vectored thrust on a full-scale aircraft: an F/A-18. The F/A-18 High Alpha Research Vehicle (HARV) first flew in 1987 from Dryden Flight Research Center (now Armstrong), where it was based for the testing. Center engineers and mechanics eventually added vectoring paddles to the airplane, three per nozzle, and the thrust-vectoring control system phase that extended the high-alpha research ran through 1996.[4]

The Navy had responsibility for the X-31's initial flight evaluation, which took an entire year to accomplish because of the Navy's safety controls and procedures. MBB, Rockwell, and DARPA could not endure this pace because, in addition to the need for envelope expansion work with each subsequent research phase, each schedule slip threatened funding. These two factors led DARPA to move the project from the Naval Air Station Patuxent River test site to NASA Dryden at Edwards Air Force Base, and in 1992 both aircraft arrived at the Center.

[W]e did things we knew how to do. The Germans did things that had never been done before.

—DARPA X-31 Manager

X-31: The First International X-Plane (continued)

NASA, MBB, and guest pilots flew both X-31s through different phases of research.[5] Not only did the aircraft meet its design objectives, but there was an opportunity to see how it performed in mock combat with U.S. fighters. Before it was initially flown against the Center's F/A-18s, NASA researchers thought a 3:1 kill ratio likely. It was 30:1. Against Air Force, Navy, and Marine fighters and pilots, the ratio was almost the same, the exception being the F-16, and its pilots admitted having to modify tactics to win what they did.

Considered the most dramatic, if not ultimate, demonstration of thrust vectoring's potential, the X-31 was able to perform the Herbst Maneuver, reversing course mid-flight by pitching up steeply and, when nearly vertical, pivoting 180 degrees on its exhaust nozzle while nosing down and back the way it had come. This maneuver enables the pilot to engage an opponent in close combat when the opponent is in the midst of a much bigger turn and thus unable to defend against the threat. The maneuver has been compared to what a competitive swimmer does when making a rapid turn at the end of a lap with an almost zero-degree turn radius.[6]

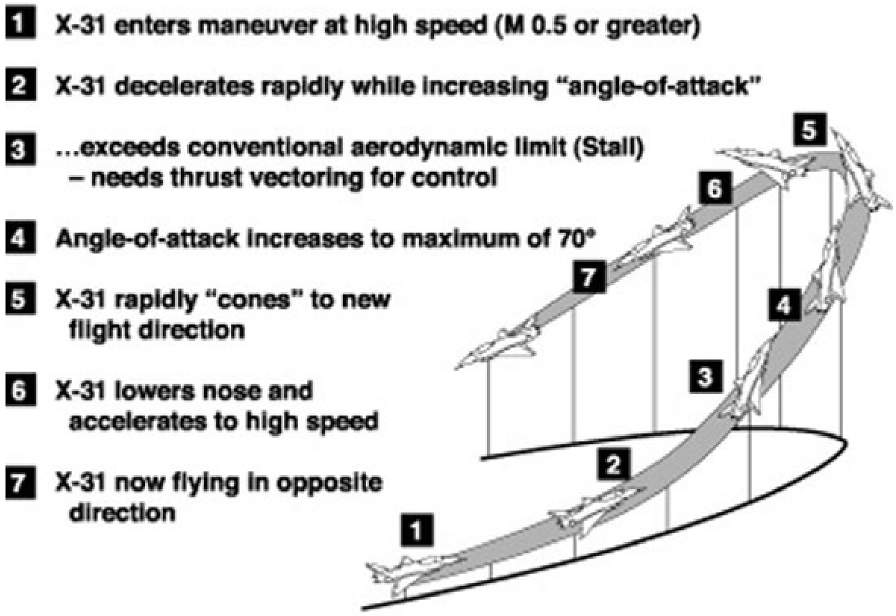
Wrapping up nearly a decade of research, in January 1995 Karl Lang took the first X-31 up for the project's last flight. Unaware that a pitot tube heater was unconnected, he flew through some low clouds, and the probe iced up. This led to inaccurate airspeed data in the cockpit, control room, and, most significantly, the flight computer (it had a digital fly-by-wire control system). Responding to the data it had, the flight computer suddenly pitched the X-31 up steeply and would not respond to Lang's nose-down commands.[7] Like other pilots in the program, he'd seen the drop-test results at Langley showing how nasty the X-31 could be after loss of controlled flight at high AOA, and he ejected.[8] Despite the crash, in less than five months NASA and its partners had determined the cause of the accident, addressed it, and found a way to ship the second X-31 to that year's Paris Airshow, where the Herbst Maneuver wowed even those to whom it had been explained.

This perspective highlights the X-31's thrust-vectoring paddles and high AOA at which it could maneuver. (Photo credit: NASA)

Watch the X-31 perform a post-stall Herbst Maneuver.

International cooperation on a military project to this extent was new to the United States and Germany, and both parties expected that issues would crop up. MBB and Rockwell worked in two units of measure (one was metric the other standard), two cultures (MBB's approach to digital control laws unsettled Rockwell engineers until they became familiar with them), and very different time zones. But after initial difficulties, the friction eased. Given the distance and time between Germany and California, for example, the project developed a two-shift system, and problems unsolved at one end were often transferred to the other partner for their next shift to tackle, and vice versa.

Since the X-31 and other projects (among them NASA's F-18 HARV and F-15 Advanced Controls Technology for Integrated Vehicles, or ACTIVE), thrust vectoring has appeared on U.S., European, Russian, and Chinese military aircraft. But interested parties have drawn different conclusions about thrust vectoring. Everything must "buy" its way onto an airplane, which is one reason thrust vectoring does not appear on every fighter: its suitability depends on the aircraft's purpose. More recent work in this field focuses on nonmechanical thrust vectoring—manipulating the exhaust flow with fluid dynamics.[9] To date, despite the project's success, the X-31 remains the only international X-plane. ■



↑ An illustration of the Herbst Maneuver. (Image credit: NASA)

Endnotes

1 See Erich Wilson, *An Introduction to Thrust-Vectored Aircraft Nozzles* (London: Lambert Academic Press, 2013).

2 Albion H. Bowers, Joseph W. Pahle, R. Joseph Wilson, Bradley C. Flick, and Richard L. Hood, *An Overview of the NASA F-18 High Alpha Research Vehicle* (Edwards, CA: NASA TM 4772, 1996), p. 3.

3 Col. Michael Francis in Lane Wallace, *Nose Up: High Angle of Attack and Thrust Vectoring Research at NASA Dryden, 1979–2001* (Edwards, CA: NASA SP-2009-4534, 2006), p. 35.

4 The paddles—made of Inconel-X, a very dense metal amalgam—and the six hydraulic systems used to operate the paddles added almost a ton to the very back of the airplane, significantly affected its center of gravity, and led some to say the airplane now had "a ton of thrust" (Wallace, *Nose Up*, p. 45).

5 A Center photographer flying in the back seat in one of the Center's F/A-18s recalls chasing the X-31 day after day and the F/A-18 stalling no matter what the pilot did, and they never could keep up with the X-31 (Gelzer conversation with James "Jim" Ross, Armstrong chief photographer).

6 Wallace, *Nose Up*, p. 37.

7 Wallace, *Nose Up*, p. 50. See also Joseph R. Chambers, "High-Angle-of-Attack Technology: Progress and Challenges," in *High-Angle-of-Attack Projects and Technology Conference*, NASA CP-3149, vol. 1, May 1992; and Chambers, "High-Angle-of-Attack Technology: Lessons Learned," AIAA-86-1774, June 1986.

8 Engineers noted that by pushing a button, Lang could have reverted to the standard flight control program that would have returned him control, but this observation came after the crash. No one in the control room mentioned the inoperative pitot heat until Lang mentioned turning it on after entering the clouds, by which time it was too late.

9 Jose C. Páscoa, Antonio Dumas, Michele Trancossi, Paul Stewart, and Dean Vucinic, "A Review of Thrust Vectoring in Support of a V/STOL, Non-Moving Mechanical Propulsion System," *Central European Journal of Engineering* 3, no. 3 (2023): 374–388.

The "Greatest Communications Experiment in History" or a Case Study in Geopolitics During the Cold War?[1]

The Satellite Instructional Television Experiment

» By **Stephen Garber**, NASA Historian

EARLIER THIS YEAR, India became one of the latest nations to sign the Artemis Accords.[2] The roots of NASA–Indian Space Research Organisation (ISRO) cooperation extend back to the early 1960s, however, and notably included the Satellite Instructional Television Experiment (SITE) during 1975–76. Through SITE, India became the world's first nation to broadcast television to an audience of millions of viewers. Largely successful, SITE indeed was a significant technical and diplomatic achievement during the Cold War, if not the greatest communications experiment until that time.

Dr. Vikram Sarabhai, considered the father of India's space program, is a notable figure in this story, although he did not live to see it come to pass. He was a charismatic, prominent physicist who was influential in Indian and international scientific circles. Specifically, Sarabhai was the scientific chairman of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) in the late 1960s and was a major force behind SITE until his death in 1971.[3]

While a visiting professor at the Massachusetts Institute of Technology in March 1961, Sarabhai expressed interest in cooperating with NASA; later that year, NASA loaned the Indian Physical Research Lab some telemetry receiving equipment for a gamma-ray satellite.[4] More generally, in the early 1960s, NASA and Indian space officials had ongoing discussions about cooperation on scientific sounding rockets and siting satellite tracking stations in India.[5] These discussions yielded an October 1962 Memorandum of Understanding (MOU) on sounding rockets between NASA and the Indian Department of Atomic Energy (DAE), where Indian space efforts were then housed. In 1963, Indian personnel launched a NASA-provided sounding rocket from a new facility in Thumba on India's southwestern coast.[6]

The following year, NASA officials began exploring the idea of using a forthcoming Applications Technology Satellite (ATS) for a direct satellite TV broadcasting experiment, which interested Indian officials.[7] Presidential Science Advisor Dr. Jerome Wiesner traveled to India early in 1965 to discuss collaboration in nuclear energy, space, and general science. Also that year, Sarabhai met with NASA Administrator James Webb, Deputy Administrator Hugh Dryden, and NASA international affairs head Arnold Frutkin. They converged on efforts that would have a "meaningful impact on Indian technology and industrial growth, not spectaculars that would drain resources to no useful social effect," nor technology that was not home-grown.[8]

They converged on efforts that would have a "meaningful impact on Indian technology and industrial growth, not spectaculars that would drain resources to no useful social effect," nor technology that was not home-grown.

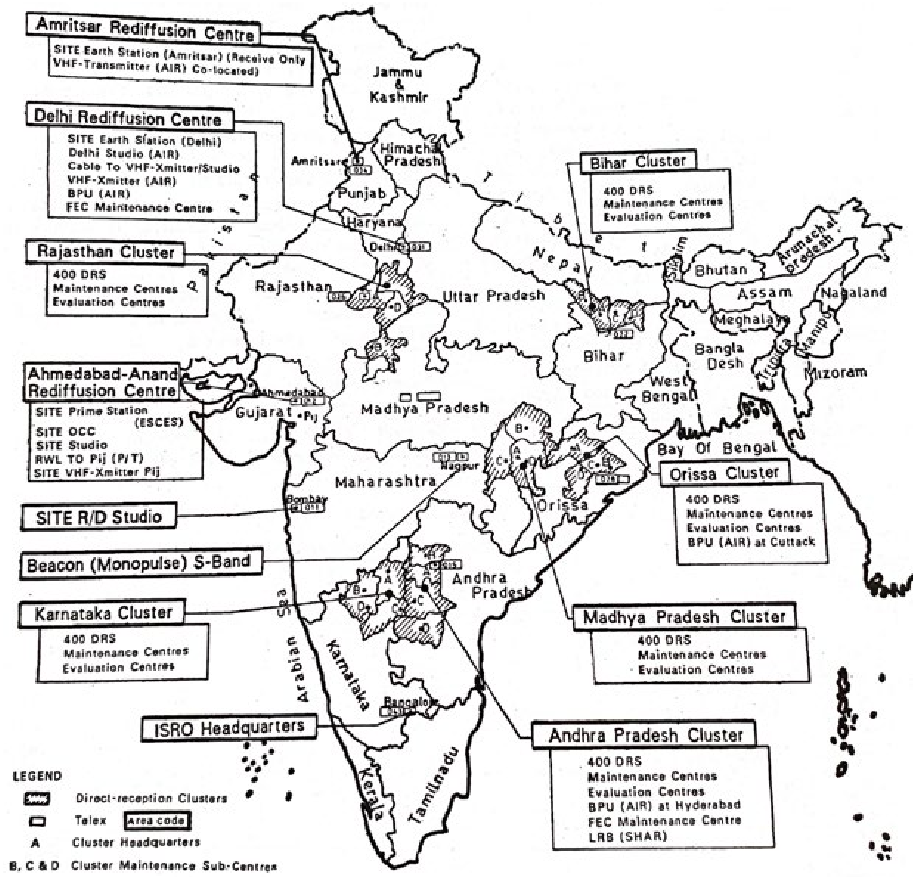
Webb then proposed a satellite broadcasting initiative using a geosynchronous satellite over India to the Department of State official. In March 1967, Sarabhai submitted a formal proposal to NASA for what later became SITE. Earlier, State officials had been embarrassed when Indian officials had rejected a proposal to place Voice of America transmitters there, so Frutkin deliberately asked Sarabhai to initiate this request. Sarabhai's proposal was then accepted.[9]

In September 1969, officials from ISRO signed an MOU establishing the SITE program. At the signing ceremony, Sarabhai noted that India had more than half a million villages, most of them isolated, and acknowledged the project's mutuality.[10] He looked forward to using this satellite communications project to address the "education needs of India's rural population rather than the entertainment wants of the urban masses."[11]

The SITE project involved NASA loaning India the use of the ATS-6 satellite for one year, from 1 August 1975 to 31 July 1976, to broadcast educational TV programming to six clusters of approximately 400 villages each for approximately 4 hours daily. In turn, India was responsible for providing the ground equipment, including 10-foot antennas, front-end converters, and TV sets,[12] as well as the preparation and transmission of original programming.

More broadly, as general principles for international cooperation in space, Frutkin emphasized that there would be no exchange of funds between nations, and SITE was no exception. "So we came up with [a fundamental guideline that precluded any] exchange of cash; each side in a cooperative project would do what it could do at its own expense; the project would be considered only on the basis of mutual interest."[13]

In addition to NASA, the Indian organizations participating in SITE were ISRO (which by 1975, was part of the Department of State), the Ministry of Information and Broadcasting (known as Doordarshan), Indian state governments, and the Ministries of Agriculture, Education, Health, and Family Welfare. SITE's stated goals included gaining experience with a satellite-based educational television system in rural areas, demonstrating the potential value of satellite technology for mass communication in developing countries, and stimulating Indian national development.[14]



Map of India showing the regions chosen for the SITE project. (Image source: "Satellite Instruction Television Experiment," *Space Research, Technology, and Applications* 2, no. 3 [February 1976], copy in file 14642, NASA Headquarters Archives)

While some basic statistics about the Indian population at the time of SITE may seem surprising to Westerners half a century later, they underscore the point that India was indeed a developing country. When the SITE project was being planned in the late 1960s and early 1970s, India had a population of approximately 600 million (U.S. officials noted that it was world's largest democracy) with 70 percent of the population living in villages, 70 percent illiterate, and 60 percent living in poverty. Moreover, TV existed only in Delhi in India, with no national distribution network. Frutkin and Leonard Jaffe, NASA's director of satellite communications, assessed that it would be too expensive to set up regular TV infrastructure. Setting up TVs in communal locations meant that many villagers could watch simultaneously, and a satellite-based approach actually would be a more cost-effective method than building up a conventional, ground-based TV infrastructure of local transmitters.[15]

Indian officials selected six poorer states, Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Orissa, and Rajasthan, to host a total of 2,332 SITE villages. With an average village population of 1,200, this meant that about 2.8 million people had access daily to SITE programs, and there were over 300,000 average daily viewers. Indian officials initially fanned out across these provinces and visited approximately 6,000 villages to find ones that met program criteria, such as capability to be electrified relatively quickly, distance from a maintenance center, population, and existing infrastructure (educational, agricultural, health). It was neither a random selection nor a process of elimination.[16]

The public placement of TVs meant that programming was available to everyone, regardless of caste, although a disproportionately high percentage of low-income farmers composed the new viewership. Programming was tailored to rural people "who have rarely seen moving pictures," but the audience included viewers from "all socio-economic strata."[17]

The public placement of TVs meant that programming was available to everyone, regardless of caste....

An ISRO technician stands next to a working model of the specially designed SITE TV set. (NASA image reproduced in Raman Srinivasan, "No Free Launch: Designing the Indian National Satellite," chapter 16 in *Beyond the Ionosphere: Fifty Years of Satellite Communications*, ed. Andrew J. Butrica [Washington, DC: NASA SP-4217, 1997], p. 221)

To fill 4 hours of original programming daily (over 1,200 hours for the year), Doordarshan built three TV production studios in Delhi, Cuttack, and Hyderabad.[18] These studios created 90 minutes of daily educational shows for children aged 5 through 8 and 9 through 12 years old. (The programming was divided into these two target audiences). At village schools, students watched these shows, which focused on "enrichment" of school lessons; "numeracy, language and techniracy" skills; "community living skills"; "habits of hygienic and healthy living"; "aesthetic sensitivity"; and awareness of "modernization of life and society around them." For two and a half hours at night, the programming targeted adult villagers with shows about family planning, hygiene, health, weather forecasts, and agriculture. During school vacations, SITE programming included teacher training programs. The project also included some entertainment programs.[19] While some latter-day observers might well find some of this language paternalistic and culturally insensitive, these quotations come from Indian documentation.

SITE utilized the ATS-6 spacecraft, which launched about a year before the SITE program officially began. Considered the first satellite used for educational purposes, ATS-6 was also used to conduct other early telemedicine and educational experiments in Alaska and elsewhere. Its broadcasting strength enabled small, relatively inexpensive and large-scale ground equipment to be deployed successfully in India for SITE. As one author pointed out, this video broadcasting technology is similar to that commonly used today for videoconferencing.[20]

After the SITE program ended in 1976, evaluators assessed it somewhat positively. Specifically, they judged the reliability of program delivery to be good, and viewership was also considered good, although it tailed off at some venues over the year. In terms of whether the viewers learned, evaluators gave SITE tentatively good marks. As to whether there were significant changes in "appropriate behaviors," the data were inconclusive. Again, some of these criteria are shaded by paternalistic language. Assessments of some initial hypotheses about how SITE

Illustration of NASA's ATS-6 satellite that the Satellite Instructional Television Experiment used. (Image credit: NASA)

would affect students turned out to be more surprising and more of a mixed bag. Students' language development did improve, and students were curious enough to seek additional information. On the other hand, students' school achievement, interaction with teachers, and attendance did not significantly improve.[21]

At another level, SITE did succeed by demonstrating that a satellite-based educational television system was feasible in a developing country such as India, and it did stimulate Indian national development in space. Indian provincial and local government participation was key to this success. Provincial and local governments often supplied existing infrastructure and electricity to almost 2,000 buildings that previously lacked it; hence, electrification was itself a major ancillary benefit.[22]

SITE also laid the figurative (and in some ways, the literal) groundwork for future Indian space activities, some of which also benefited the United States. The Indian National Satellite (INSAT) program started in the 1980s. In 1984, Rakesh Sharma became the first Indian in space, flying on the Soviet Salyut 7 mission.[23] In 1997, Kalpana Chawla was the first woman of Indian descent to fly on the Space Shuttle.[24]

Citing Sarabhai, Frutkin waxed enthusiastically about SITE before it began. SITE was "one of those widely-sought but rarely-grasped opportunities to use modern technology in a developing country so as to leapfrog historical development stages.... Dr. Vikram Sarabhai, the guiding spirit in India for the experiment, has stated that the use of satellites for direct broadcasting will make it possible to bring televised instruction to illiterate millions of India's 550,000 villages in only ten years as against thirty years required for the construction and extension of a conventional microwave TV distribution system—given the same annual rate of investment."[25] The head of Doordarshan also sung SITE's praises by contending that it was unique in that it had something for everybody, "Indians and foreigners, high status and low, rich and poor, specialist and non-specialist."[26]

To appreciate SITE's significance to the United States, however, it is paramount to consider the overall geopolitical context in the late 1960s and the 1970s. While the United States and Soviet Union competed for influence in the "third world" during the Cold War, leaders of decolonized countries such as India sought a third, nonaligned path. China's role complicated things in Asia as well. China had defeated India in a 1962 border war, leading to increased Indian military spending. For U.S. foreign policy-makers, SITE offered the example of India as a counterpoint to communist China for a developing country, "part of a broader strategy to channel Indian resources down the path of civilian technologies. And, by withdrawing the satellite from service after a year, NASA successful[ly] encouraged the Indian government to buy additional models from US business."[27]

While the United States was angling to win over nonaligned countries such as India, many in the U.S. foreign policy establishment were not fully comfortable committing to a strategic alliance with India. As early as the Kennedy administration, Pakistan was the United States' preferred ally on the subcontinent. Yet Indian Prime Minister Jawaharlal Nehru met with President John F. Kennedy in 1962, and the two leaders issued a joint statement on cooperation, including in space. The geopolitical tides continued to shift during the 1970s. After the 1971 Indo-Pakistan war and the 1974 Indian peaceful nuclear explosion, Prime Minister Indira Gandhi sought cooperation with the Soviet Union, which launched three Indian satellites.[28]

Given all these geopolitical twists and turns, SITE was a notable achievement both for NASA and India. Putting aside Arthur C. Clarke's hyperbolic rhetoric, SITE was indeed a significant milestone in the history of satellite telecommunications. Even more important, however, was SITE's geopolitical significance, as well as the precedent it set for further U.S.-India space cooperation and the development of indigenous Indian space capability.

In the decades since, India has made considerable progress in various aspects of exploring space, to the point where some analysts consider it a "great space power."[29] Bringing the story up to date, last month NASA Administrator Bill Nelson traveled to India to discuss space cooperation.[30] ■

Endnotes

1 The quotation is from Arthur C. Clarke, who was an enthusiastic consultant to SITE and received a special TV set for his home in Sri Lanka. In addition to being famous for his science fiction writing, Clarke is credited with developing the idea for satellite telecommunications. He also was quoted as saying that the "TV satellite is mightier than the ICBM [Intercontinental Ballistic Missile]." For these quotations, see Yash Pal, "A Visitor to the Village," *Bulletin of the Atomic Scientists* 33, no. 1 (January 1977) and *Next Ten Years in Space, 1959–1969*, Staff Report of the Select Committee on Astronautics and Space Exploration, 85th Cong., 2nd sess., p. 32, cited in Ashok Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," chap. 12 in *NASA in the World: Fifty Years of International Collaboration in Space* (New York: Palgrave, 2013), pp. 235, 239. Regarding Clarke's role in SITE, see Raman Srinivasan, "No Free Launch: Designing the Indian National Satellite," chap. 16 in *Beyond the Ionosphere: Fifty Years of Satellite Communications*, ed. Andrew J. Butrica (Washington, DC: NASA SP-4217, 1997), p. 221.

2 India became the 27th country to sign the Accords on 27 June 2023. See "NASA Welcomes India as 27th Artemis Accords Signatory," https://www.nasa.gov/news-release/nasa-welcomes-india-as-27th-artemis-accords-signatory/ (accessed 29 November 2023).

3 Clifford Block, Dennis Foote, and John Mayo, "A Case Study of India's Satellite Instructional Television Project [*sic*] (SITE)," January 1977, p. 25, copy in file 14642, NASA Headquarters Archives; Ashok Maharaj, "An Overview of NASA-India Relations," chap. 11 in *NASA in the World*, pp. 213–215. Dr. Homi Bhabha was an important, earlier figure in India's space program. Bhabha was an aristocratic scientist in post–World War II India who was considered the father of India's nuclear energy program and pushed to build an Indian satellite before his death in 1966. Bhabha was a decade older than Sarabhai, and the two were colleagues and friends. See Srinivasan, "No Free Launch," p. 222.

4 Ashok Maharaj, "An Overview of NASA-India Relations," chap. 11 in *NASA in the World*, p. 217.

5 Maharaj, "An Overview of NASA-India Relations," pp. 216–217. For more information on the international aspects of NASA's tracking stations, Maharaj cites Sunny Tsiao, *"Read You Loud and Clear": The Story of NASA's Spaceflight Tracking and Data Network* (Washington, DC: NASA SP-2007-4232, 2008).

6 Maharaj, "An Overview of NASA-India Relations," pp. 218–219.

7 Arnold W. Frutkin, "The India-US Satellite Broadcasting Experiment" (undated white paper prepared before SITE officially began), p. 5, copy in file 14641, NASA Headquarters Archives.

8 Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," pp. 237–238 (quotation is from p. 238).

9 Webb proposed this to State Department official U. Alexis Johnson in May 1966. See Ashok Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," p. 238; Frutkin, "The India-US Satellite Broadcasting Experiment," pp. 5–8; and Srinivasan, "No Free Launch," p. 220.

10 Maharaj, "An Overview of NASA-India Relations," p. 222; "Remarks by NASA Administrator Dr. Thomas C. Paine and Dr. Vikram Sarabhai, Chairman, Indian Space Research Organization and the Department of Atomic Energy at the Signing of the India/U.S. Instructional Television (ITV) Satellite Experiment Project Agreement," 18 September 1969, copy in file 14642, NASA Headquarters Archives.

11 Brian Shoesmith, "Footprints to the Future, Shadows of the Past: Toward a History of Communications Satellites in Asia," chap. 17 in *Beyond the Ionosphere*, ed. Butrica, p. 230.

12 Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," p. 243.

13 Arnold W. Frutkin, oral history by Rebecca Wright, Washington, DC, 11 January 2002, https://historycollection.

The "Greatest Communications Experiment in History" or a Case Study in Geopolitics During the Cold War? (continued)

jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/NASA_HQ/Administrators/FrutkinAW/FrutkinAW_1-11-02.htm (accessed 29 November 2023).

14 Block et al., "A Case Study," p. 1, and see https://www.isro.gov.in/genesis.html (accessed 11 December 2023) for a synopsis history of ISRO and where it stood organizationally at this time.

15 UN-UNESCO Panel Meeting on SITE Experiences, 31 October–5 November 1977, report (Space Applications Centre, Indian Space Research Organisation), p. 5, copy in file 14641, NASA Headquarters Archives; Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," pp. 237, 239; Srinivasan, "No Free Launch," p. 220.

16 Block et al., "A Case Study," pp. 1, 3; P. V. Krishnamoorthy, Director General, Doordarshan, "A Satellite in the Service of the Underprivileged The Indian Experience with SITE," (undated), pp. 2, 13, copy in file 14641, NASA Headquarters Archives; V. K. Nair, *Satellite Instruction Television Experiment*, rev. ed. (Bangalore: ISRO, July 1974), p. 14, copy in file 14642, NASA Headquarters Archives.

17 Block et al., "A Case Study," pp. 22, 31; E. V. Chitnis and J. E. Miller, "Social Implications of Satellite Instructional Television Experiment—Use of Advanced Communication System for National Development," copy of paper from Institute of Electrical and Electronics Engineers (IEEE) meeting in Philadelphia, June 1976, p. 2, copy in file 14641, NASA Headquarters Archives; Krishnamoorthy, "A Satellite in the Service," p. 13.

18 Krishnamoorthy, "A Satellite in the Service," p. 1.

19 *Satellite Instruction Television Experiment: Technical Evaluation of the Ground Segment* (Bangalore: ISRO, October 1977), p. 7, copy in file 14642, NASA Headquarters Archives; Nair, *Satellite Instruction Television Experiment*, pp. 7–9; Block et al., "A Case Study," pp. 4, 29.

20 Bert Cowlan and Dennis Foote, "A Case Study of the ATS-6 Health, Education and Telecommunications Project," Agency for International Development, Bureau for Technical Assistance, Office of Education and Human Resources, August 1975, copy in file 14641, NASA Headquarters Archives. Shortly before SITE initiation, this satellite also helped relay signals for the historic Apollo-Soyuz Test Project (ASTP) docking in orbit. See Craig Gralley, *Pisgah Astronomical Research Institute: An Untold History of Spacemen & Spies* (Charleston, SC: History Press, 2023), pp. 54–55 regarding the ASTP docking and p. 51 regarding videoconferencing technology.

21 Block et al., "A Case Study," pp. 30, 33.

(continued on page 32) »

NASA's Tracking Stations

A Tale of International Collaboration

» By **Christine Stevens**, Archivist

Dr. John Clark and his wife June (partially visible) lead the way as a group walks past a tracking station antenna in Quito, Ecuador. This photo is part of the Goddard Space Flight Center Archives collection. (Photo credit: NASA)

HAVE YOU EVER WONDERED how NASA engineers are able to track and communicate with spacecraft? How Mission Control can have conversations with astronauts in space? NASA's tracking networks make it all possible. NASA has utilized several tracking networks throughout its history, the first of which was the Minitrack System, built by the U.S. Navy. The Minitrack System was transferred to NASA in 1958 and served as a building block for the Space Tracking and Data Acquisition Network (STADAN). Other follow-on networks included the Manned Space Flight Network (MSFN), the Spaceflight Tracking and Data Network (STDN), the Deep Space Network (DSN), and others. All tracking networks were and continue to be managed by various offices at NASA's Goddard Space Flight Center (GSFC).

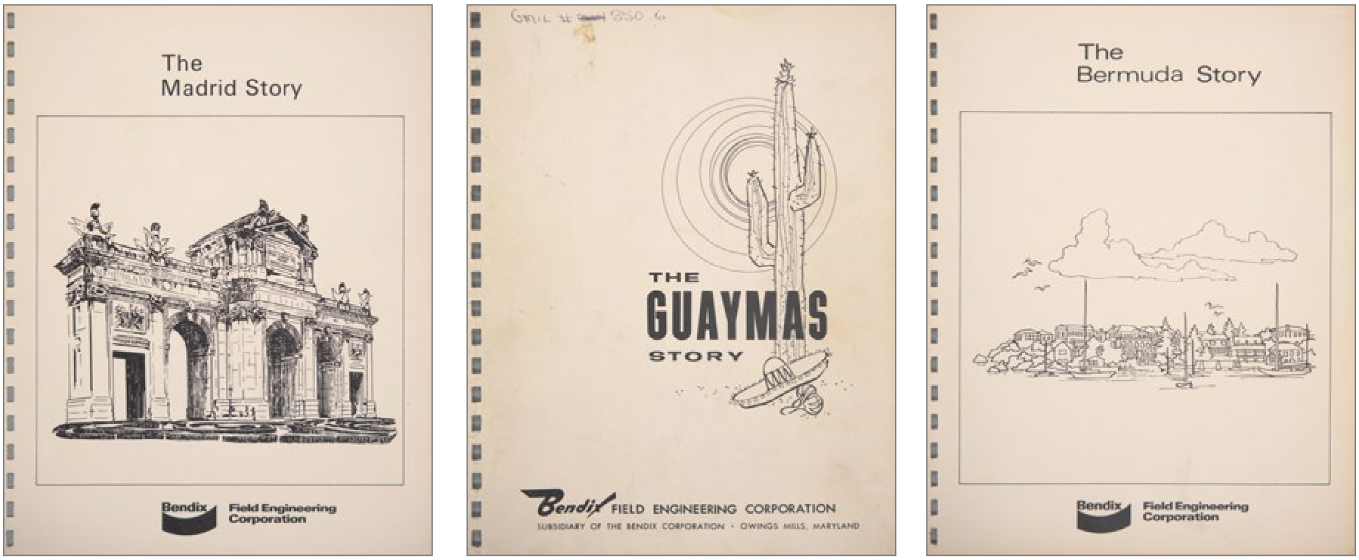
Every tracking network requires tracking stations to operate. In the early years of the space program, NASA relied on tracking stations located in the United States. However, depending on where a spacecraft is, it might not be able to contact a U.S. station—but it could make contact with a station in another part of the world. As the program expanded, it became clear that a global network of tracking stations was necessary to track and communicate with spacecraft as they circled Earth.

The first international tracking station was built in Woomera, Australia, in 1957 and was used to track the orbits of early satellites, such as Explorer 1 and Echo 1. Throughout the 1960s and 1970s, NASA's tracking station network expanded rapidly, reaching across continents and fostering partnerships with countries eager to participate in the exploration of space. In 1961, stations were established in Canberra, Australia, and Madrid, Spain, providing critical support for the Project Mercury and Gemini missions. The list kept growing, with stations being built in Chile, Ecuador, Mexico, Madagascar, England, South Africa, the Bahamas, and more.

As the program expanded, it became clear that a global network of tracking stations was necessary to track and communicate with spacecraft as they circled Earth.

Before tracking stations could become operational, they needed to be staffed. NASA employees and contractors moved across the globe in support of the effort. To help employees acclimate to their new homes, the Bendix Corporation created informational booklets on the tracking stations where their employees would be sent. Each booklet included information about places to live, local customs, weather, entertainment, and what working at the station would be like. Titled after the location of the station, *The Madrid Story*, *The Guaymas Story*, and *The Bermuda Story* informational booklets gave employees a glimpse of what life would be like at their new job.

NASA's Tracking Stations (continued)



↑ Covers for three Bendix Corporation informational booklets from the Goddard Archival Collection are shown. These booklets briefed NASA employees and contractors about the tracking stations where they could be stationed. (Photo credit: NASA/Goddard Archives)

The establishment of tracking stations around the globe was not merely a logistical necessity; it represented a conscious effort to foster international relationships. These stations served as hubs for collaboration, bringing together scientists and engineers from diverse backgrounds to work toward common goals. The sharing of expertise and resources among these partners proved to be invaluable.

In the Goddard Archives, there is a collection from Dr. John Clark, Goddard's Center Director from 1965 to 1976, that contains photographs and letters from Dr. Clark and his wife during their visits to the Quito Tracking Station in Ecuador and Santiago Tracking Station in Chile. While in Quito, Dr. Clark met with a variety of people, including the Station Director, the U.S. Ambassador to Ecuador, two employees from the Polytechnic Institute of Quito, local contractors, and a cultural affairs specialist from the United States Information Service (USIS). These visits provide evidence that NASA was invested in fostering cultural exchange while making scientific and technological advancements in the realm of space exploration.

↓ Dr. John Clark's collection at the Goddard Space Flight Center Archives include NASA identification cards for Clark and his wife June for a trip to the Santiago, Chile, tracking station. (Photo credit: NASA/Goddard Archives)

NASA's tracking stations have played a vital role in the success of the Agency's space missions since its beginning. These stations have tracked the orbits of spacecraft, received telemetry data, and provided two-way communication with astronauts even when they were out of range for U.S. tracking stations. This network of tracking stations located strategically around the world continues to be essential for the Agency's missions in Earth's orbit, across the solar system, and into interstellar space. ■

Learn more about the history of NASA's Spaceflight Tracking and Data Network with the 2008 NASA History Series publication *"Read You Loud and Clear!"*

The United States–Japan Partnership in Space

» By **Joshua Schmidt**, Former Presidential Management Fellow at NASA Headquarters

A History of Cooperation

FOLLOWING DECADES of cooperation in space, Japan joined the United States and six other countries as one of the initial signatories to the Artemis Accords on 13 October 2020. Japan's further commitment to cooperation with NASA, the Canadian Space Agency (CSA), and the European Space Agency (ESA) on the Gateway project quickly followed, with the most recent update to the agreement signed in November 2022. Through this partnership with the Japan Aerospace Exploration Agency (JAXA), the United States gains an important ally with many notable achievements in the peaceful use of space to advance scientific understanding. JAXA was established on 1 October 2003 and brings together a wealth of knowledge from three previously separate organizations: the National Space Development Agency of Japan (NASDA), the Institute of Space and Astronautical Science (ISAS), and the National Aerospace Laboratory of Japan (NAL).

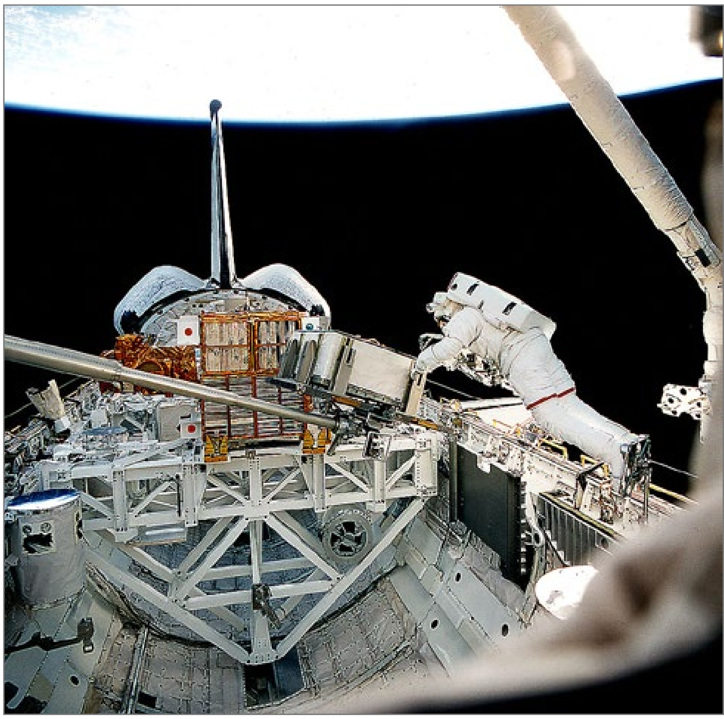
Recent accomplishments and collaboration aside, this U.S.-Japan partnership follows decades of cooperation in space on various projects. From large endeavors such as the construction and maintenance of the International Space Station (ISS) to smaller projects on weather and observational satellites, and even licensing agreements for launch vehicle technology, both countries have gleaned a wealth of experience from their interactions.

First Forays

Japan, a technologically advanced nation with close ties to the United States, was a natural choice when considering partners for the construction of the ISS, along with CSA and ESA. However, unlike the other program participants, up until 1992, the Japanese government had yet to conduct any piloted space ventures and had not participated in the Space Shuttle Program. NASDA first contacted NASA about an opportunity for research utilizing Spacelab and the Shuttle Program in January 1984 after issuing a call for experiments throughout Japan in 1979. In July 1984, 34 experiments were selected, and a final agreement between the United States and Japan was signed on 31 March 1985 establishing the Spacelab J mission. Under this agreement, NASDA was responsible for developing the payload for the Spacelab module and providing one mission specialist to fly with the experiments, and the United States was responsible for providing reimbursable launch services and mission management.

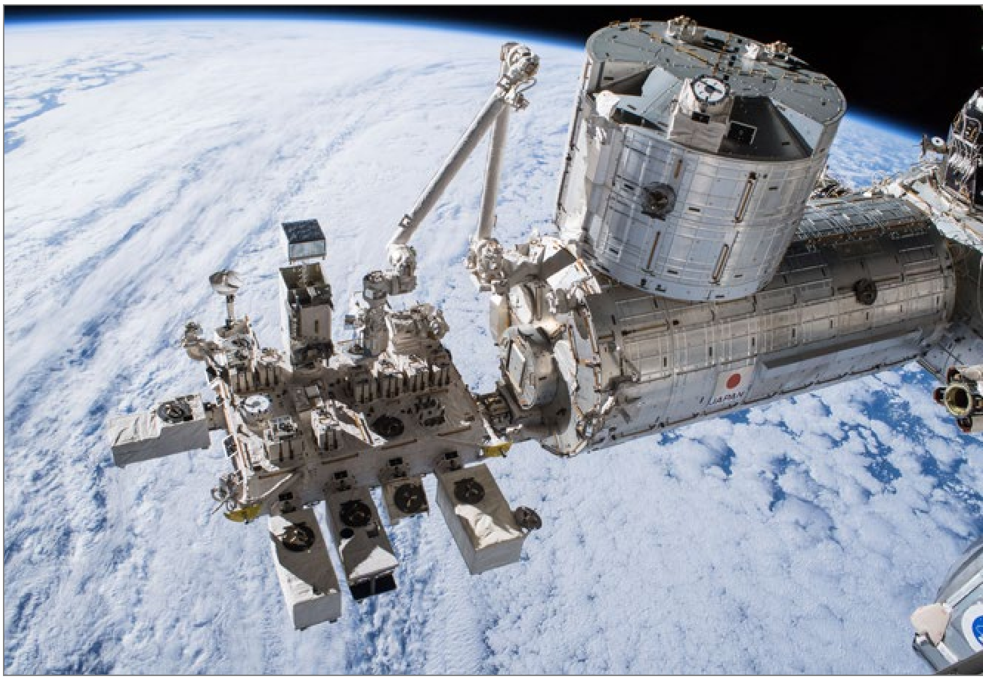
The original Spacelab J mission was slated for February 1988 aboard Space Shuttle Challenger as STS-81G. However, following the 1986 Challenger accident and the subsequent hiatus in the Space Shuttle Program, the mission was postponed. Though it meant the mission would be delayed for several years, the Japanese government made the decision to keep to the deal brokered with the United States. Japan even turned down an offer from the Soviet Union to utilize the new Mir space station.[1] Interestingly, the first Japanese citizen in space, a reporter

↓ Japanese astronaut Takao Doi performs an EVA during the STS-87 mission in December 1997. (Photo credit: NASA)



named Toyohiro Akiyama, would fly aboard the Soviet Union's Soyuz TM-11 in 1990 as a commercially funded research cosmonaut.[2]

Spacelab J finally launched on 12 September 1992 as STS-47 aboard Space Shuttle Endeavor, and Mamouri Mohri became the first Japanese astronaut to fly with the United States into space. The seven-day mission included 43 experiments, such as 20 life science experiments that focused on human health in space. The schedule was even extended during the mission to allow one additional day of experiments to be conducted before the Shuttle's return.



↑ JAXA's Kibo laboratory module (composed of a pressurized module and exposed facility, a logistics module, a remote manipulator system, and an inter-orbit communication system unit) is pictured in 2018. (Photo credit: NASA)

ISS Collaboration

While Japan eagerly awaited participation in the Shuttle Program, it continued to analyze and develop the plans necessary for its contribution to the ISS. In March 1986, the first proposal for the Japanese Experiment Module, or Kibo (Hope), was presented. In March 1989, an Intergovernmental Agreement was signed between the United States and Japan, outlining involvement in the effort to complete the Space Station.

Following the Spacelab J mission, Japan continued to send astronauts into space in order to gain the essential skills required to ensure the successful development and assembly of the Kibo module upon its delivery. In November 1997, Dr. Takao Doi flew aboard Space Shuttle Columbia during STS-87 as a mission specialist and became the first Japanese astronaut to complete a spacewalk. During the 15-day mission, Winston Scott (mission specialist) and Doi completed two extravehicular activities (EVAs) with the goal of testing assembly techniques and practices to be used in the upcoming ISS construction.

This experience proved invaluable when it came time for Doi to temporarily attach the first Japanese module (Logistics Module) to the ISS in March 2008 after it was flown on STS-123. The second module (Pressurized Module) flew during STS-124 and was successfully attached by Akihiko Hoshide utilizing the Station's robotic arm. The final component, the Exposed Facility Module, was brought on STS-127 in July 2009 and would later be attached by Koichi Wakata during an EVA.

To support Kibo and the ISS, Japan developed and operated the H-II Transfer Vehicle (HTV), an expendable cargo spacecraft also called Kounotori (White Stork). From 2009 to 2020, the HTV successfully resupplied the ISS nine times. The HTV became especially important once the Space Shuttles were retired, and the HTV was the only vehicle with International Standard Payload Racks (ISPR) installed to aid in the efficient movement of new equipment to the ISS.[3]

Upon its completion, Kibo became the largest module on the ISS, and this space has allowed astronauts to complete experiments in life science, medicine, Earth and planetary science, astronomy, and materials and physical science in microgravity. Japan has also confirmed its commitment to continued ISS participation alongside the United States, Canada, and ESA until 2030.

Into the Future

Utilizing the lessons learned from participation in Spacelab and the ISS, in addition to the strong partnerships created from these and other efforts, Japan is in a position to be a significant contributor to the Artemis missions and the Gateway space station.

As a part of the Gateway program agreement, JAXA will provide Gateway's life-support system and thermal controls. Japan will also provide crucial components for many other modules, including camera and batteries for the International Habitation (I-Hab) module and batteries for both the European System Refueling Infrastructure and Telecommunication (ESPIRIT) module and the Habitation and Logistics Outpost (HALO) module.

Additionally, Japan plans to use its experience resupplying the ISS with the HTV to develop the next generation of autonomous transfer vehicles for potential use in the Gateway Program.[4] In the vein of a continued partnership in human space exploration, the United States and Japan have also affirmed aspirations to include Japanese astronauts not only on missions to Gateway, but also on missions to the lunar surface. In short, Japan and the United States have a growing bond in space exploration that continues to strengthen with every joint venture. As summed up in a statement from Vice President Kamala Harris:

> Japan's contributions will advance scientific knowledge and protect our brave astronauts exploring the depths of outer space. And this brings us one step closer to one day having a Japanese astronaut walk on the moon. Today we celebrate U.S.-Japan cooperation in space, which has never been stronger.[5] ■

Endnotes

1 Brian Harvey, Henk H. F. Smid, and Theo Pirard, *Emerging Space Powers: The New Space Programs of Asia, the Middle East, and South America* (London: Praxis, 2009).

2 Ibid. Toyohiro Akiyama became the first journalist to give live reports from space, and this venture became the first commercially sponsored and funded spaceflight of an individual when the Tokyo Broadcasting Service paid for the experience.

3 Pete Harding,"HTV-3 Arrives to Make Large Delivery of Supplies and Research Cargo to ISS," NSF, 27 July 2012, https://www.nasaspaceflight.com/2012/07/japans-htv-3-large-delivery-supplies-and-research-cargo-to-iss/ (accessed 1 December 2023).

4 JAXA, "HTV-X," https://humans-in-space.jaxa.jp/en/htv-x/mission/ (accessed 17 November 2023).

5 "Statement by Vice President Kamala Harris on U.S.-Japan Space Cooperation," 17 November 2022, the White House, https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/17/statement-by-vice-president-kamala-harris-on-u-s-japan-space-cooperation/ (accessed 17 November 2023).

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22 Block et al., "A Case Study," pp. 21–22; Maharaj, "Satellite Broadcasting in Rural India," p. 235.

23 See, for example, Gurbir Singh, "ISRO Prepares for Human Spaceflight," 23 October 2023, https://thespacereview.com/article/4673/1/ (accessed 29 November 2023).

24 Chawla flew on the STS-87 mission then. She later flew on the STS-107 mission, which ended tragically when the Columbia orbiter broke apart on atmospheric reentry on 1 February 2003.

25 Frutkin, "The India-US Satellite Broadcasting Experiment," p. 2.

26 Krishnamoorthy, "A Satellite in the Service," p. 12.

27 Quotation is from John Krige, "Introduction and Historical Overview: NASA's International Relations in Space," chap. 1 in Krige et al., *NASA in the World*, p. 15. See also Maharaj, "An Overview of NASA-India Relations," pp. 211–213, 218. U.S.-based Ford Aerospace built four satellites for the previously mentioned INSAT program. See Maharaj, "Satellite Broadcasting in Rural India: The SITE Project," pp. 240–241, 246.

28 Maharaj, "An Overview of NASA-India Relations," pp. 211–213, 218, 221, 230.

29 Daniel Duchaine, "Enter India, the Fifth Great Space Power," 4 December 2023, https://www.thespacereview.com/article/4702/1 (accessed 14 December 2023).

30 Abbey A. Donaldson, "NASA Administrator to Travel to India, UAE; Discuss Space Cooperation," NASA Media Advisory M23-140, 24 November 2023, https://www.nasa.gov/news-release/nasa-administrator-to-travel-to-india-uae-discuss-space-cooperation/ (accessed 14 December 2023).

International Project Management Course

Partnering and Learning Together

» By **Tiffany L. Smith**, Chief Knowledge Officer and Director, NASA's APPEL Knowledge Services

Participants in NASA's February 2023 International Project Management course pose for a group photo at the Kennedy Space Center Visitor Complex in Florida. (Photo credit: NASA/Daniel Connell)

EFFECTIVE INTERNATIONAL project management requires technical knowledge, organizational and cultural awareness, and a range of interpersonal and leadership skills. In addition, approaches that support team effectiveness within one culture may detract in another. How might you negotiate with an organization that handles risk using an entirely different paradigm? How would you support communication among a team with members who speak seven different primary languages at home?

NASA's International Project Management (IPM) course is designed to help engineers and project management professionals answer these and many other questions.[1] Hosted by the Office of the Chief Engineer's Academy of Program/Project and Engineering Leadership (APPEL) in collaboration with NASA's Chief Program Management Officer, the IPM course has been delivered for over 20 years. Early iterations of the course returned positive results. Then, in 2010, NASA helped to establish the International Project/Programme Management Committee of the International Astronautical Federation, which focuses on learning and development for space programs and projects.[2] NASA asked the committee to review materials and provide feedback to improve the IPM course. Today, NASA continues to gather input from committee members and other international partners and invites representatives from their organizations to share expertise as guest speakers and participants in the biannual workshop.[3]

Many participants have joined the course with extensive prior experience in international projects, although participants do not need to have a complete understanding of all aspects of international collaboration. Course participants gain familiarity with the processes and practices of international partners, learn how other aerospace organizations formulate and implement their projects, and practice collaborating and negotiating across cultural and geographic boundaries.[4] Through these activities, course participants develop the competence needed to achieve mission success in the international environment.

The next IPM offering is planned for February 2024. A typical agenda includes sessions on cultural awareness, lessons learned, international ethics, and export control, as well as case studies and featured topics. APPEL welcomes expert guest speakers and participation from historians and those at NASA with personal experience in international aeronautics and space projects.

Learn more about the International Project Management course and find out how to register.

Endnotes

1 APPEL, "International Project Management (APPEL-IPM)," https://appel.nasa.gov/course-catalog/appel-ipm/ (accessed 1 December 2023).

2 International Astronautical Federation, "International Project/Programme Management Committee (IPMC) (2018-2021)," https://www.iafastro.org/about/iaf-committees/administrative-committees/international-project-programme-management-committee-ipmc.html (accessed 1 December 2023).

3 APPEL, "The International Project Management Program as a Leading Practice," https://appel.nasa.gov/2016/09/20/the-international-project-management-program-as-a-leading-practice/ (accessed 1 December 2023).

4 APPEL, "Understanding International Project Management," https://appel.nasa.gov/2012/11/01/understanding-international-project-management/ (accessed 1 December 2023).

News from Around NASA

CALL FOR PAPERS: NASA and Archaeology from Space

A Symposium in Honor of Dr. Thomas L. Sever

18–19 September 2024 • Washington, DC

The organizers invite proposals for papers to be presented at a two-day symposium to be held in person 18–19 September 2024 in Washington, DC. We welcome diverse voices and perspectives to examine the history of NASA and archaeology from space.

The purpose of this symposium is to honor the pioneering work of former NASA archaeologist Dr. Thomas L. Sever in the field of archaeology and remote sensing over his many decades of service and numerous contributions. The symposium also seeks to provide insight and contextualization of past archaeology projects at NASA, highlight the current state of the field in terms of research and capabilities, and point to new opportunities in government and commercial sectors.

Potential topics include, but are not limited to, past archaeological projects, technology/capability developments, geopolitical considerations, assessments of the current state of remote sensing/archaeology, future trajectories, potential breakthroughs, and interdisciplinary approaches.

Presentations might also consider the impact of environmental, geopolitical, social, and cultural issues on archaeology/remote sensing projects over the decades and today.

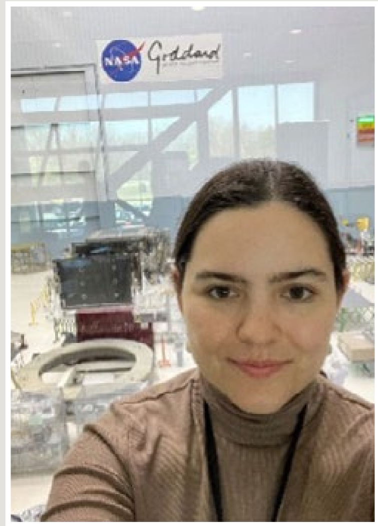
The symposium will be a combination of panel discussions, keynote talks, and presentations on current NASA and industry capabilities. The intention is to publish an anthology of selected papers.

Submission Procedures

If you are interested in presenting, please send your presentation's title, an abstract of no more than 300 words, and a short biography or curriculum vitae, including affiliation, by 15 April 2024 to Brian C. Odom or Kelsey Herndon. Questions about the symposium are also welcome. ■

Learn more about Dr. Thomas Sever's archaeological research.

INTERN SPOTLIGHT



Laura Pratt is a second-year master's student in library and information sciences at the University of Maryland. After her first internship at Goddard Space Flight Center in spring of 2023, Laura returned for a fall 2023 internship. During this internship Laura has worked to continue processing the records of Dr. Claire Parkinson, who served as a NASA climatologist for 40 years. Processing the collection included physical preservation, donor relations work, and digital file management. Laura has also worked to evaluate records for accessioning into the collection and created a preliminary processing plan for the Angelita Castro-Kelly Collection. Following the close of her NASA internship, Laura will be joining the National Archives and Records Administration in College Park as a civil servant archives technician.

CALL FOR PAPERS

Contributions of the DC-8 to Earth System Science at NASA: A Workshop

NASA's DC-8 Airborne Laboratory flies over the snow-capped Sierra Nevada mountain range in February 1998. (Photo credit: NASA/Jim Ross)

13–14 August 2024 • Washington, DC

Jointly organized by the NASA History Office and the Earth Science Division, this workshop seeks to document the important contributions of airborne campaigns implemented on NASA's DC-8 Airborne Science Laboratory. The workshop will be a combination of keynote talks, panel discussions, and roundtables. The intention is to publish an anthology of selected papers of key presentations.

NASA's DC-8 aircraft recently completed nearly four decades of service to NASA with its retirement in early 2024 following the completion of the Airborne and Satellite Investigation of Air Quality campaign. The DC-8, which NASA acquired in 1985, was a workhorse aircraft for the Airborne Science Program of NASA's Earth Science Division (ESD), serving as the primary platform—or one of several platforms—of many airborne campaigns. Its contributions are legendary, from flying as part of the first polar stratospheric ozone campaigns in the late 1980s through campaigns focused on ice sheets, sea ice, terrestrial ecology, greenhouse gases, and air quality that continued throughout its lifetime.

Besides the process knowledge that the DC-8 provided, it served as an important proving ground for new instrumentation and techniques that helped pave the way for their eventual use in ESD's spaceflight program; as a source of calibration/validation data for ESD's satellite instruments; and as a flying laboratory for students, postdocs, and early-career professionals to design, build, and test instruments and acquire and analyze data. It also was the primary platform for NASA's now-15-year-old Student Airborne Research Program (SARP), which has provided hands-on opportunities for well over 400 young scientists and has an outstanding "STEM retention rate" for its past participants.

In this workshop, the ESD and related investigator communities are invited to share examples of the scientific, programmatic, and human achievement of the DC-8 over its nearly four decades of service to NASA. Besides descriptions of the science accomplished, workshop planners invite discussion of "lessons learned" about the operation of a large airborne research laboratory that can be used as NASA moves ahead with furnishing and outfitting the DC-8's successor, a B-777 that NASA acquired in 2023 in response to a strong recommendation from a 2021 report by the National Academies of Science, Engineering, and Medicine that said ESD needed to have such a platform following the retirement of the DC-8 (Airborne Platforms to Advance NASA Earth System Science Priorities: Assessing the Future Need for a Large Aircraft).

Workshop planners are seeking proposals for papers from ESD and related investigator communities—including academia, interagency and international partners, and private-sector/nonprofit entities—that detail scientific and programmatic results, lessons learned, and personal examples of how the DC-8 advanced science, informed decisions, and provided training opportunities for several generations of NASA.

If you wish to present a paper, please send an abstract of no more than 250 words and a short biography or curriculum vitae, including affiliation, by 31 March 2024 to Dr. Brian C. Odom. Questions about the symposium are also welcome.

More about the DC-8 program.

In Memoriam

Thomas K. Mattingly II

Rear Admiral Thomas K. Mattingly II, prime crew astronaut for Apollo 13, Apollo 16, STS-4, and STS-51C, passed away on 31 October 2023 at the age of 87.

Watch a video memorializing his contributions to NASA's human spaceflight program and learn more about his career.

Frank F. Borman II

Astronaut Colonel Frank Borman, commander of the Gemini VII and Apollo 8 missions, passed away on 7 November 2023 at the age of 95.

Read Administrator Bill Nelson's statement regarding his passing.

Learn more about his career at NASA.

Stephen G. Jurczyk

Steve Jurczyk, whose career at NASA spanned more than 30 years, passed away on 23 November 2023 at the age of 61. Among other leadership roles, he served as the Director of Langley Research Center (2014–15), the Agency's Associate Administrator (2018–21), and NASA's Acting Administrator in 2021.

Read his NASA biography.

Mary L. Cleave

Dr. Mary Cleave, scientist, engineer, and veteran of two Space Shuttle flights (STS-61B and STS-30), passed away on 27 November 2023 at the age of 76. In March 2000, she served as Deputy Associate Administrator for advanced planning in the Office of Earth Science at NASA Headquarters. Then, in 2005, Cleave became the first woman to head NASA's Science Mission Directorate until her retirement in February 2007.

Read NASA's article celebrating her contributions to the Agency.

Upcoming Meetings

4–7 JANUARY 2024
American Historical Association Annual Meeting
San Francisco, California
https://www.historians.org/annual-meeting

8–12 JANUARY 2024
American Institute of Aeronautics and Astronautics (AIAA) SciTech Forum
Orlando, Florida
https://www.aiaa.org/events-learning/event/2024/01/08/default-calendar/2024-aiaa-science-and-technology-forum-and-exposition-(aiaa-scitech-forum)

18–19 JANUARY 2024
Discovery@30, New Frontiers@20 Symposium
Washington, DC
https://www.nasa.gov/feature/call-for-papers-for-discovery30-new-frontiers20-symposium

2–3 FEBRUARY 2024
Policy History Studies: The State and Future of the Field
Tempe, Arizona
https://jph.asu.edu/conferences

20–22 MARCH 2024
American Astronautical Society's Annual Robert H. Goddard Memorial Symposium
College Park, Maryland
https://astronautical.org/events/goddard/

26–28 MARCH 2024
International Astronautical Federation Spring Meetings 2024
Paris, France
https://www.iafastro.org/events/iaf-spring-meetings/iaf-spring-meetings-2024.html

3–7 APRIL 2024
American Society for Environmental History Annual Meeting
Denver, Colorado
https://www.aseh.org/events

11–14 APRIL 2024
2024 Conference on American History
New Orleans, Louisiana
https://www.oah.org/conferences/oah24/

12–15 APRIL 2023
National Council on Public History Annual Meeting—"Historical Urgency"
Salt Lake City, Utah
https://ncph.org/conference/2024-annual-meeting/

30–31 MAY 2024
Society for History in the Federal Government Annual Meeting
Washington, DC
https://shfg.wildapricot.org/page-18391

20–21 JUNE 2024
Environmental Justice in Space Workshop
Virtual meeting
https://bit.ly/ejis-workshop

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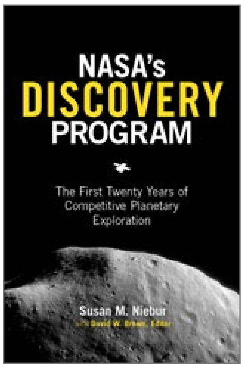
View of the International Space Station Payload Operations Center at NASA's Marshall Space Flight Center in Huntsville, Alabama, in 2001. (Photo credit: NASA)

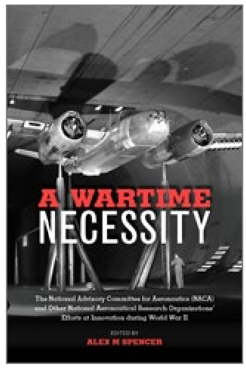
EXPLORE

New Titles in the NASA History Series



NASA's Discovery Program

By Susan M. Niebur with David M. Brown (ed.)



COMING SOON

A Wartime Necessity

Edited by Alex M Spencer

NACA to NASA to Now

by Roger D. Launius

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