SCIENCE & DIPLOMACY

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

A quarterly publication from the AAAS Center for Science Diplomacy

Julie Payette, "Research and Diplomacy 350 Kilometers above the Earth: Lessons from the International Space Station," *Science & Diplomacy*, Vol. 1, No. 4 (December 2012). http://www.sciencediplomacy.org/article/2012/research-and-diplomacy-350-kilometers-above-earth.

Research and Diplomacy 350 Kilometers above the Earth: Lessons from the International Space Station

Julie Payette

THE construction of the International Space Station (ISS) began in earnest and dramatic fashion in 1998[1] when the U.S.-built module Unity was mated with a Russian module using the Canadian-built robotic arm on the space shuttle. After fourteen years of multiple redesigns, cutbacks, and intricate intergovernmental negotiations, the dream of a permanent, peaceful, and collaborative occupation of near Earth orbit had begun. Fittingly, the Russians had named their first module Zarya to signify the dawn of a new era of international cooperation in space. What is perhaps the most complex and technically ambitious large-scale engineering project ever undertaken by a group of nations—the building of a scientific laboratory in the harsh environment of lower Earth orbit—is as much a foreign policy and human achievement as it is a technical one.

ISS Today

A massive object spanning the area of a U.S. football field, the ISS[2] was painstakingly built in bits and pieces over dozens of assembly flights spanning

Julie Payette is currently serving as Québec's Scientific Delegate to the United States. She is a Canadian engineer and astronaut who flew two space missions aboard the Space Shuttle for the construction of the International Space Station. While a public policy scholar at the Woodrow Wilson International Center for Scholars in 2011, she investigated the political and social impact behind international collaboration in large-scale scientific projects.

more than a decade. Comprised of ten pressurized modules, it has more livable room than a conventional five-bedroom house, featuring two bathrooms, numerous pieces of exercise equipment, sleeping quarters for six crewmembers, and a 360 degree bay window. Following a short line of previous space stations that includes the Soviet Salyut stations, the U.S. Skylab, and the Russian Mir,[3] the ISS is the only habitable research laboratory currently operational in microgravity.

Barreling at twenty-five times the speed of sound[4] some 350 kilometers above the surface of the Earth, ISS orbits the Earth sixteen times every day. When observed from Earth at the times of the most visible illumination (which happens shortly after sunset or before sunrise to the ground observer), the ISS is the brightest star in the firmament, and the only one obviously on the move.

Besides electricity, which is generated on board via four pairs of gigantic solar arrays, all supplies and payloads for ISS are brought from Earth through cargo spacecraft. Water, in particular, is a very precious resource used to produce oxygen, to rehydrate food, and for hygiene. Its rate of usage and reserves are heavily monitored and the station recycles most of its air and water. Equipment and crew transfer needs are provided via government-owned spacecraft from Russia, Europe, Japan, and, up until recently, the United States, via the Space Shuttle. On May 25, 2012, however, U.S.-based Space Exploration Technologies Corporation (SpaceX) became the world's first privately held company to design, launch, dock, and recover a re-supply ship, the Dragon spacecraft, to the ISS.

Although consisting of one physical entity, jointly managed and monitored by all partners, the ISS is operationally divided into a U.S. segment and a Russian segment, which are separately (but not exclusively) controlled from the ground via two main mission control centers (MCC): one at the NASA (National Aeronautics and Space Administration) Johnson Space Center in Houston, Texas, and one operated by the Russian Space Agency in Korolev, north of Moscow. Additional control centers are in Tsukuba, Japan (for the KIBO Japanese laboratory complex), Munich, Germany (for the European-built Columbus laboratory), and Montreal, Canada (for robotics operations), but MCC-Houston is the primary center for mission design, development, and integration.

The station has been continuously occupied for more than twelve years by astronauts of fifteen different nationalities. It has long exceeded the previous record of 3,634 days set by Mir in 2010.[5] On board ISS, crew members serve as operators, engineers, maintenance personnel, and scientists, conducting research in basic life and physical sciences, human health, and earth and environmental science. The station is also used as a test bed for new spacecraft systems and future technologies. The official language of the station is English, but operations are conducted in both Russian and English. No passport or visa are required to board and move about the station. Funded until 2020, the ISS is expected to operate until 2028.

ISS—A Foreign Policy Decision

In the early 1980s, after years of Soviet dominance of human presence in lower Earth orbit and the demise of America's own space station, Skylab—which was abandoned after two years of use and came crashing into the Earth's atmosphere in 1979, with debris falling over western Australia—the U.S. government was eager to launch its own module station as a counterpart. The idea was made official in January 1984 in President Ronald Reagan's State of the Union address. In a style somewhat reminiscent of President John Kennedy's famous 1961 Moon speech, President Reagan asked for a space station to be built in partnership with other countries "within a decade." Europe, Japan, and Canada responded to the invitation and Reagan's station was named "Freedom" as a symbol of unity of the Western world in the Cold War. "We can follow our dreams to distant stars, living and working in space for peaceful, economic, and scientific gain," Reagan said. "Tonight, I am directing NASA to develop a permanently manned space station and to do it within a decade, NASA will invite other countries to participate so we can strengthen peace, build prosperity, and expand freedom for all who share our goals."

After the fall of the Soviet Union and with the space race therefore effectively over, the former Cold War warriors were quick to sign the 1992 Agreement between the United States of America and the Russian Federation Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes in which they pledged to collaborate and have their crew members fly on each other's vehicles. Meanwhile, plagued by budget and design constraints, the plan of building the Freedom space station had hardly progressed and the project was nearly cancelled.[6]

By June 1993, the Advisory Committee on the Redesign of the Space Station recommended that NASA pursue opportunities for cooperation with Russia in order to reduce costs, enhance Freedom's capabilities, and (it was hoped) achieve earlier completion of the assembly.[7] The committee also recommended that the redesigned space station be launched to an orbit that would accommodate Russian launches in order to provide alternative transport to the station.[8] The Russians agreed to join in and the new space station configuration, which included hardware to be purchased from Russia, was renamed the International Space Station Alpha (ISSA). The 1993 ISS agreement was in fact a contract with the Russian Space Agency (Roscosmos) that was to be executed in three phases, considered as single packages, with the ultimate objective of building and operating a joint scientific research complex in space.

The first phase was designed to allow the United States to learn from Russian experience in long-duration spaceflight and to foster a spirit of cooperation between the two nations. It involved nine shuttle flights to Mir between 1995 and 1998. Space Shuttle Atlantis was modified and outfitted with a Russian docking mechanism so that a connection between the two vehicles could be made. Conducted while intense negotiations and on-going dealings regarding the details of the ISSA's construction were taking place, the joint Phase 1 flights were a great success and set the table for the development of techniques for the assembly and operation of the future station. Mir was last visited in 2000 and successfully de-orbited on March 23, 2001, making a spectacular, controlled re-entry into the Earth's atmosphere and scattering its unburned fragments as planned over an uninhabited remote area of the South Pacific Ocean.

In 1998, the ISS partners (Canadian Space Agency [CSA], the European Space Agency [ESA], the Italian Space Agency [ASI], the Japan Aerospace Exploration Agency [JAXA], NASA, and Roscosmos) were ready to formalize their plans. They dropped the "Alpha" from ISSA and signed a series of Intergovernmental Agreements and Memoranda of Understanding amongst themselves that established the ownership of modules, the station usage by participant nations, the contractual obligations, and the rights and responsibilities of each. Spearheaded by the determination of the United States government to get everyone on board and tap into the potential of scientific cooperation as a unifying tool, this unprecedented body of international framework agreements laid out the basis for the station that orbits Earth today.

Science Goes International

The idea of nations getting together and collaborating to build some elaborate scientific platform is part of what seems to be a clear international trend of the past few decades: science, and particularly "big science," has become a global affair.

Large-scale international projects involving several countries with formal agreements to achieve specific science, R&D, or engineering goals are now not only common, but utterly successful. As is the case for the ISS, such projects pursue highly complex technical objectives, require global knowledge and industrial resources, span years or even decades, and usually entail the design, construction, and operation of large, unique facilities.

As Barry Shore and Benjamin J. Cross wrote in the *International Journal of Project Management*, "these projects are more complex because they often require cooperation from organizations or groups whose managers come from countries where management processes and decision-making behaviour are very different. One underlying factor that helps to explain and understand these differences is the national culture in which these managers have been raised, educated, and trained."[9]

As an example, the world's largest particle accelerator—the Large Hadron Collider (LHC)[10] built by the European Organization for Nuclear Research (CERN)—is a masterpiece of international scientific collaboration. Lying in a 27 km radius circular tunnel buried beneath the border of France and Switzerland, the LHC was built in collaboration with thousands of scientists and engineers from around the world and helps answer some of the most fundamental and exciting questions of modern physics. Another consortium of nations is completing the construction of an array of sixty-six radio telescopes—the Atacama Large Millimetre/sub-millimetre Array (ALMA)[11]—at an altitude of five thousand meters in the Atacama Desert of northern Chile. The ALMA Observatory is expected to provide unprecedented images of local star and planetary formations.

ITER,[12] a long-haul research and engineering project in plasma physics, is similarly promising. Located in the south of France, ITER is currently building the world's most advanced experimental nuclear fusion reactor. It is sponsored and run by a massively global group of nations: the European Union (EU), India, Japan, China, Russia, South Korea, and the United States. ITER, scheduled to be in operation in the 2020s, carries high hopes that its outcome will eventually lead to the construction of plasma fusion power plants that will bring this highly efficient, renewable, and clean energy to the commercial market.

Many surmise that international scientific collaboration has intensified as of late mostly because large research is too costly for single nations to undertake alone. While this may be true, there is more to it than just finance.

ISS as a Foreign Policy Tool

The benefits of the space station are manifold. As a permanent, habitable infrastructure in lower Earth orbit, it advances the understanding of the impacts of living outside the boundaries of the planet, helps build a foundation for future technologies and for the human exploration of the Moon, Mars, and beyond. A world-class microgravity laboratory also adds to our knowledge base in human health and physical sciences and enhances the quality of life here on Earth. The station also benefits the science and engineering community by creating jobs for tens of thousands of highly qualified personnel involved in the design, development, fabrication, mission control, management, training, and operation of such a complex infrastructure. Finally, the presence of humans onboard an orbital outpost is viewed by many as quite inspiring and serves to motivate the next generation of scientists, engineers, writers, artists, politicians, and explorers. However, the ISS's tour de force is not simply in engineering and R&D, it is in the unprecedented collaboration, synergy, and entente the partners have displayed through its planning, construction, and, now, utilization phase.

In today's world, communications are as instantaneous as they are far reaching. Nations are forced to collaborate if they are to remain competitive in a constantly evolving technological landscape, and the participation in multilateral projects produces important collateral foreign policy benefits.

Most governments acknowledge both the imperative of teaming up in order to address the mounting number of global challenges requiring multilateral solutions, such as climate change, overpopulation, and disease, and the ability of science to create new or reinforce existing partnerships between countries that can be sustained regardless of the political winds.

Although built on the argument of scientific advances and economic benefits to come, many are convinced that bringing Russia into the ISS program was mainly prompted by foreign policy reasons. In "Partnership – The Way of the Future for the International Space Station," Tara Miller wrote, "One reason Russia was asked to join the space station program dealt with financial problems. However, since the inclusion of the RSA into the partnership, the ISS has become a foreign policy tool. The ISS is used to help prevent the transfer of advanced engine technology from Russia to other countries. It is hoped Russia's space program can be used in a constructive manner, to ensure that inter-continental missile technologies do not fall into the hands of warring states."[13]

The truth is that ISS has been a model of science diplomacy.

The ISS has been constructed by a group of eclectic partners—some of whom were more or less enemies in the not-so-distant past—who chose to believe in the same vision and to surmount their cultural, organizational, and political differences in order to march in the same direction. It is being operated, maintained, and used around the clock 365 days a year in one of the most unforgiving environments possible, with facilities, equipment, managers, and crew located around (and above) the globe, across time zones, borders, languages, and cultures. Consider also that the station has been inhabited by men and women without interruption for over a decade. All this occurred without an onboard scuffle or major international incidents. In fact there has been so little drama surrounding ISS that the station rarely makes headlines.[14]

To make it to the goal of "Assembly Complete" and overcome the odds, the partners were careful in working out solutions that were viable in the context of the global economy and global inequality. They had made plans, negotiated financing, organized resources, allocated personnel, created schedules, and controlled the activities in proportions that were compatible with their national priorities.

In 2009, as the construction of the ISS neared completion, the partners reflected on this achievement and attempted to capture the lessons learned over the design, development, assembly, and operations phases.[15] They emphasized that one of the keys to the success of such endeavours was to develop a long-term shared vision that transcended domestic policies and fostered a shared destiny. They wrote that they had learned that the mission objective should be a succinct, inspiring statement and goals should be clearly defined to enable partners to participate based on their objectives and priorities to the greatest extent possible while ensuring the provision of all critical path items. Formal frameworks were deemed essential and plans should account for unforeseen events, or withdrawal of participants, without jeopardizing the overall mission objective.

The ISS partners also recognized the role of key characteristics such as flexibility, realistic objectives, graceful integration, workable provisions for export control, and the definition of clear processes for the common interfaces and the critical systems. They underlined the strength of using a consensus approach for decision making and of having agreements on communication processes, conflict resolution, and codes of conduct. They understood the need to anticipate and accommodate partner budget cycles and fluctuations, the importance of securing and maintaining political support, and the benefits of considering and including commercial involvement.

Their foresight paid off. And unbeknownst to the ISS partners, by using a scientific platform to showcase their benevolence and their know-how, they may have set a new trend. Nowadays, in an effort to demonstrate and maintain leadership, make a mark, be part of the forerunners, or simply be noticed, many nations have updated their traditional model of political, commercial, and cultural representation to include diplomatic representation of their innovative skills, research achievements and potential, and of the quality of their highly qualified workforce. In other words, science diplomacy is on the rise.

As Australia's chief scientist, Ian Chubb, pointed out, "It stands to reason, then, that scientific expertise should be a fundamental part of diplomatic efforts. As single nations can neither solve them alone nor develop solutions to every problem, scientific cooperation becomes an increasing necessity."[16]

Legacy

The International Space Station represents a paradigm shift from the way we used to approach human exploration of space. Although its accomplishments may not be widely recognized at the present, ISS will go down in history as a first of its kind and a formidable example of an effective foreign policy tool. ISS brought (and somewhat forced) nations to work together, causing them to think not from a microcosm of nationality, but in terms of pushing the boundaries of the known world as partners, in a collaborative spirit and a peaceful manner. While it may be an unusual behavior for human beings to adopt when it comes to opening uncharted territory, it is a promising development.

Hopefully, the lessons of collaboration the station brought will encourage emerging countries and nations that are currently still going it alone to reach out, and the mechanisms that made ISS and other large scientific projects a success can be applied to other domains elsewhere on Earth, and follow us beyond, as we continue to push the frontier of our search and travels. SD

Endnotes

1. Space Shuttle Endeavour. Mission STS-88. December 4-15, 1998. Featured in the 2002 documentary "IMAX Space Station 3D."
2. The first element of the ISS was launched on November 20, 1998, and the space station was completed more than a decade (and 41 assembly flights) later, in May 2011. For more information on the International Space Station visit http://www.nasa.gov/mission_pages/station/main/onthestation/facts_and_figures.html.
3. Salyut 1, the first space station, was launched by the USSR in 1971. Seven Salyut stations were built during the Soviet era with the last one, Salyut 7, last visited in 1986 and de-orbited in 1991. Skylab was launched and operated by NASA from 1973 to 1979. Mir was built and launched in 1986 but continued to be operated by the Russians until 2001, well after the fall of the Soviet Union.
4. Average orbital speed: 28,000 km/hr (17,500 miles/hour)
5. As of December 1, 2012, ISS has been in orbit 5,125 days and continuously inhabited since November 2, 2000.
6. David Harland, *The Story of Space Station Mir*. (New York: Springer-Verlag New York Inc., 2004). ISBN 978-0-387-23011-5 (from http://en.wikipedia.org/wiki/Mir).
7. United States General Accounting Office. 1994. *Space Station: Impact of the Expanded Russian Role on Funding and Research.* Report to the Ranking Minority Member, Subcommittee on Oversight of Government Management, Committee on Governmental Affairs, U.S. Senate. Washington, DC, Government Printing Office. GAO/MUD-94-220.
8. Hence the selection of a 51.6 degree inclination for the orbit of the ISS, which is the latitude of the Baikonur Cosmodrome, the main Russian rocket launching site in the south of Kazakhstan.
9. Barry Shore and Benjamin J. Cross, "Exploring the role of national culture in the management of large-scale international science projects," *International Journal of Project Management* 23 (2005): 55-64, accessed Nov 20, 2012, http://www.kth.se/polopoly_fs/1.226500!/Menu/general/column-content/attachment/shore.pdf.
10. European Organization for Nuclear Research (CERN). "The Large Hadron Collider," accessed November 21, 2012, http://public.web.cern.ch/public/en/lhc/lhc-en.html.
11. Atacama Large Millimeter/submillimeter Array, accessed November 20, 2012, http://www.almaobservatory.org/.
12. ITER, accessed November 20, 2012, http://www.iter.org/
13. Tara S. Miller, "Partnership – The Way of the future for the International Space Station." NPMA 16, no. 5 (2004).
14. Of course, some would point out that it is easy to avoid conflict between six highly trained individuals. There is truth to that: the station crews consist of professional astronauts who have been selected and groomed for years to stay focused, get along, and put aside their personal interests for the sake of the mission. ISS crewmembers are incessantly conscious of representing their nations and unfailingly on their best behavior. When space tourism expands and public orbital infrastructure becomes a reality, as will likely happen in the decades to come, and a greater number and variety of people enter the expanses of space, undoubtedly conflict will arise.
15. International Space Station Program. Multilateral Coordination Board (MCB) Consolidated Lessons Learned. NASA Kennedy Space Center, July 22, 2009, http://www.nasa.gov/pdf/511133main_ISS_Lessons_Learned_7-22-09_complete.pdf.
16. Ian Chubb, "The Value of Science Diplomacy," Commonwealth of Australia, accessed November 21, 2012, http://www.chiefscientist.gov.au/about/.

The author thanks Kathryn Tokle of the University of Montana and the Quebec Washington Bureau for assitance with this article.