The International Space Station:
DECISION 2015

Executive Summary

The United States should continue its participation in the International Space Station (ISS) program until 2020 or beyond. The nation should support a comprehensive research agenda throughout this time, fully using the unique resources available aboard this orbiting national laboratory.

1. Continued use of the ISS will help the United States maintain its international leadership position in space activities.

2. The United States will demonstrate that it is a reliable collaborator for future international projects by continuing to work with its international partners to capitalize upon the unique, paid-for capabilities of this research platform.

3. The United States can continue to drive innovation by supporting a full research agenda on the ISS with participation from government agencies as well as academic and commercial enterprises.

4. The ISS provides unique facilities and opportunities to carry out research that will better prepare the United States for future long-term space exploration.

5. Education initiatives associated with the ISS, which have already reached more than 31 million students in the United States, will continue to inspire students and enhance U.S. competitiveness by providing hands-on opportunities to learn about math and science.

6. Utilization of the ISS can help the United States nurture its high-tech workforce, with thousands of people across 37 states currently associated with the ISS program, also contributing to global competitiveness.

7. NASA can continue to encourage commercial space development by providing opportunities for commercial operators to undertake ISS resupply missions and other tasks and operations.

8. ISS completion is scheduled for 2010, after which the cost of continuing operations will be relatively low, while the potential benefits to be gained from onboard research and development will be higher than at any previous time.

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Evolution of the International Space Station

The ISS is orbiting about 350 kilometers (220 miles) above Earth. Previously operated by three international crew members, it is now continuously occupied by a multinational crew of six. It is the largest human-made object ever to orbit the Earth. Fifteen countries are involved in the project, and all of the partners are contributing components to be integrated in orbit. The operations and management centers involved in the program are located in eleven countries and staffed by international teams. In 2008, the laboratory space and research facilities were tripled with the addition of the European Space Agency's (ESA's) Columbus module and the Japan Aerospace Exploration Agency's Kibo module joining NASA's Destiny Laboratory, creating a research area about the size of three large buses.[1]

Despite these accomplishments, the United States is currently planning to end its participation in the program in 2015, and the ISS is scheduled for a controlled de-orbit in 2016. International partners are interested in continuing the program but its fate is still uncertain. To understand why, it is useful to have an understanding of how the ISS program developed and how the current situation evolved.

A view of the International Space Station from Space Shuttle *Discovery* as it departs after a successful mission in September 2009.

Credit: NASA

As far back as 1959, the NASA Office of Program Planning and Evaluation's *Long Range Plan of the National Aeronautics and Space Administration* set a target date of 1965-1967 for launching a program leading to a permanent near-Earth space station. The plan predicted that manned flight to the Moon would happen later.[2] These plans were changed as the United States began its race to the Moon in competition with the Soviet Union. After the success of Apollo, NASA reiterated its interest in a permanently manned space station.

In September 1969, the NASA Space Task Group noted that "a space station module would be the basic element of future manned activities in Earth orbit, of continued manned exploration of the Moon, and of manned expeditions to the planets." The base was to be used as a laboratory for a broad range of physical and biological experiments.[3] In 1973, the Skylab space station was launched to test some of the concepts and technologies for living in space. Over the course of a year, Skylab was used for three missions ranging from 28 days to 84 days in length. Further missions were prevented by unexpectedly high solar activity that would have posed a danger to the astronauts. Skylab later re-entered the Earth's atmosphere and broke up over Australia and the Indian Ocean.[4]

The funding provided to NASA did not allow the agency to implement the long-term vision put forth by the Space Task Group until the 1980s, when NASA again began to pursue the objective of developing a continuously manned station in low Earth orbit. Although the idea had been around for many years, and had long been a part of NASA's plans, the path to political approval was rocky. Many political actors, including members of Congress and those in the executive branch, did not support proposals to create a space station. The significant costs of space endeavors, while quite small in the landscape of the overall federal budget, are seldom easily approved. However, President Ronald Reagan was very supportive of the project, and it was likely his support that helped gain approval for the program.[5]

To build and sustain broad interest in the project, NASA incorporated the interests and goals of many different potential users. Allowing form to follow function, NASA opted to put forth a list of missions that the space station would be designed to carry out. This helped NASA ensure that there was widespread interest in the project without it becoming prematurely "locked in" to a specific technical design. NASA proposed a modular design, allowing the desired capabilities, as well as others not yet imagined, to be added later. In his State of the Union address in 1984, President Reagan declared the space station to be one of the great national goals and directed NASA to develop a permanently manned space station, to be called Space Station Freedom.[6]

Dextre, the world's most complex space robot, was built by the Canadian Space Agency for the ISS. Dextre has arms 3.35 meters (11 feet) in length and can use power tools as fingers.

Credit: NASA

In 1985, memoranda of understanding (MOU) were signed with Japan, Canada, and the European Space Agency. By 1988, an intergovernmental agreement among participating countries was signed, and development of the station got under way. However, the program soon encountered difficulties.[7] In 1989, Congress recommended a $400 million cut in the funding request for the station. It also recommended an additional $600 million cut the following year. The effect of these budget cuts was a reduction in the space station's missions and capabilities, requiring that a scaled-down version of the station be designed. A piecemeal building plan was put together and development, manufacturing, and launch of the space station were postponed.[8]

In 1993, the Clinton Administration directed a complete reconsideration of the space station program, which resulted in a further simplification of the design. Also in 1993, due in part to a desire to promote post-Cold War cooperation between the United States and the former Soviet Union, Russia was invited to join the program, which would be renamed the "International Space Station." This invitation was accepted, and the details of Russia's participation were agreed in 1994.[9] Development of the space station continued, and the first module was launched in November 1998.[10] Since then, construction of the ISS has continued, although the loss of the Space Shuttle *Columbia* and subsequent grounding of the shuttle fleet caused significant delays.

In 2004, President George W. Bush unveiled the Vision for Space Exploration. Prominent in this vision was the commitment to complete the assembly of the ISS by the end of the decade. It called for research conducted aboard the ISS to focus on science related to exploration, including the need for research on how the space environment affects astronaut health and capabilities, and how to counter the effects of long-duration space flight. The "vision" also points out the importance of the United States living up to its agreements with, and obligations to, international partners.[11]

In 2005, the ISS was designated by Congress as a National Laboratory to encourage full use of the space station's unique research capabilities. National Laboratory status means that commercial entities and government agencies other than NASA are now also able to design and carry out research aboard the ISS.[12] NASA has established partnerships with the Department of Energy, the Department of Defense, and the Department of Veterans Affairs. MOUs have been signed with the National Institutes of Health and the U.S. Department of Agriculture, and Space Act Agreements have been signed with three private firms and a university. NASA continues to evaluate and pursue additional partnerships.

Impacts of Future ISS Use

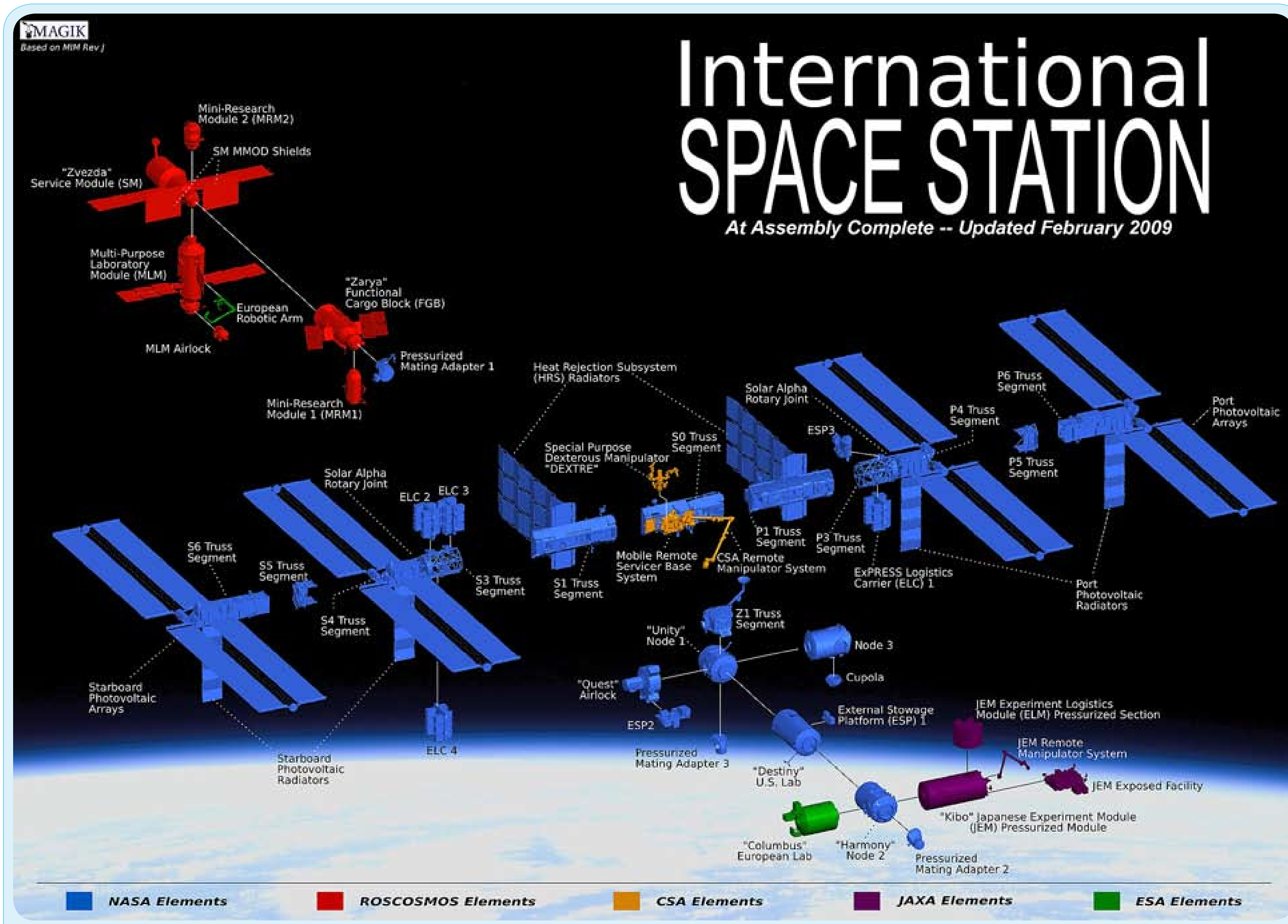
The role of the ISS, especially the impact of its continued operation past 2015, affects a wide range of issues important to the United States, including: international perceptions of the United States, international partnerships, innovation, preparation for space exploration, U.S. education and workforce development, commercial space activities, and life cycle costs.

Table 1. Overview of ISS Impacts

ISSUE	ISS IMPACT TO DATE	IMPACT OF ISS CONTINUATION
International Perceptions of the United States	• ISS is a highly visible effort • Currently demonstrates technological leadership	• Supports United States' leadership position • Sustains "soft power" for the United States
International Partnerships	• 15 international partners • More than 20 years of successful cooperation on ISS	• Shows respect for international partners, relationships, and agreements • Paves the way for future cooperation
Research and Innovation	• Government and private company interest in conducting research • More than 100 experiments carried out during ISS construction period	• Continues research that may create new technologies • Carries out cutting-edge human-tended microgravity research not possible on any other existing platform
Technology Development, Maturation, and Transfer	• New companies created in more than 20 states based on technologies developed for the ISS	• Continues to provide opportunities for ISS-developed technology to be applied to new fields
Preparation for Space Exploration	• Various hardware and software components proven successful for use in space • Studies on physiological effect of long-term space flight on humans	• Tests technologies in near-Earth orbit where launch, operation, and resupply are less costly and less demanding • Learn more about the effects of long-term spaceflight on humans
U.S. Education and Workforce	• Educational activities with ISS have included more than 31 million students in the United States, providing real-life illustrations of math and science at work • ISS workforce includes thousands of people in 37 states	• Continues educational activities and opportunities for students • Continues to sustain a highly technical workforce of thousands of Americans
Commercial Space Activities	• Commercial Orbital Transportation Services (COTS) program has provided an important market for new space launch companies	• Provides extended mission to support commercial space launch development
Cost	• $100 billion investment made in constructing ISS	• Benefits of use outweigh remaining operational costs • Continued operation costs only five cents per taxpayer each day

International Perceptions of the United States

Space activities have historically proven to be an important source of advanced technologies, power, and prestige for a nation, and the United States currently has the largest and, in most respects, the most advanced space program in the world. According to *Futron's 2009 Space Competitiveness Index*, the United States is the current leader in space competitiveness.[13] Space is viewed by many nations as an area that has the potential to benefit all of humankind, and civil space programs are viewed almost universally in a positive light.



Credit: NASA

Improving the United States' image may also increase its influence around the world. In *Space as a Strategic Asset*, Dr. Joan Johnson-Freese, an expert on space policy, addresses this aspect of the U.S. space program. She argues that leading inclusive international space programs allows the United States to build its soft power, which she defines as "reaching goals through popularity and persuasion rather than coercion." Building a positive image of America as a leader increases U.S. influence around the world.[14]

The United States initiated the ISS program and it continues to manage the assembly, servicing, operation, resupply, and most astronaut training for the station program. Through the International Space Station project, the United States is able to display international leadership and demonstrate American technical and political leadership in the context of a peaceful, widely respected undertaking. The ISS is a highly visible program, and its technologically advanced nature is obvious. This makes its contribution to the United States' global image particularly important. This aspect of the ISS program was highlighted by President Reagan when he announced the project in 1984, saying: "Our progress in space - taking giant steps for all mankind - is a tribute to American teamwork and excellence. Our finest minds in government, industry, and academia have all pulled together."

If the United States allows its leadership of the ISS program to expire in 2015, it will likely fuel negative international perceptions of U.S. capabilities, reliability, and leadership. The nation's inability to lead the ISS to the end of its design life would reflect poorly on U.S. commitment to scientific and technical endeavors. Although unlikely, it is possible that international partners would continue to operate the ISS, even if the United States abandons its investment in the project. The image of the United States is likely to suffer as it retreats from the leadership role on the largest international technical project ever undertaken. As the Review of U.S. Human Space Flight Plans Committee describes the situation, "*Not* to extend [ISS] operation would significantly impair U.S. ability to develop and lead future international spaceflight partnerships."[15] In addition, leaving the program would result in an unprecedented retrenchment: the United States abandoning a National Laboratory to other nations. Reduced to the role of a bystander, the nation would no longer benefit from the cutting-edge research and international collaboration conducted by other nations.

International Partnerships

As the world becomes increasingly interconnected, strong international partnerships are essential to the success of any nation, including the United States. The ISS allows the United States to maintain and continue to forge such partnerships and to explore ways of working successfully with other nations on technical projects. It provides a starting point for future collaboration beyond space programs, for projects of any kind.

The utility of international partnerships was recognized early in NASA's history. In 1969, considering the future of the U.S. space program, the Space Task Group noted the importance of international participation and communication. It believed this would promote a sense of world community; optimize international scientific, technical, and economic participation; apply space technology to humanity's needs; and share the benefits and costs of space research and exploration.[16] These factors continue to drive international cooperation today.

Even if increased cooperation is desirable and has been put into action during the construction phase, one may still question whether the ISS program is designed to promote future collaboration. In *The Evolution of Cooperation* by Robert Axelrod, an expert on strategic interactions, two of the primary methods for promoting future partnerships include making interactions more durable and more frequent.[17] The ISS does both. It is a highly visible, long-lasting program backed by international agreements, and therefore is more durable than other, less publicized or less formal

Japan's H-II Transfer Vehicle (HTV) on its maiden flight in September 2009, shortly before docking and unloading at the ISS. Additional HTV missions are planned as part of the resupply process for the ISS.

Credit: NASA

international arrangements. Due to the technological challenges involved in design, development, production, launch, and operation of so complex an orbital facility, frequent international interaction and iterative cooperation are essential.

Global cooperation on large-scale technical projects is a growing phenomenon, and the International Space Station has been studied as a model for these types of partnerships.[18] A great example is the 2008 integration of two international laboratories, the European Columbus lab and the Japanese Kibo lab, into the ISS. The Canadian Special Purpose Dexterous Manipulator has been added, and both the European Automated Transfer Vehicle (ATV) and the Japanese H-II Transfer Vehicle (HTV) have successfully performed servicing missions. These concrete steps forward provide strong evidence that the program is succeeding.[19]

International partners place a great deal of importance in the ISS. The name of the Japan Aerospace Exploration Agency's (JAXA) laboratory Kibo means "hope" in Japanese. When the first module of the laboratory was delivered in March 2008, the Prime Minister of Japan hailed it as the beginning of Japan's new "home in space."[20] Each international partner mentions its participation in the ISS program as a major effort of its space program. The JAXA vision statement, written in 2005, notes that participation in the ISS program shows Japan's status as an "equal partner with the United States and European countries" and establishes its status in the international community.[21] Russian, European, and Japanese space policy documents all mention the importance of research done on the ISS to successful future human spaceflight missions.[22]

If U.S. support for the ISS program lapses in 2015, it is likely that one of the most significant negative impacts would be on international relations, and global perceptions as to whether or not the U.S. is a reliable partner. Concern over U.S. intentions is already apparent. Even amid the excitement of the *Kibo* module being launched, an article was published in the *Daily Yomiuri*, an English-language online supplement to Japan's largest selling newspaper, that warned people not to be overly optimistic.[23] The article notes that the United States plans to shut down the ISS in 2015 and, if that happens, the Kibo laboratory will not be operational for the 10 years it was designed to last, in which case benefits from the project may be limited. The article highlights the risks of "international projects in cooperation with countries like the United States, where policies can change abruptly with the changing of administrations." The article also says that Europe has engaged in diplomatic talks with Russia and the United States about the ISS, while Japan, "has relied almost completely on the United States, and has fallen behind Europe as a result."[24] At the 2009 Paris Air Show, international partners voiced their interest in continuing the ISS mission past 2015, possibly to 2025. European Space Agency partners noted that they have a strong desire to extend the program to fully exploit their Columbus science lab.[25]

Mission specialist Hans Schlegel works on the outside of the Columbus laboratory module, built by the European Space Agency. Columbus has ten racks for experiments that can be controlled from the station or the Columbus Control Centre in Germany.

Credit: NASA

The ramifications of a decision to withdraw from the ISS program in 2015 would, therefore, extend far beyond this single project. The United States' choice to honor (or not) international commitments vis-à-vis the ISS will affect other countries' views of the United States as a partner in virtually all future endeavors. The ISS provides the opportunity to cement lasting partnerships and cooperation in many areas. A unilateral U.S. decision to end the program against the wishes of the international partners will adversely affect future programs. If the United States is unable to sustain its engagement with its international partners, it will either have to forgo future large-scale space programs, or undertake all costs on its own.

Research and Innovation

The International Space Station is the *only* existing platform that allows long-term, tended research in microgravity conditions. In the past, microgravity experiments could only be carried out using drop towers, parabolic flights, retrievable capsules, or the space shuttle, allowing research periods ranging from a few seconds to about two weeks. Experiments on the ISS have the potential to stay in microgravity for many years. This provides a unique opportunity for basic scientific research that simply cannot be done on Earth. A few of the areas of potential discovery include:

1. Basic materials research that could advance the state of the art in metallurgy, construction, manufacturing, computing, and many other fields;

2. Biological and medical research that could improve our understanding of the human body, aging, and disease, leading to new medical treatments and protocols;

3. Cellular research targeting cancer;

4. Fluid and thermal physics research with implications for alternative energy, resource management, and climate change mitigation;

5. Protein crystallography and other techniques to aid in the design and manufacture of next-generation medicines and vaccines;

6. Plant/agriculture research leading to improved crops, forestry, and environmental management.

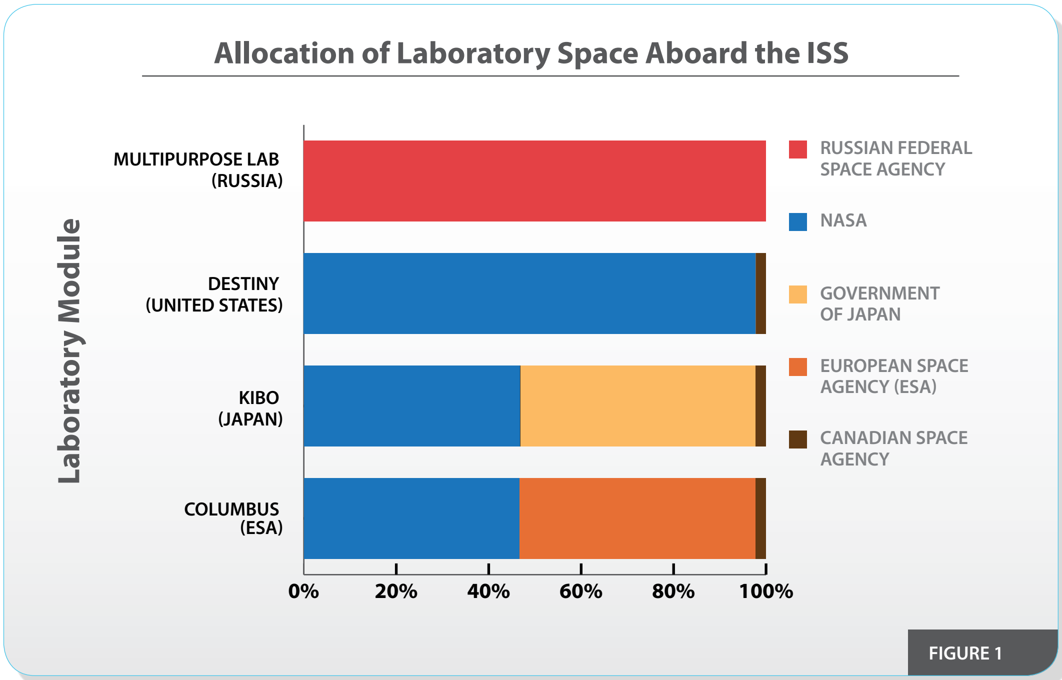


FIGURE 1

Although on-board research facilities are not yet complete, more than one hundred research projects have already been carried out.[26] According to a recent National Institutes of Health (NIH) publication, it is believed that the agency can use this unique opportunity to conduct research in the microgravity environment on the space station to provide insight into bone mass loss, muscle-wasting diseases, and disorders of the inner-ear. It may also help provide an understanding of infectious diseases and immune system response.[27] Experiments conducted on the International Space Station have already shown that pathogens become much more virulent in microgravity. Ongoing experiments are focused on bacteria such as Salmonella, which is known to cause hundreds of thousands of infections worldwide each year. Researchers hope to use this to dramatically reduce the time required for vaccine discovery.[28] Another experiment found that astronauts with basic training and minimal audio guidance could use high quality ultrasound imagery necessary for medical diagnosis. Not only does this provide a promising diagnostic tool for future space missions, it also has applications on Earth for patients in remote areas, disaster zones, and the military.[29]

The potential for technological and scientific breakthroughs based on ISS research has been one of the justifications for the program since its beginning. Some critics ask why, ten years after ISS construction began, there have been only limited advancements based on research conducted on the station. First, the ISS has been a construction zone for the past ten years. During this time, the emphasis has been on building and assembling the infrastructure for the equivalent of a research university in space – one of the greatest engineering feats in human history. Second, the assembly schedule for the ISS was delayed three years by the tragic loss of the Space Shuttle *Columbia*. Research laboratories, experimentation facilities, crew quarters, full electrical power, and other infrastructure are only now coming on line. The ISS was developed as a laboratory but the benefit of this investment cannot be fully realized until a full research agenda is carried out. If completed on schedule in 2010, performing at least a decade of research requires that the U.S. continue to lead the ISS program through at least 2020.

Astronaut Peggy Whitson works at the Microgravity Science Glovebox in the Destiny laboratory of the ISS.

Credit: NASA

Technology Development, Maturation, and Transfer

Benefits to science from basic research advancements are only one aspect of how the ISS can contribute to technological innovation. The space program is one of the most well-known sources of advanced technological research in the country. In the process of researching and designing very complex space systems, advances are made that have benefits outside the space program. The NASA Innovative Partnerships Program helps transition these advances into the private sector, benefiting global competition and the economy.[30]

Research associated with the development of the ISS, in particular, has contributed greatly to this phenomenon. For example, technology developed to recycle waste water on the ISS has led to the creation of a filtration system with the ability to purify water from the most challenging water sources. This could have important impacts in remote areas where well water is heavily contaminated by bacteria and it is already being used to purify the water supplies of hospitals in the developing world and dental practices in developed nations.[31]

For further information on the ways in which space technology provides benefits here on Earth, visit the Space Technology Hall of Fame web site at **www.spacetechhalloffame.org**

Other technologies derived from work on the ISS include air purifiers, biosensors, and advanced fire alarms. ISS-inspired technology can be found in the most unlikely places: wireless sensors developed for the program can now be found monitoring the structural integrity of three tunnels in the Netherlands.[32]

The companies associated with these advances are often partnered with NASA as part of the agency's Small Business Innovation Research (SBIR) program. The success of small businesses is essential to innovation and growth in the economy. Moreover, although some of these companies are based in states such as Texas, Florida, and California, which are often associated with the space program, others reside in a wide variety of states, including New York, Oregon, Virginia, Montana, Pennsylvania, Arizona, Georgia, Connecticut, Michigan, Colorado, Massachusetts, New Mexico, Maryland, Nevada, and New Hampshire.[33] The ISS has already proven to be an efficient engine for the creation of new, advanced technologies. The longer the program continues, the greater the likelihood that even more technologies will be developed to benefit the United States, and people worldwide.

Preparing for Exploration

One of the most broadly recognized objectives of the ISS is articulated on the NASA Exploration Web site: its "use as a test bed for technology development, demonstration, and problem resolution in the areas of life support, fire safety, power, propulsion, thermal management, etc."[34] The ISS provides the unique ability to carry out this important task.

If the United States intends to undertake long-duration exploration missions, it is essential that NASA collects empirical data on the maintainability and availability of space hardware systems. This can only be accomplished with operating experience, and the ISS offers this capability. NASA has already been able to develop and refine ventilation systems, air filtration systems, water recycling systems, and oxygen producing systems, to name only a few. When hardware components malfunction, the ISS crews have demonstrated creativity, collaboration, and teamwork in order to carry out repairs in orbit. This has led to the development of new repair techniques and has provided valuable lessons on what does and does not work in space.[35]

The benefits of having a relatively close "island in space" where systems can be tested are evident in the experience with the Remote Power Control Mechanism. This component, similar to a circuit breaker, is used frequently in space systems. When this component malfunctioned, NASA was able to study the problem and create an improved version. Thousands of replacements were shipped to the ISS and installed. Had this problem occurred on a vehicle destined for the Moon or Mars, studying the problem, creating replacements, and carrying out repairs would have been much more difficult, if not impossible.[36]

Cosmonaut Yury Lonchakov participates in a session of extravehicular activity (EVA) to perform maintenance on the ISS. The knowledge and techniques being developed will be invaluable as humans venture deeper into space.

Credit: NASA

Research on humans in space is at least as vital as research on space hardware. The ISS offers the only option for research on the effect of long-duration spaceflight on humans. The Vision for Space Exploration mentions the critical role of the ISS to "understanding the effects of space environments on the human body, developing techniques for mitigating these hazards, minimizing the logistical burden of supporting humans far from Earth, and addressing remote medical emergencies."[37] Extensive research is being done to create countermeasures to the bone and muscle loss astronauts experience during long-duration flights. Research on medical devices and procedures is also essential. Similarly, research and advances in radiation exposure and protection will be vital to the safety of astronauts on future exploration missions.

Human factors research associated with long duration space travel is also critically important. For example, research is now being carried out wherein an astronaut keeps journals that will be analyzed to help better understand the effects of living in an isolated and confined environment for extended periods.[38] Research is also being carried out on crew member and crew-ground interactions. Preliminary findings from this experiment indicate that crew members improve in mood and social climate over the course of their missions as they adapt to the new environment.[39] Research carried out on ISS allows the United States to be better prepared for its future exploration endeavors.

Bolstering Advanced Education and Workforce Development

The space program has long been recognized as a program that stimulates public interest in science and technology. According to a recent Gallup poll, 69 percent of people believe that the U.S. space program encourages young people to consider an education in science, technology, math or engineering fields.[40] These results are consistent with a study carried out by the Annenberg School of Communications and the Space Foundation in the early 1980s, which demonstrated that space-based curriculum and instruction is considerably more effective in capturing student interest than other forms of instruction.

In the first five and a half years of continuous human presence on the ISS, a wide range of student experiments and educational activities were performed. Educational activities associated with the ISS have involved more than 31 million students.[41] In early education, children perform classroom versions of ISS experiments, giving them an understanding of the type of research done in space, and allowing them to compare the results of their tests to the ones done by astronauts in orbit. With the help of a teacher or mentor, these students may design an experiment to be conducted on the ISS. High school or college students interested in engineering may participate in hardware development or space operations activities. University students work with professors to participate in NASA investigator experiments. There have been numerous types of educational demonstrations and activities, including links that allow students to speak directly with astronauts in space. With the designation of the ISS as a National Lab, NASA has partnered more closely with the Department of Education, and these education-related opportunities will continue to grow – as long as the station remains operational.

Encouraging children to go into science and technology fields is only one aspect of a national strategy to increase America's competitiveness. It is also important to attract and keep a technologically advanced workforce. This is clear in the bipartisan "America Competes Act" of 2007, in which Congress affirms the importance of NASA's contribution to innovation and competitiveness.[42] NASA requires a highly trained workforce and the ISS program contributes to this need. According to the *NASA Reference Guide to the International Space Station*, "the ISS effort involves more than 100,000 people in space agencies, and 500 contractor facilities, and in 37 U.S. states."[43] Aerospace engineers and other space-related occupations often earn salaries well above the private-sector average and help drive economic growth in these communities.[44]

A decision to cut short the lifespan of the ISS will ultimately force student experiments and station-related education initiatives to come to an end. Although new educational activities should occur in conjunction with new NASA initiatives, the ISS is uniquely well-suited for these programs. Space activities can and should be used to promote science and technology education and to inspire the next generation.

Paving the way for commercial space

An interesting benefit that also results from the ISS program is a boost to the commercial space sector. Research done on the ISS concerning space systems and human safety will benefit any future space travel companies in addition to government spaceflight programs. As we learn more about how to protect humans in space and how to make systems that are more reliable for space travel, the commercial space sector is becoming increasingly robust. To date, seven "private spaceflight participants" have visited the ISS. While small in scope, this effort has demonstrated that there is interest, even at very high prices, for commercial human spaceflight. Several companies are using this information to better understand the market for commercial space travel; one start-up company, Virgin Galactic, has already begun taking deposits and waitlisting passengers for its upcoming suborbital spaceflight operation.

The ISS is also acting as a catalyst for commercial development in another way. The Commercial Orbital Transportation Services (COTS) Program seeks to stimulate commercial space transportation services companies by creating a market for supply flights to the ISS.[45] This has been likened to the government purchasing air-mail services during the early days of aviation to promote the growth of the airline industry. The COTS program may result in less expensive and less risky launch options for future NASA payloads, as well as for other customers. Companies involved in NASA's COTS effort may eventually provide commercial options for human space transportation, allowing NASA to focus on its goal of cutting-edge development and exploration rather than routine transportation.

The ISS is essential to this effort since it is the destination for which these vehicles have been designed. However, COTS vehicles are unlikely to be ready before 2010, and if the U.S. breaks away from the program in 2015 these technologies may not reach their full potential. The effect on COTS-D, the program aimed at supporting commercially-developed space systems to transport humans to the ISS, may be even more pronounced, as these technologies are not scheduled to be ready until after the cargo vehicles have been developed and tested.

Even the infrastructure of the station is being opened to the commercial industry on some fronts. NASA has signed a service-based contract with one company to provide water production services aboard the ISS. NASA does not need to purchase any hardware, just the water. The company will provide the equipment, and if the system does not work, NASA will not pay for it. The contractor is responsible for all system development and performance. This is a fundamental change in the way NASA works with private companies and demonstrates the willingness of industry to invest in space systems.[46]

The designation of the ISS as a National Laboratory also opens new possibilities for the participation of commercial industry in the experiments and operation of the ISS. As with other forms of government research, the longer the ISS is available as a research facility, the more likely companies are to engage in research leading to break-through findings and innovations.

Cost in Perspective

Given the structure of the ISS program, which included up-front costs followed by benefits to be accrued after construction, there is a strong argument against ending participation in the program at such a late stage, after development costs have been paid but before research benefits have been fully realized. The space station has gone through a costly 30-year design and construction period and is now entering a time when research can begin to produce the expected benefits of the program. The designers of the ISS believed that the benefits of the station would outweigh its cost, including development costs, and that those benefits would be realized upon its completion. Members of Congress reaffirmed this belief in 1993 when they voted to continue the program.

In the future, operating costs for the ISS are estimated at approximately $2.5 billion per year after 2010.[47] In comparison to other federal programs, this funding plan is not large. NASA's budget accounts for less than 1 percent of the federal budget, and less than 15 percent of NASA's budget goes to the ISS program.[48] That means the ISS program accounts for less than 0.15 percent of the federal budget. The budget for the space station amounts to $20 a year per taxpayer, or approximately five cents a day.[49]

Conclusion

The ISS program has created a wide range of benefits and will continue to produce high-value research results. It allows the United States to show its technological leadership on a highly visible international endeavor, thus increasing its prestige and soft power. It helps the United States foster better relationships with international partners and gives the United States the opportunity to prove itself a trustworthy partner in complicated, long-term commitments.

The development of the ISS has already resulted in a number of important innovations with direct benefits to society. The station gives scientists the opportunity to conduct long-term microgravity research, an opportunity impossible to find elsewhere. It provides a test bed for space systems and for understanding the effects of long-term space flight upon humans – something that is critical for future human space exploration not only for the United States, but also for the world as a whole.

The space station serves as a unique platform for educational experiences, and for improving science, technology, engineering, and mathematics (STEM) education from preschool through graduate school. The ISS program supports the United States' goal of fostering a highly skilled technical workforce by employing thousands of individuals all over the country. Finally, the station provides a stimulus for the commercial space sector, which has the potential to benefit the economy and accelerate technological advances in space systems.

As policy makers evaluate the future of this program, they should consider the wide range of benefits that the United States continues to receive as a result of its investment in the ISS, as well as the broad and deep negative effects that will be felt if the program is not continued until at least 2020. The ISS is a testament to the ability of international partners to complete a highly advanced technological program and, through its benefits to society, it has proven to be an endeavor worthy of continued support.

If you have questions about this paper, please contact research@spacefoundation.org or call 202.463.6122.

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End Notes

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