

**Statement of
Mary Lynne Dittmar
Executive Director
Coalition for Deep Space Exploration**

before the

**Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives**

SUMMARY OF KEY POINTS

1. The International Space Station is the cornerstone of NASA's human spaceflight program, both through operations in low Earth orbit (LEO) and by providing the foundation of the nation's development of a deep space human exploration program.
2. The 2014 "Pathways to Exploration" report published by the National Academies identified continued funding of the ISS past 2024 as a limiting factor on the development of a deep space exploration program; however, the continuing use of the ISS also benefits that program and will be the most cost-effective way for ongoing research both for Earth benefit and deep space exploration for many years to come.
3. The international partnership at the heart of the ISS is also critical for deep space human exploration and the process of extending human presence into the solar system. Continued engagement with partners old and new through the ISS is required at least until such time as a robust international program is established beyond LEO.
4. Economic development of low Earth orbit offers an opportunity to reduce government investment in LEO potentially offloading some of the operating costs of the ISS and/or providing sufficient revenues for new LEO platforms operating commercially after the ISS has ended. While early progress is being made, the timeline for such development is uncertain. Some conclusions can already be made regarding transition, however.
5. In addition to the international implications, there are several interdependencies between the ISS and deep space exploration that were not sufficiently addressed in the Pathways report; these should be better understood and taken into account before any decisions about the disposition of the ISS are made.
6. Additional time is needed to better define the conditions under which ISS transition should occur, with particular attention to avoiding any "gap" in ongoing human space exploration activities.

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Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the future of the International Space Station (ISS). The ISS is the cornerstone of human spaceflight and near-Earth research and technology development for NASA, the United States, the ISS international partners, and dozens of countries who have participated in the program to date. Currently authorized to continue operations through 2024, the ISS can last until at least 2028. Given the central role currently played by the ISS national consideration of its future after 2024 is of critical importance. Such consideration should take into account the full range of functions played by the platform in LEO and implications of ISS activities and costs upon the human exploration of deep space.

Funding Constraints: The “Pathways to Exploration” Report

In the 2010 NASA Authorization Act, NASA was directed to ask the National Academies to perform a study to review “the goals, core capabilities, and direction of human spaceflight.” In 2012, the National Research Council convened a Committee on Human Spaceflight charged with a wide-ranging statement of work intended to address Congressional interests described in the request. The resulting report, entitled “Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration” was published in 2014 by the National Academies.¹

Notional projections of annual costs and available funding for human spaceflight as a function of time were plotted in “sand charts” presented in Chapter 4 of the report. One of these, Figure 4.29, shows current and planned programs of record as of early 2015. Near term costs were based on the FY 2014 budget request with run out to 2018, at which point both the Space Launch System and Commercial Crew would reach their operational capability. The Orion spacecraft would continue development, ramping down until 2022. Two bounds of the NASA human spaceflight budget were presented; one in which the budget remained flat at 2015 levels and an upper bound where the budget began at 2015 levels and increased with inflation, at roughly 2.5% per year. Under these assumptions, extension of the ISS to 2028 was not possible under flat funding. Had this scenario prevailed, NASA would have to terminate ISS sometime after 2020 but well before 2028, unless funds were transferred from one of development programs to the ISS account.

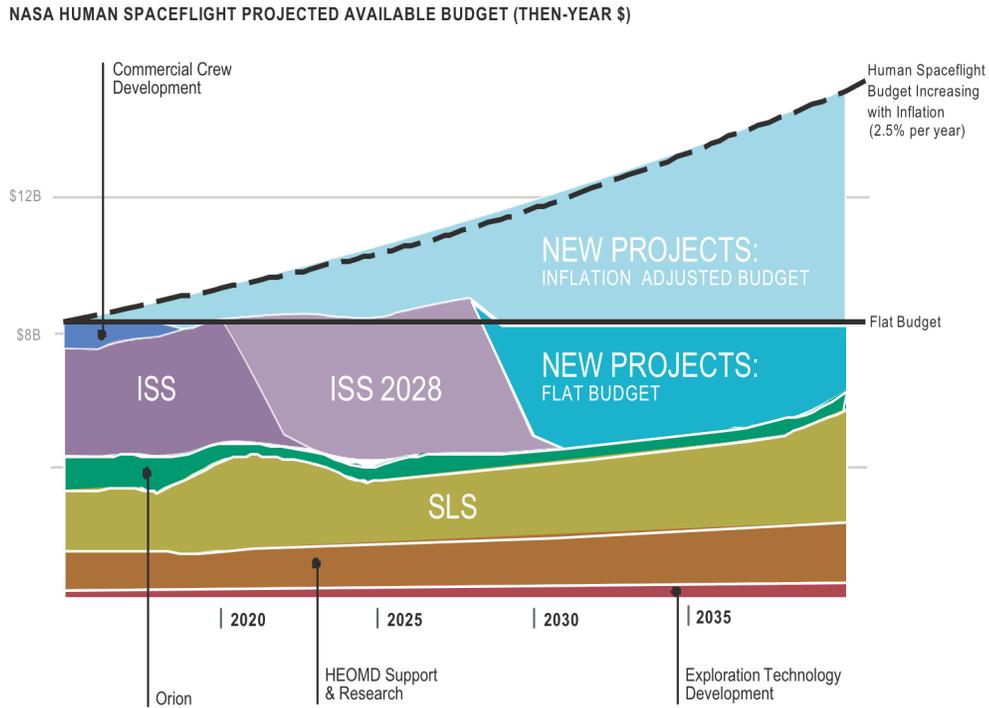


FIGURE 4.29. Projected available budget and costs of the currently planned human space flight program. Used by permission.

In 2016, after the report was published, Congress appropriated almost 10% more for human exploration than in 2015. Figure 4.29m, below (modified and used by permission) includes a new function representing the increase from 2015 to 2016, with a new lower bound (aka “flat budget”) running out beyond 2016. Under this scenario, which represents the enacted budget in that year, extension of the ISS to 2028 is possible.

Although the ISS *can* be extended past 2024, doing so while completing and operating the Space Launch System, the Orion spacecraft, the exploration ground systems upgrades at the Kennedy Space Center and undertaking development of a cislunar hab (not pictured) beyond 2024 could constrain NASA to a limited program in cislunar space. On the other hand, ramping down the ISS after 2024 would increase the funding available for deep space development and missions, depending upon the extent to which NASA continues to invest in LEO. In other words, unless options for cost reduction emerge in LEO, cislunar space, or both, the committee felt that at approximately \$3B/year to operate the ISS (including transportation costs), NASA could not afford both an ongoing program in LEO (the ISS) and a deep space human exploration program much beyond 2024.

NASA HUMAN SPACEFLIGHT PROJECTED AVAILABLE BUDGET (THEN-YEAR \$)

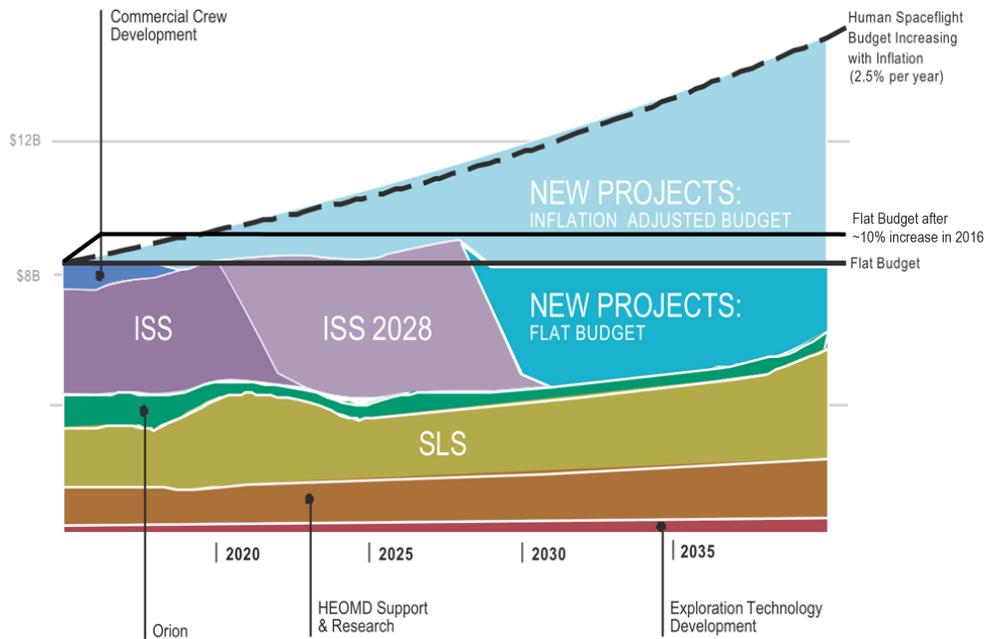


Figure 4.29m, with enacted levels in 2016 (modified by M. L. Dittmar) Used by permission.

International Collaboration and Diplomacy

Given the importance of the ISS for both current and future human space exploration, it is important to understand the roles played by the program, beginning with its international nature. The ISS is the focus of a strong international partnership. NASA’s work side-by-side with international counterparts, through changing political climates, has demonstrated the stabilizing effect of international collaboration and an ability to bridge the gaps and tensions that inevitably emerge within global politics. The ISS is also the means for emerging space nations such as India, UAE, Singapore and South Korea to establish their own human spaceflight programs, forming the basis for an international, collaborative architecture in space that begins in Low Earth Orbit (LEO). To date, over 100 countries have participated in some way in the International Space Station program.

The international relationships, operational and diplomatic protocols, commitments and cooperation established over the past decades in support of the ISS are important as NASA prepares to return to deep space for the first time in 50 years. Indeed, a central finding of the Pathways report was the NASA’s deep space exploration program – particularly one focused on Mars – must be international in nature. Continued engagement is critical to maintaining this successful partnership. The ISS should continue at least until such time as international projects beyond LEO are better defined.

Economic Development in LEO

One avenue for reducing the government's investment in LEO is by developing alternate sources of revenue. Accordingly, NASA's commercial activities have changed over the past several years, migrating from mission-directed innovation and development - projects sponsored by NASA for the benefit of its missions - to distributed innovation and development. New projects are initiated by a variety of different actors with varied objectives. This increasing diversification of projects and actors maximizes the likelihood of identifying breakthrough technologies or research outcomes that might spur sustained economic activity in LEO, given sufficient time and funding.

There are some signs of progress. The Center for the Advancement of Science in Space (CASIS), which manages the National Lab, has helped to engage investors willing to invest \$100,000's of dollars. High-potential applications include manufacturing of advanced optical fiber (ZBLAN) under the auspices of a company called Made in Space. NanoRacks, another commercial company, has raised private capital and has a range of customers including NASA, other governments, biopharmaceutical companies, space companies including Urthecast and Planet Labs, schools and other private customers – all of whom pay for services on a commercial basis.

Generating enough revenue to transition economic activity off the ISS to a commercial LEO platform with reduced government involvement sometime after 2024 requires two things to occur. First, public investment must lead to private sector revenues or investment via subsidized use of the ISS that are in turn invested into space infrastructure. These investments could include enhancements of the ISS, offloading of some portion of transportation costs from the government to ISS customers, or the development of commercial modules attached to the ISS. The first of these is already underway, with NanoRacks, Made in Space, BioServe, TechShot, and a new platform launched in 2016, SpaceTango, each operating commercial facilities onboard the ISS. NASA is also assessing the viability of attaching one or more commercial modules to the ISS in the near future.

The second step would involve closing the gap between public investment (NASA/CASIS), private sector gain, and enough revenues to lead private investors to fund new orbital facilities that would be available for both private and public use. This outcome is much more uncertain, and will probably require additional investment on the part of the government above current levels in order to speed up diversification, target promising development efforts, and encourage private investment. A definitive date for termination of the ISS could reduce some uncertainty for investors and developers. However, it is also apparent that there is currently a large gap between commercial activity and the revenues that would be needed to significantly offload ISS operations costs or to cover operating costs of a new LEO platform. Long-term stability of the ISS past 2024 may enable commercial markets to develop, although there is no guarantee. However, it is an absolute certainty that abandoning the ISS too soon will cause economic development to fail. Such an outcome would impact commercial transportation partners,

discourage private sector investment in LEO-based ventures, and cut short promising research and technology development.

Continuing access to a LEO research platform will remain the most cost effective means of testing systems and other capabilities for deep space for many years to come. Assuming that the United States wishes to remain in LEO in some capacity beyond 2024, several conclusions can be stated regarding the transition from ISS to commercial LEO platforms:

- We should avoid a gap in LEO capability and access, which would not be in the best interests of the United States (“lesson learned” from Shuttle);
- Transitioning the ISS to more and more commercial use would enable commercial entities to make a smoother transition to another platform;
- Alternate LEO destinations are essential to sustain the business model for commercial crew and cargo as well as other commercial entities such as those now providing facilities onboard the ISS; and
- To justify a business model for commercial entities to invest in another platform there has to be a plan, funding, and the continued development of economic activity in LEO for several years

From Earth to LEO to Deep Space and Back Again

The ISS supports scientific research and systems development and testing, including research and development with benefits to the people of the Earth as well as technologies needed by NASA to pursue the nation’s deep space aspirations. For example, the environmental control and life support system (ECLSS) currently operating onboard the ISS is not sufficiently robust to transfer to vehicles or habitats intended for long-duration operations in deep space, as it requires significant maintenance and replenishment. Development of an advanced ECLSS will probably require continuance of the ISS until at least 2024.

There are other interdependencies between ISS utilization in LEO and NASA’s activities in deep space. In addition to human research and research in the biological and physical sciences, commercial utilization encourages the private sector to advance technologies with applications not only to Earth but in space. 3D printing projects such as those conducted by Made In Space are themselves pathfinders for utilization of native materials on the Moon or Mars. Meanwhile, NASA is pursuing public private partnerships as a mechanism for driving technology by means of the Next Space Technologies for Exploration Partnerships (NextSTEP) programs, wherein companies invest in habitat architectures for crews traveling from cislunar space to Mars. As mentioned, technologies developed in LEO can be leveraged for deep space; however, research and technology underway for deep space could also be leveraged to the development of platforms in LEO.

Finally, the ISS is the heartbeat of human spaceflight - 24 hours a day, 365 days a year – not just for NASA and its international partners but for the industrial base that supports the ISS community across the globe. Once underway, flights of the Space Launch System and the Orion spacecraft into cislunar space are anticipated once or twice a year, in comparison to 16 missions (crew and cargo) to the ISS anticipated for 2017 alone. The steady rhythm of human spaceflight

operations provided by the ISS is important to providing a continuous presence in space, which should continue until a robust program has been established in cislunar space.

Conclusion

The ISS is at the center of U.S. human spaceflight, with ongoing research across a range of disciplines and technology applications for Earth and in space. It is also the basis for economic development in low Earth orbit and provides a destination for transportation systems developed under the auspices of NASA's commercial cargo and crew programs. The ISS is a also critical asset for development of systems needed for human deep space exploration. Ongoing utilization beyond 2024 without significant cost reductions will limit NASA's deep space exploration programs; however, too-early termination could also have deleterious effects by slowing technology development with applications to deep space, cutting short economic development in low Earth orbit, and limiting or terminating U.S. presence in LEO. Prior to making a decision about the ISS, additional time is needed to better define the nature of international collaboration in deep space, to seed economic development and broaden both the range of actors and the nature of research and technology development with the goal of stimulating economic demand in LEO, and to ensure that a human spaceflight program to cislunar space is well underway, avoiding any "gap" in human activities in space as the United States charts a course into the future of human space exploration.

Thank you for the opportunity to appear before you, Mr. Chairman. I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

¹ National Research Council of the National Academies Human Spaceflight Committee (2014). Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration. Washington, D.C., National Academies Press.