Ensuring a Robust U.S. Human Spaceflight Program

An AIAA Information Paper

ABSTRACT

The United States has led the world in human spaceflight for the last five decades. However, since the end of the Apollo program in 1972, human spaceflight has been limited to travel to and from low Earth orbit (LEO). Changes in mission objectives and goals, cancelled human spaceflight initiatives, and unstable budgets – all primarily occurring during transitions across administrations and Congresses – have driven numerous programmatic direction modifications and setbacks in the nation's deep space exploration endeavors.

Sustainment of U.S. leadership in human space exploration requires that a well-defined mission roadmap be established early and that stable long-term funding be provided to continue development and deployment of human-rated deep space exploration vehicles. Continuation of the International Space Station (ISS) is important as a research facility and test bed, as well as a proven model for international cooperation in space, as we prepare for more challenging missions. Support for NASA's robotic science missions is also critical as we evaluate and prepare for the environments in which humans will live and work during exploration missions.

ISSUE BACKGROUND

Space exploration is a modern extension of the human aspiration to discover and learn about new places, and to eventually benefit from them. Ever since President Kennedy announced the beginning of the Apollo program in 1961, human spaceflight has played a critical role to inspire generations of young people to enter fields of science, technology, engineering, and math. Investments in the technologies required for space exploration are investments in our future, enabling leapfrog advancements in weather forecasting, navigation, energy efficiency, biomedical applications, manufacturing, microelectronics and numerous other fields that touch our everyday lives. However, support for the Apollo endeavor was based on geopolitical circumstances that no longer exist. In the post-Cold War era, the extensive financial support that NASA had enjoyed gave way to a more sober reality in which the agency's purchasing power has remained flat and its share of federal discretionary funding hovers at less than one half of one percent of the federal budget.

While the space science community is guided by the Decadal Surveys, there is not presently an equivalent process for human spaceflight that assesses the priorities and interests of stakeholders, evaluates the technological readiness of NASA and its partners, and provides an externally vetted roadmap that ties human spaceflight missions to national strategic objectives. The National Research Council Committee on Human Spaceflight, mandated in the 2010 NASA Authorization Act, is a step in that direction with its upcoming report on the value of human space exploration, but a sustained process for creating and evaluating the value proposition for human spaceflight is needed to ensure continuity of focus and clarity of purpose across both the political spectrum and the technical disciplines.

NASA and the agency's industry partners continue to make excellent progress in developing a heavy lift rocket, the Space Launch System (SLS), and a multi-purpose crew vehicle, Orion, that will enable deep space human missions to multiple destinations including the moon, asteroids, the moons of Mars, and Mars itself. The SLS will be the first human-rated exploration-class vehicle since Saturn V took humans to the moon and will be the most powerful rocket in history. It is designed for flexibility to support either crew or cargo missions. The rocket design maximizes use of proven systems and cutting-edge tooling and manufacturing technologies, thereby reducing programmatic risk and minimizing development costs. The eventual design calls for a rocket with 9.2 million pounds of thrust at liftoff and a payload capacity of 286,000 pounds to orbit. The SLS program, led by NASA's Marshall Space Flight Center, is five months ahead of schedule in meeting critical development milestones.

Orion is the first spacecraft in history capable of taking humans to multiple destinations beyond LEO. Design and development of Orion, led by NASA's Johnson Spaceflight Center, began in 2006 and the program has undergone successful tests of all major systems including the highly advanced launch abort system, the crew module structure, and the reusable recovery parachute system. Orion development remains on schedule, with the

first flight-worthy vehicle being readied at Kennedy Space Center for launch in fall 2014. During the uncrewed test flight, Exploration Flight Test 1 (EFT-1), Orion will travel 3600 miles above Earth's surface, further than any human-rated vehicle has ventured since the Apollo program.

The first uncrewed integrated flight test of SLS and Orion, Exploration Mission 1 (EM-1), is scheduled to take place in 2017 and the first crewed flight, EM-2, is scheduled for 2021. NASA has stated that the biggest risk to the program is budget uncertainty, emphasizing the need for a long-term stable budget to maintain U.S. leadership in human space exploration. Also, the lack of financial and political support for specific mission objectives and associated mission systems – such as habitats, landers, and mission-related equipment – threatens the ability to utilize effectively the deep space transportation architecture that NASA is expending significant resources to create.

In addition to developing new capabilities, the United States must also build on the existing assets and lessons learned in space operations, on-orbit assembly, visiting vehicle management, microgravity research, technology development, and international project management established through the International Space Station program. As the only crewed outpost in space, NASA is using the ISS to retire key risks in human health and performance, determine the efficacy of new life support technologies needed for long duration missions, and conduct basic research in the physical and life sciences. The NASA Commercial Crew and Cargo Program has successfully mentored two companies with little human spaceflight experience as they developed robotic spacecraft that safely deliver cargo to the International Space Station. Orbital Sciences Corp joined SpaceX in meeting this goal as of 2013.

Beyond accomplishing critical science and technology development for NASA missions, the U.S. Operating Segment of the ISS serves as a National Laboratory for the benefit of private industry, academia, and other government agencies that can use microgravity research and/or access to the space environment to improve life on Earth. The Center for the Advancement of Science in Space (CASIS), the nonprofit created specifically to manage the ISS National Laboratory, has succeeded in developing over 50 flight projects in its first two years of operations. The first CASIS-funded experiments were delivered to the ISS in January 2014 by the Orbital Sciences Cygnus vehicle. This capability would not exist, though, if not for the international collaboration model that is the hallmark of the ISS Program. Further utilization of the ISS for both NASA missions and fulfillment of the promise of the ISS National Laboratory depends on sustained and timely cargo access for delivery and return, continued progress in lowering operational costs through such programs as NASA's Commercial Crew initiative, advancements in on-orbit data collection and analysis, and intellectual property protections for National Lab users that ensure their ability to translate discoveries into products.

In order for the United States and international partners to complete successfully a human mission to Mars, NASA must play a leading role in developing new technology that extends the world's capabilities in areas such as life support, power generation, utilizing resources from Mars, surviving radiation from space, entering and landing through the Martian atmosphere, communications, and propulsion. In February 2013, NASA created the Space Technology Mission Directorate (STMD) to emphasize the important tasks facing the agency to invent, mature, and operate new human spaceflight technologies. These technologies have relevance both in space and on Earth. STMD operates by competitively offering research grants, prizes, and contracts to NASA centers, small businesses, U.S. universities, and established firms. Continued support for NASA's technology development efforts is necessary to ensure future human spaceflight.

The space exploration landscape in space is changing. Many developing countries in Africa, Asia, and Latin America are establishing national space programs with a focus on using satellite services. Meanwhile, China has demonstrated the ability to land and operate a rover on the moon, and India, with a launch in November 2013, aims to be the fourth nation to reach Mars, with both of these missions as precursors to their future human spaceflight operations. The globe continues to be fascinated with interplanetary space exploration and looks to the United States for leadership. Thus, it is imperative that the United States maintains a robust human spaceflight program to ensure our political, technical, and programmatic interests remain preeminent in this expanding sphere of human experience.