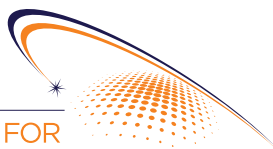


Executive Summary

- For more than 50 years, American global leadership in human space exploration and space science has been a shining “jewel in the crown” of U.S. innovation, technological and scientific achievement, and peaceful international collaboration.
- Our daily lives are inextricably interwoven with space-based assets – including GPS, communications, weather and intelligence – and with opportunities for discovery, development of advanced technology, space commerce and geopolitical influence that an active and robust deep space exploration program returns to the nation.
- For the last decade, there has been bipartisan consensus on the path forward for human exploration of deep space, using NASA’s new Orion crewed spacecraft powered by the super heavy Space Launch System (SLS) rocket. There are three distinct phases that map to NASA’s plans: to conduct human missions around the Moon in the 2020s, build up the in-space technologies and expertise needed to safely transport astronauts to Mars, and to conduct human exploration missions there beginning in the 2030s.
- The first of these missions is scheduled for 2018 and is the next step in reestablishing the U.S. as the only country capable of transporting astronauts to the Moon and beyond.
- There is strong bipartisan support of NASA’s space science portfolio, including robotic planetary missions, heliophysics (studies of the Sun), Earth observation, astrophysics and cosmology. These programs push the boundaries of knowledge and advance our understanding of the universe and our place in it.
- A government-led program that opens the frontier beyond Earth for ourselves, our international partners, commerce and science is crucial if we wish to control our national destiny and lead the way to a future guided by American values and freedoms.



THE COALITION FOR
DEEP SPACE EXPLORATION

The Coalition for Deep Space Exploration is the industry association representing American companies that are building NASA’s next-generation rocket and spacecraft for human exploration to the Moon and Mars, as well as cutting-edge science telescopes and robotic spacecraft. It was founded by Boeing, Lockheed Martin, Northrop Grumman, Orbital ATK and Aerojet Rocketdyne and has grown to more than 40 large, medium and small companies across the U.S. Further information about U.S. human space exploration and space science programs may be found at the Coalition’s website at www.exploredspace.com or by calling 202.747.4378.

Key Recommendations

1. Develop and maintain close alignment between the new Administration and Congress on space policy, priorities and funding levels, building on the bipartisan consensus reflected in the 2010 NASA Authorization Act and in the annual appropriations bills adopted over the last six fiscal years.
2. Ensure robust and dependable U.S. access to deep space missions, including the near-term uncrewed test flight of the SLS rocket and the Orion spacecraft in 2018, and a 2021 test flight with crew that will enable American astronauts to lead the way into deep space.
3. Advance U.S. leadership and achievement in space science with the 2018 launch of the James Webb Space Telescope and the Insight mission to Mars, funding for upcoming Mars and Europa planetary missions, and ongoing investment in missions across NASA’s science portfolio.
4. Ensure use of the International Space Station as a technology test bed and cornerstone of NASA’s comprehensive plan for future deep space exploration.
5. Focus new transportation services on supporting NASA’s low-Earth orbit activities and missions without sacrificing safety and mission assurance.
6. Strengthen NASA’s effectiveness by streamlining its institutional footprint, bureaucracy and procurement practices to ensure effective deployment of existing resources.
7. Ensure development of new technologies and space capabilities which directly support science, exploration and national security needs.

The attached paper makes recommendations that ensure national leadership for space exploration and science, and describes the benefits and justifications for continuing bipartisan support for these pursuits.

Executive Summary

For more than 50 years, American global leadership in human space exploration and space science has been a shining “jewel in the crown” of U.S. innovation, technological and scientific achievement, and peaceful international collaboration. Our daily lives are inextricably interwoven with space-based assets – including GPS, communications, weather and intelligence – and with opportunities for discovery, development of advanced technology, space commerce and geopolitical influence that an active and robust deep space exploration program returns to the nation. After many decades spent developing systems, testing capabilities and conducting research in low-Earth orbit, we are once again looking beyond our home planet toward deep space. A government-led program that opens the frontier beyond Earth for ourselves, our international partners, commerce and science is crucial if we wish to control our national destiny and lead the way to a future guided by American values and freedoms. This paper makes recommendations that ensure national leadership for space exploration and science, and describes the benefits and justifications for continuing bipartisan support for these pursuits.

Mission Statement

The principal objective of the U.S. space exploration program is to ensure American leadership in human deep space exploration and scientific investigation of our solar system and our universe, building on momentum established by bipartisan and bicameral consensus and support for NASA’s exploration plans and progress over the past several years.



The next-generation Orion spacecraft, powered by the super-heavy lift Space Launch System rocket, will launch off from the Kennedy Space Center in 2018.

Engineers across the country have been busy taking a closer look at NASA's Orion spacecraft and the data it produced during its successful flight test in December 2014. Image Credit: NASA



NASA's next-generation deep space crew vehicle, super heavy-lift rocket and space telescopes in anticipation of their 2018 launches. The Administration should ensure these missions remain on schedule.

2. Ensure robust and dependable U.S. access to deep space for all future exploration and science missions.

Space has become indispensable to commerce, communication and national security. For example, all mass media, including the internet, depend upon it. U.S. access to space using domestic systems is a critical capability needed for continued space exploration both in low-Earth orbit and deep space. Programs sponsored by NASA are developing the next generation of systems that will provide access to space for astronauts and a wide variety of payloads.

NASA must pursue the earliest possible full development of the Orion crew vehicle and Space Launch System (SLS) rocket, currently planned for their first integrated flight (EM-1) in 2018. Together with the advanced ground systems and operations currently under development at the Kennedy Space Center to support NASA's next-generation exploration program, completion of the SLS and Orion with unique capabilities to push human presence into the solar system and to remain the global leader in human exploration and science. In addition, NASA should be funded to complete development and commence full operation of cargo and crew transportation to low-Earth orbit. Ongoing vigilance and insight into launch capabilities required for government missions is crucial.

Recommendations

The long-term goal of the U.S. human space exploration program is "to expand permanent human presence beyond low-Earth orbit" in collaboration with international partners, with the ultimate goal of landing humans on Mars. In an era where space systems and capabilities are propagating across the globe, American competitiveness, influence and leadership in pursuit of visionary goals such as this one are more important than ever. Accordingly, NASA is developing the capabilities to explore farther into space than ever before, meeting milestones and building momentum toward the launch of the first "Exploration Mission (EM-1)" in 2018.

These programs are building on knowledge, facilities, and operations developed over the past decades, benefiting from the nation's wise investment in human space exploration in the past. NASA is also pursuing an ambitious science portfolio across multiple disciplines, requiring exacting instrumentation and promising new understanding of the universe and of our own planet.

In order to maintain U.S. leadership and ensure our national future in space, the following actions are required:

1. Develop and maintain close alignment between the new Administration and Congress on space policy, priorities and funding levels.

There has been tremendous support across both Republican and Democratic majorities in Congress for NASA's plans to return American astronauts to deep space, beyond Earth's orbit – including bipartisan authorizations in 2005, 2008 and 2010. Additionally, Congress prioritizes funding for NASA's human exploration and space science programs each year. Science priorities are guided by means of the decadal surveys overseen by the National Academies of Sciences, Engineering and Medicine, while human exploration plans and priorities are developed by NASA's Human Exploration and Operations Mission Directorate.

Open exchange, collaboration and agreement between the Administration and Congress create the best environment to plan and execute space programs, which by their nature have long-lead times spanning multiple election cycles. Significant progress has been made on development of

3. Advance U.S. leadership and achievement in space science.

U.S. leadership in space is exemplified by its space science programs in heliophysics, planetary science, atmospheric science and astrophysics. Collaborating with researchers from around the world, NASA and its contractors conduct scientific exploration and discovery missions, such as the Mars Curiosity rover and the New Horizons mission to Pluto and beyond. The next decade will include: the arrival of the Juno mission at Jupiter on July 4 of this year; the launch of the James Webb Space Telescope (JWST) and the Insight mission to Mars in 2018; the launch of the OSIRIS-REx asteroid sample return mission, its arrival at asteroid Bennu in 2018 and return to Earth in 2023; the Mars 2020 rover mission; the study of the Moon by cubesats during EM-1; orbiter and lander missions to Jupiter's moon, Europa, in the 2020s; and ongoing studies of Earth as a system. Robust funding of space science pays dividends in new knowledge and technology development and continues U.S. engagement with the international science community.

4. Ensure the use of the International Space Station as a technology testbed and cornerstone of NASA's comprehensive plan for future deep space exploration.

Through the ISS program, America and its international partners have built a cooperative framework in which U.S. leadership is the cohesive force guiding the exploration and development of the solar system. The recent completion of the "One-Year Mission," in which astronaut Scott Kelly completed 340 days in low-Earth orbit, demonstrated again the capability of U.S. space systems to sustain the life and health of crew members while providing unparalleled insight into the effects of the space environment upon the human body at a genetic level. The ISS also serves as a platform for testing habitat and crew health and safety systems for deep space. NASA's research and testing on ISS should focus on validating both human and technical capabilities for long-duration space missions, while still in the relative safety of low-Earth orbit.

In addition to serving as a crucial testbed for exploration, microgravity research conducted daily at the ISS National Laboratory is leading to discoveries



Astronaut Scott Kelly conducting research aboard the International Space Station.

that improve our lives on Earth. Privately funded research in pharmaceuticals, wound healing and materials science, along with private companies focused on space technology development, are using the ISS to develop products and services for the marketplace. The ISS is currently set to operate through at least 2024, but may be operable to 2028. At a logical transition point, NASA and interested partners should evaluate transferring operations from a traditional NASA-led model to a commercial one for a sustained presence in low-Earth orbit. This will enable growth of private sector opportunities in low-Earth orbit if they are viable and sustainable. NASA can then further focus on human exploration of deep space.

5. Focus new transportation services on supporting NASA's low-Earth orbit activities and missions without sacrificing safety and mission assurance.

NASA has made multi-billion dollar investments to create domestic capabilities for crew and cargo transportation services to the ISS with the promise of reducing overall costs and creating new commercial space markets in low-Earth orbit. These systems have delivered cargo to the station, which is located in a relatively benign low-Earth orbit space environment, and are expected to begin ferrying crew members in 2018. However, they are not designed for and have not demonstrated the necessary performance and capabilities to play a critical role in deep space science and exploration.

In addition to providing a needed transportation capability, the intended purpose of these programs is to help create a commercial market that is



The Ground Systems Development and Operations Program is overseeing upgrades and modifications to the Vehicle Assembly Building (VAB) High Bay 3, including installation of the new work platforms, to prepare for NASA's Journey to Mars. The newly installed platform will complete the second of 10 levels of work platforms that will surround and provide access to the SLS rocket and Orion spacecraft for EM-1. Image Credits: NASA/Dimitri Gerondidakis

eventually sufficient to sustain these systems without continued government investment. The government can then act as a “smart buyer,” selecting providers best suited to meet government needs, based on a proven service record and sustainable business models. It is important that these technology efforts remain focused on improving performance and reliability in order to support private investment in and development of low-Earth orbit capabilities, goods and services.

6. Strengthen NASA’s effectiveness by streamlining its institutional footprint, bureaucracy and procurement practices, to ensure effective deployment of existing resources.

Over more than 50 years, NASA operations have been improved by advances in technology and capabilities. This has rendered some of the earlier infrastructure and equipment obsolete or inefficient. NASA’s current efforts to identify these and to free up additional resources should be encouraged and continued. Resources then can be reinvested in NASA’s core human and science missions to help offset rising costs and inflation. In addition, NASA’s facilities and infrastructure should be evaluated against specific, future mission needs as they become known in order to minimize future program overhead. Partnering with outside entities that can provide infrastructure, technology and equipment at lower costs than “reinventing the wheel” within the agency is also important to sustaining NASA’s mission.

7. Ensure development of new technologies and space capabilities which directly support science, exploration and national security needs.

Government agencies responsible for space activities - NASA, NOAA, FAA, USGS, and the DoD - can increase cooperation by identifying and prioritizing common technology and capabilities needed for future space missions, as appropriate. These agencies also should explore options for timely and cost-effective, shared-development. In addition, NASA’s human exploration, science, space technology and aeronautics programs, which are already collaborating, should continue these efforts in order to support multidimensional missions addressing both exploration and scientific interests. Technology development within the agency should primarily be directed to meet mission needs across directorates and NASA centers to improve effectiveness and maximize the return on agency technology investments. Here, too, continued partnerships with external entities to both “transfer in” and “transfer out” technology will spur innovation and leverage government investment in research and development.



**THE COALITION FOR
DEEP SPACE EXPLORATION**



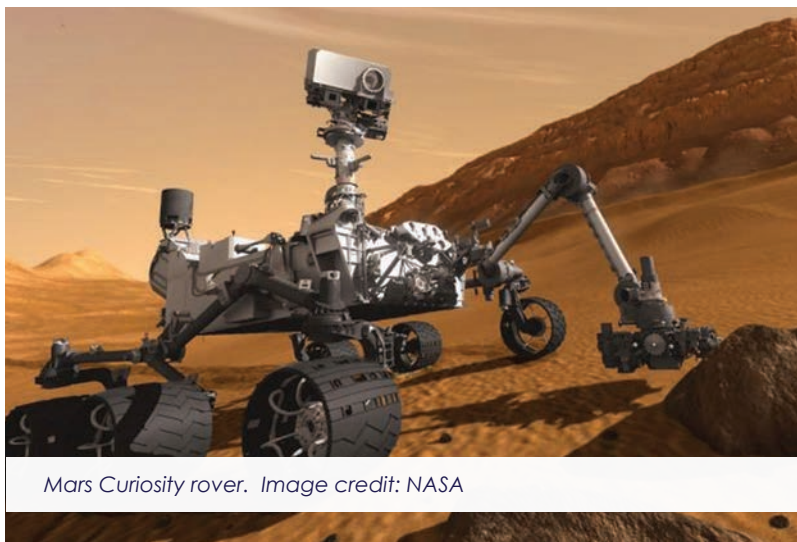
The Orion spacecraft arrives at the Moon, returning U.S. astronauts to deep space.

Value and Benefits

The sections that follow provide justification for continued investment in and development of U.S. space-based capabilities and operation of human exploration and science missions across the next several decades.

Technical Leadership

America faces an increasingly competitive field of space-faring nations, including close allies and potential adversaries. In the decade ahead, it is likely that additional countries will demonstrate advances in space access, space science and human spaceflight. The U.S. has a distinct competitive advantage, however – an unparalleled architecture for deep space exploration. We are now building the world's only exploration-class super heavy-lift rocket – the SLS – and the only human spacecraft – Orion – designed from the ground up to take humans to multiple destinations deeper into space than ever before. These core systems provide a strategic advantage enabling American-led human missions to lunar orbit or the Moon in the 2020s and Mars in the 2030s, as well as speeding our missions to deep space science destinations such as Europa. These systems also provide a natural “on-ramp” to cooperative relations with the U.S. in space, opening the door to international cooperation with current and future partners and enabling commercial space resource development, such as mining of precious metals and volatiles.



Mars Curiosity rover. Image credit: NASA

The technical demands of human space exploration and deep space science require exacting and precise engineering, instrumentation and development. These needs spur advances in areas of interest to government, industry and entrepreneurs, such as additive manufacturing, biotechnology, robotics, environmental control and materials science. Continued progress towards new exploration and science missions will affirm the U.S. as the natural leader for a range of international initiatives, including shared technology development and deep space human exploration and science missions.



THE COALITION FOR
DEEP SPACE EXPLORATION

Advances in Space Science

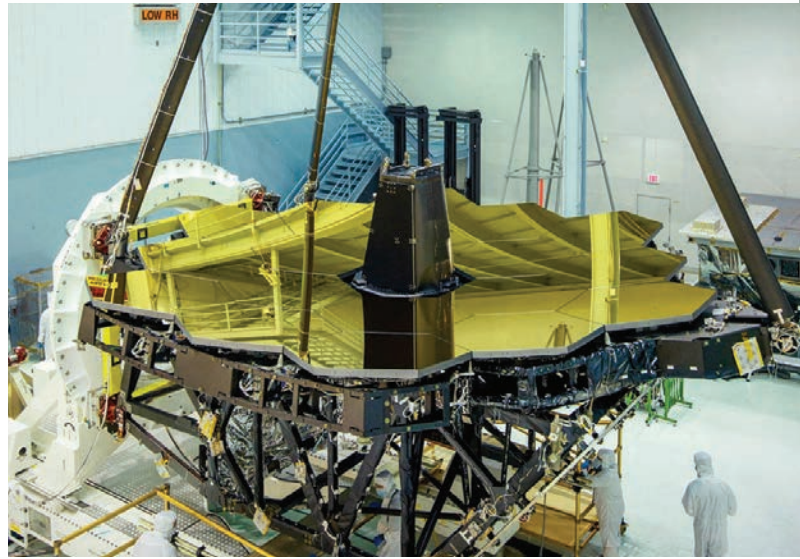
After more than 50 years in space, we have made unprecedented advancements in space science, yet many of the mysteries of the universe remain.

The greatest of these is the question, “Are we alone?” In 2015, NASA discovered flowing liquid water on the surface of Mars. Scientists believe that water is fundamental to the development of life. The search for life in the universe encompasses all science disciplines and human exploration efforts: from the building blocks of matter to the origins of the universe; from solar wind to the formation of exoplanets; from the search for volatiles on our own Moon to the surface of other planetary bodies in our solar system and beyond.

NASA's Science Mission Directorate is responsible for developing and executing the agency's science portfolio. These efforts span an international community of scientists representing a range of disciplines, hundreds of science missions and a flagship effort nearing completion. The latter of these is the JWST, now in the final stages of construction. JWST is the formal successor to the Hubble Space Telescope and the Spitzer Space Telescope. Together with the Wide Field Infrared Survey Telescope, which has recently entered formulation, these next-generation space observatories will answer foundational questions about the earliest formation of galaxies after the Big Bang, the nature of dark energy and the expansion of the universe, and how planetary systems develop. Such answers will help us to understand what factors determine the habitability of Earth-like worlds and provide clues about the possibility of life on other planets.

Additional planetary science missions – such as Mars InSight (also launching in 2018) and Mars 2020 (the next-generation Mars rover) – are precursor missions to the Red Planet in advance of human exploration and habitation. Still other science missions teach us about our own solar system and planet, and about space weather, including transitions in the state of our sun with the potential to inflict major damage to our electrical grid and other sensitive electronic systems. All of these areas of scientific endeavors contribute to our knowledge about our own past, present and future, as well as provide opportunity to collaborate with scientists worldwide.

Standing tall and glimmering gold inside NASA's Goddard Space Flight Center's clean room in Greenbelt, Maryland is the James Webb Space Telescope primary mirror. It will be the largest yet sent into space. Image credits: NASA/Chris Gunn



Preserving the National Space Industrial Base

The U.S. space industrial base is key to enabling our national security, civil and commercial space programs. The industrial base supply chain for human space exploration and space science is distributed across all 50 states and ranges from large contractors with thousands of employees to hundreds of small, privately owned businesses. This large and diverse industrial base ensures competition that drives technological innovation. It also ensures robust space capabilities with multiple sources for critical systems and capabilities for exploration, science and defense.

Small businesses, in particular, bring technical innovation, creativity, expertise and rapid adoption of new approaches to the American deep space enterprise. Space systems are complex and operate in unforgiving environments. Components made by small suppliers are just as important to the overall success of a mission as are any contributions from industry. Space systems are long-lead time efforts, requiring years to build workforce expertise. While larger companies have some flexibility to adjust and accommodate fluctuations in program funding, smaller businesses often do not. Funding predictability and stability is crucial to maintaining health throughout the entire industrial base supply chain and to reaping the benefits to American competitiveness driven by contributions from the aerospace economic sector.

Economic Development and the Commercial Use of Space

A shining example of how federally funded research and development is supposed to work occurred in the U.S. in the 1960s, when government investments in space systems laid the groundwork for a national harvest of related technologies and emerging markets 20-40 years later. These investments have created a competitive advantage for U.S. industry both within and outside of the space sector, leading to technologies that improve almost every aspect of our everyday lives. GPS, smartphones, medical devices, medical imaging and advanced communications are just a few of the applications that owe some part of their heritage and development to the space program.

Similarly, decades of government-led programs have paved the way for transferring routine space transportation services to private industry. Today, U.S. companies are building upon well-demonstrated government space capabilities, infusing modern manufacturing and computing capabilities to make these systems more cost-effective and reliable. Industries with the potential to drive new technologies and generate economic returns are using the ISS National Laboratory to develop applications that may hold the key to sustained economic activity in low-Earth orbit. Other entities are exploring activities as diverse as asteroid mining and commercial robotic exploration. Just as it always has, continued government development of advanced space systems and engagement in discovery missions for which there are no viable business cases will create the “bow-wave” of knowledge and technology needed to create commercial opportunities and new markets in the future, generating a tremendous return on investment for the nation.

International Leadership

U.S.-led space exploration and space science provide direction and incentive to strengthen collaborative international partnerships to benefit all. Other nations are interested in pursuing complementary capabilities to Orion and the SLS in order to enable their own exploration ambitions. Living and working in a deep-space habitat near the



Moon by the mid-2020s, astronauts will rely on solar electric propulsion modules to ferry cargo deep into the solar system. These developments will open the door to Mars in the 2030s, cementing the U.S. as the unquestioned leader in human space exploration.

Meanwhile, space science missions representing consortiums of nations engaging together in exploration and science discovery are underway. The Committee on Space Research (COSPAR) of the International Council of Science, which facilitates international cooperation on international science missions, recently elected its first American president. Created at the beginning of the Space Age, COSPAR promotes scientific research in space on an international level and provides a forum for discussion for space scientists across the world.

Space-faring nations have tremendous influence with international peers who may seek access to space assets or opportunities for participation. This is particularly true in human spaceflight programs, which carry with them significant prestige and influence. While international cooperation should be sought when it is in the national interest, it is imperative that the U.S. lead these initiatives from a position of strength. Preserving and growing core national launch, space operations, science and exploration capabilities are essential to maintaining American leadership among our partners and guaranteeing that space remains free for commercial, civil, scientific and national security activities.





National Aspiration and Achievement

Space exploration is an expression of the human need to discover and learn about our solar system and universe, and to benefit from that knowledge here on Earth. The unique combination of scientific knowledge, innovation, technology and competitiveness achieved through space exploration creates economic benefits, strengthens national security, advances U.S. technical, engineering and scientific achievement, and reaffirms national aspiration and pride.

Space exploration is an expression of the foundational human need to discover and learn about our solar system and universe, and to benefit from that knowledge here on Earth.

History teaches us that nations which explore benefit from their endeavors, reaping economic growth, international prestige and national pride from their investments. The research and technologies required for space exploration encourage innovation, as well as enable leap-frog advancements and achievements in weather forecasting, navigation, energy efficiency, computing, medicine and a multitude of other fields that touch our everyday lives. National achievements in space foster active, life-long learners and inspire students to pursue careers in science, technology, engineering and mathematics (STEM). Space exploration and science improve our quality of life. Beyond these benefits, they encourage our nation to look beyond our own boundaries – even beyond our own planet – to consider our place in the universe, and to chart our course to a vibrant future.

About the Coalition

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