

## **Human spaceflight:**

### **Why and How?**

#### ABSTRACT

The valuable partnership of humans and robots in space was demonstrated with the building of the ISS and the servicing of the Hubble Space Telescope. Machines alone cannot perform many of the intellectual and manual activities required for space utilization and development. Humans have proven themselves capable and often indispensable in advancing space objectives. With the completion of the International Space Station, human missions beyond low Earth orbit are the next logical steps. Of all possible destinations beyond LEO, the Moon provides the optimum location for the development of new space faring capabilities and the best opportunity to maintain a permanent presence in space. The lunar surface contains the material and energy resources required to develop a permanent, extensible space transportation system. By using an incremental, scalable architecture, our civil space program can realistically achieve two components vital for success – affordability and sustainability. This system will provide access to the lunar surface and all points within cislunar space, permitting the construction of large, distributed satellite systems. A permanent transportation system in cislunar space – fueled by propellant made from lunar water – creates an extensible, maintainable space faring capability.

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## **Human spaceflight: Why and How?**

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The United States and its civil space program stand at a critical juncture. Due to strategic confusion and loss of direction, our nation is in imminent danger of permanently destroying this once-great capability. It is crucial that this committee understands that our nation's technical competitiveness and economic health, along with that of other countries who value and champion individual liberty through the power of free markets and democratic pluralism, is at stake.

As requested in your call for papers, I organize my thoughts around your suggested questions.

### **1. What are the important benefits provided to the United States and other countries by human spaceflight endeavors?**

Humans are needed in space to do those important and critical tasks and activities that only people can accomplish. These types of jobs break down into three main categories.

***To explore, discover and learn.*** While scientific exploration is often thought to be central to the robotic space program, the Apollo and Space Shuttle programs demonstrated the critical role humans play in this area. Field science is interacting with an exotic environment such that specific and relevant questions are both posed and answered in real time. Beyond sample collection and the deployment of equipment, human creativity is crucial. The spontaneous interaction of human cognition and intelligence, skills honed through highly interpretive knowledge, innate manual dexterity and real-time adaptation in the event of difficulties and/or opportunities, all offer important advantages over purely robotic spaceflight.

***To create, build and maintain.*** This category of activities takes advantage of the proven ability of people and machines working together to build and maintain large distributed space systems on orbit. The most complex spacecraft ever built, the International Space Station (ISS), was constructed this way; this platform could not have been built and launched en masse in a single launch vehicle – it had to be assembled on site. In a similar manner, space systems constructed in the higher orbits of cislunar space (e.g., geosynchronous orbit - GEO) could likewise be made to possess unprecedented degrees of power and capability; an ISS-sized communications complex constructed in GEO with global coverage and virtually unlimited bandwidth would render the current terrestrial cell phone network obsolete. For this practical reason alone, routine movement of people and machines throughout cislunar space should be a priority goal of human spaceflight. Once built, such a space transportation system will serve as our means to travel into the Solar System beyond the Moon.

***To preserve, protect and survive.*** It has been posited by some that the movement of humanity into the cosmos is the “ultimate” long-term goal of human spaceflight. A species present in multiple locations faces better survival odds than a single-planet species in the event of a planetary catastrophe. Although this may be an ultimate rationale for human spaceflight, it is not a viable objective for a federal civil space program. Before we can settle space, we must develop

the ability to get there. Once there, we must create the ability to stay there. These latter two tasks constitute the development of a space faring capability, a *sine qua non* to space settlement and human expansion into the universe. Developing such skills is an appropriate task for our national space program. Instead of fixating on Mars, human space exploration should focus on becoming space faring – a goal that includes Mars, but one far richer in possibilities, both exploratory and practical, and one whereby we create wealth rather than simply consume it.

In short, we desire to develop the ability to go wherever we want or need to in space, with people and machines, to accomplish whatever goals and objectives we may desire. By accepting this as our overall goal and stating at the outset what our endpoint is, the development of a strategic approach and tactical path to attain this ability becomes possible.

## **2. What are the greatest challenges to sustaining a U.S. government program in human spaceflight?**

Although it is tempting to ascribe the cause of our current space malaise to a lack of funding, in fact the problem is more fundamental – it is a failure of to fully understand exactly what we are trying to accomplish and why. I discuss the “why” in the section above; if these objectives are granted as valid for the sake of argument, how then might we best begin to establish such capabilities?

Human spaceflight requires specific destinations to be programmatically viable. The idea that we should develop technical systems before we decide where we will go takes us nowhere. The clear next step for human spaceflight in the post-ISS era is beyond low Earth orbit. The Moon offers the best near-term, sustainable destination to practice and accomplish those space faring goals mentioned above. The reasons are three-fold:

1. ***The Moon is close.*** Only a few days away, the Moon is constantly accessible for launch at any time. Its proximity permits remote control of machines by operators on Earth, allowing us to perform many menial and preparatory tasks by teleoperated robots prior to human arrival. The closeness of the Moon makes our early venture beyond LEO safer, as mission aborts are easier and opportunities occur more frequently than for trips of interplanetary dimensions. Milestones and capabilities for lunar return can be set and met in achievable timeframes.
2. ***The Moon is interesting.*** Etched in the Moon’s surface is the geological record of its history, as well as the history of the Earth-Moon system and that of the Sun and galaxy. A small rocky planet of surprising complexity and richness, the processes that operated on the Moon also operate on all of the other terrestrial planets. The Moon uniquely retains a record of the early impact bombardment history of the Earth, something no other space destination offers. A record of the ancient Sun and its output through time is recorded in the dusty regolith of the Moon’s surface, information vital to the reconstruction of Earth’s climate history. The airless, seismically quiet lunar surface is a superb platform to observe the universe by constructing astrophysical instruments of unprecedented sensitivity and capability. The Moon’s extreme vacuum and thermal environment permits scientific experiments difficult or impossible to attempt elsewhere in space or on Earth.

3. ***The Moon is useful.*** The Moon possesses the material and energy resources needed to create new spaceflight capabilities. Areas near the lunar poles contain abundant water (billions of tons) and receive near-permanent sunlight. These properties permit sustained human presence on the Moon through the use of sunlight to generate electrical power and the harvesting of water ice to both support human life and make rocket propellant through electrolysis of water into liquid oxygen and hydrogen. The Moon's surface materials provide feedstock for the production of metals, ceramics and useful objects, allowing us to construct new space systems derived from sources other than Earth, the deepest gravity well in the inner Solar System. The utilization of the Moon's material and energy resources permit us to build a permanent, reusable and extensible space transportation system, a system that not only permits access to and from the lunar surface, but to all other points in cislunar space.

All of the Earth-orbiting satellite assets upon which modern technical civilization depends reside in the volume of space between Earth and Moon (cislunar space). Currently, custom designed satellites are launched on expendable vehicles, used for a time and eventually abandoned. Because our options are limited to satellites that can fit on the largest launch vehicles, and since we cannot get people and machines to high Earth orbit (e.g., MEO, GEO and the L-points) to build, service and repair space systems, our satellite assets are mass- and power-limited and thus, capability-limited. By creating a system that can routinely access cislunar space (using rocket fuel made from lunar polar water), we are able to transport people and equipment to any point to service existing assets and build new and powerful distributed systems. Once we break free from the expense and restrictions of hauling everything out of Earth's gravity well, we become capability UN-limited in space.

To be politically sustainable over many years and decades, it is important to construct a program that is affordable and is seen to accomplish recognizable milestones at frequent intervals. One way to achieve this is to implement an architecture that consists of incremental steps, each one small enough to be affordable under reasonable funding scenarios, yet capable over time of being operated collectively as a large, distributed system. Because the Moon is close (round trip time for a radio signal is 3 seconds), we can control robots via teleoperation from Earth and prepare an outpost and manufacture rocket propellant and other useful materials prior to human arrival. People can then move into a turn-key outpost on the lunar surface, emplaced by robotic machines, with the ability to refuel a reusable lander for trips to and from the lunar surface. Such an architecture has been developed (see bibliography) with estimated costs that fit under a NASA budgetary envelope of less than one-half of one percent of the federal budget.

### **3. What are the ramifications and what would the nation and world lose if the United States terminated NASA's human spaceflight program?**

America is not the only entity interested in space. Other nations, corporations and non-government entities have already shown that they plan to be present in LEO, in cislunar space, and on the Moon. If the United States as a collective entity (i.e., the nation as represented by the federal government) is not present on the new frontier of space, what other country will promote, advance and protect our political and economic values in this area?

We depend upon a technical industrial infrastructure for our national economy and security. That industrial base has significantly deteriorated in the years since the end the Cold War. The great advances in consumer products in the last 20 years do not fully develop all of the technical capability needed for national security purposes and vice versa. A vigorous civil space program has proven to be an excellent means to develop and maintain this capability, one that we may need at any time on very short notice. Thus, civil space occupies a critical niche in the American national defense posture, regardless of our avowed peaceful intentions in space.

In an early speech defending the Apollo program, President John F. Kennedy laid out the reasons that America had to go the Moon. Among the many ideas that he articulated, one stood out. He said, “whatever men shall undertake, free men must fully share.” This was a classic expression of American exceptionalism, the idea that we explore new frontiers not to establish an empire, but to ensure that our political and economic system prevails (or at the least, is represented). That system has encouraged and defended basic human freedoms and put new wealth into the hands of the greatest number of people in the history of the world.

We make the Moon the first destination for humans beyond LEO because it has the material and energy resources needed to create a true space faring system. With both abundant water and energy available near the lunar poles, we return to the Moon to learn how to extract and use those resources to create a permanent transportation system, one that opens up cislunar space and allows routine access with machines and people. Such a system is the logical next step in space security and commerce. Cislunar development is fiscally prudent and ensures that our civil space program is relevant to important national interests of security, technology and economy, as well as advancing scientific understanding and knowledge.

Space should be more than a sanctuary for science and PR stunts. Space needs to be a true frontier, beaconing scientists and pilots as well as miners, technicians, construction workers, entrepreneurs and settlers. Decisions made now may decide humanity’s fate for generations.

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