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SPACE LEADERSHIP IN TRANSITION

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Summary

For generations, Americans have heard government officials, academics, technology pundits, and others talk about leadership in space. From this we can infer that space leadership has enduring importance. However, it seems to mean different things to different people. It also changes over time—space leadership today does not have the same characteristics and share the same priorities as in the days of Sputnik and Apollo. This paper discusses how we should characterize space leadership in the post-Cold War, twenty-first century context, and examines the hypothesis that the primary showcase for national space leadership for the foreseeable future will be cislunar space development.

The Changing Landscape

In recent years, U.S. space operators and decisionmakers have become increasingly concerned about threats to U.S. space leadership. In the civil sector, this has been driven largely by U.S. dependence on Russia for crew access to the International Space Station (ISS) since the termination of the space shuttle program in 2011. In national security, foreign development of counterspace systems has become a regular feature of public statements by U.S. defense and intelligence officials.[1] This is reminiscent of similar concerns about the Soviet Union's space program between the launch of Sputnik 1 in 1957 and the success of the Apollo lunar missions. The threat of Soviet dominance in space turned out to be less formidable than expected, but it continued to drive policy and programmatic decisions for decades, until the Soviet Union ceased to exist.

Generally, the global proliferation of space-related technologies and know-how has made the twenty-first century space environment a very different

> ***"There is rather more to space exploration than shooting men into orbit, or taking photos of the far side of the Moon. These are merely the trivial preliminaries to the age of discovery that is now about to dawn. Though that age will provide the necessary ingredients for a renaissance, we cannot be sure that one will follow. The present situation has no exact parallel in the history of mankind; the past can provide hints, but no firm guidance."***
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> —Arthur C. Clarke
> *Profiles of the Future* (1963)

playing field from what it was in the Cold War. In today's world, particularly with the rise of space activities in China, India, and many other countries, and the resurgence of Russia as a strategic competitor, U.S. leadership faces a fundamentally different challenge: how to productively interact with a global array of collaborators and competitors, not simply outperform a single peer rival.

Another critical development of the current era, at least as important as the growth in the number of spacefarers worldwide, is humanity's inflection point in space operations. For the past three generations, we have learned to use space applications that have made us safer, richer, and more connected. These impressive benefits have been achieved almost entirely using disposable space systems that receive and transmit electromagnetic information. The next plateau, for which we seem poised to reach, will be more difficult to achieve but potentially much more rewarding: the routine physical manipulation of objects in space (e.g., building, servicing, mining, manufacturing, and debris cleanup) accompanied by human habitation in space on a scale significantly beyond anything experienced to date. This could result in profound changes, not only in how we operate in space, but also to the extent that space becomes integrated with our economy and our culture.

Growth in the number of spacefaring nations and continuous improvement of technical and operational capabilities ensure that national leadership will remain a fluid concept. This makes space leadership hard to identify and categorize, and yet it has been invoked so often that it risks becoming little more than a rhetorical tool.

Calls for U.S. Space Leadership: A Brief History

In anticipation of the 2016 U.S. presidential election, a group of space-related professional associations issued a statement titled "Ensuring U.S. Leadership in Space." The group offered a list of 10 objectives to shore up U.S. leadership, such as stable budgets, a strong industrial base, innovative partnerships, and reduced trade barriers. However, the group did not try to define space leadership, leaving open the question of how to recognize when it has been achieved (aside from the size of the nation's space-related market share).[2] This is just one recent example in the long history of concern over U.S. space leadership.

Space leadership has been a staple of U.S. policy and rhetoric since the administration of President Dwight Eisenhower. In a document that can be considered the first U.S. directive on overall space policy,[3] the Eisenhower administration noted "a tendency to equate achievement in outer space with leadership in science, military capability, industrial technology, and with leadership in general." In the wake of Sputnik, "further demonstrations by the USSR of continuing leadership in outer space capabilities might, in the absence of comparable U.S. achievements in this field, dangerously impair the confidence of these peoples [non-aligned nations] in U.S. over-all leadership." At a time when the benefits of space applications had yet to be realized, the administration believed that the nation's performance in this area would be a reflection of U.S. leadership across many important national interests, especially military, economic, and scientific. Eisenhower supported research "to achieve and maintain leadership in such

applications" and listed the following as the first of four objectives in the directive [emphasis added]:

> Development and exploitation of U.S. outer space capabilities as needed to achieve U.S. scientific, military, and political purposes, and **to establish the U.S. as a recognized leader in this field**.

For the next two decades, presidential administrations addressed space policy in short, targeted directives rather than comprehensive national policies, but calls for U.S. leadership did not disappear from the dialogue. In a prominent example, at the birth of the Apollo program, President John F. Kennedy sent a query to Vice President Lyndon Johnson asking if there was a "space program which promises dramatic results in which we could win?"[4] In his response 18 days later, after consulting with NASA and other stakeholders, Johnson made it clear that he interpreted this as a "request for positive recommendations for placing this country on the way toward leadership in space."[5]

Articulation of overarching national space policy made its reappearance in the Jimmy Carter administration, including a statement that "We will maintain U.S. leadership in space science and planetary exploration and progress."[6] Early in his presidency, Ronald Reagan asserted that "The United States is fully committed to maintaining world leadership in space transportation" and will preserve its "leadership in critical aspects of space science, applications, and technology."[7] Shortly before leaving office, he noted that "a fundamental objective guiding United States space activities has been, and continues to be, space leadership.… The United States civil space sector activities shall contribute significantly to enhancing the Nation's science, technology, economy, pride, sense of well-being and direction, as well as United States world prestige and leadership."[8]

More recently, Barack Obama's National Space Policy, which remains in effect, repeatedly articulated the intent to strengthen, reinvigorate, and demonstrate U.S. leadership in a broad range of space activities.[9] Leadership also has been a theme of Donald Trump's series of Space Policy Directives.[10] In general, statements from U.S. officials insist that the United States will maintain (or regain) leadership. As a result, space projects of significant size (e.g., launch vehicle development as well as human and robotic exploration) have come to symbolize leadership, not just in the United States but also in emerging spacefaring countries.

The Old Metrics

Leadership is difficult to measure, having both quantitative and qualitative aspects. In the early days of the space age, the most widely reported and recognized measures of a nation's space activities favored the quantitative:

- The size of the space budget.
- The capacity of the largest launch vehicles.
- The frequency of launches.
- The number of operational satellites.
- The number of significant space "firsts" achieved. (This covered an array of activities; e.g., first satellite, first pictures of the lunar far side, first man in orbit, first woman in space, first multi-person space capsule, first spacewalk, first robotic probe to another planet, and first crew to land on the moon.)

The perception of who was "winning" was a key element of the geopolitical rivalry. Initially, the Soviet Union was winning on the numbers: larger-capacity launch vehicles, more launches, more satellites, and more "firsts" in both robotic and

human spaceflight. The relative amount of funding was hard to determine accurately mostly due to lack of transparency on the Soviet side, but it seemed reasonable to assume that all those firsts were backed by a lot of rubles. On the American side, funding ramped up quickly in the 1960s, but the decline of NASA budgets as the Apollo program wound down in the early 1970s was seen by some observers as neglect, or even abdication, of U.S. leadership. Another assumption at the time, less quantifiable but clearly important, was that the Soviets had matched or surpassed the United States in all or most space-related technologies. This was a subjective assessment that was measured indirectly through quantitative evidence such as number of successful missions or firsts.

These measurements of Soviet leadership turned out to be a mischaracterization. Launch vehicles were bigger because Soviet missiles had been designed for bulky nuclear warheads that were heavier than their U.S. counterparts. Launches were more frequent and satellites more numerous because Soviet satellites were not reliable and did not last very long. The Soviet space firsts were driven by often reckless political pressure from leaders seeking propaganda victories, which prompted an overestimation of the state of Soviet space technology.

Today, it is appropriate to question which of these old measures are still valid. More than a half century of experience in space has shown the world that leadership is not determined solely by how much you spend, but also by how you spend it. Investment aimed at maintaining and extending leadership ideally should yield innovation and sustained progress, even if there are failures along the way. Investment dominated by playing it safe, which can unreasonably extend legacy projects at the expense of innovation, may not earn points toward recognition as a leader. Political and business decisionmakers have not always taken the big-picture view and balanced their portfolios to ensure leadership, choosing instead to appease entrenched (often short-term) interests. [13,14]

Numbers in Perspective – 2018[11,12]

- China led the world with 39 orbital launches.
- The United States had 31 launches, all of which were conducted by commercial entities. Only one Chinese launch was commercial.
- SpaceX, a company with 6,000 employees, completed 21 of the U.S. orbital launches.

Achieving space firsts, which carried great significance in the East-West geopolitical competition to win hearts and minds around the world, counts for less in today's world, where capabilities are more dispersed and international collaboration is the norm for ambitious projects. (However, space firsts may still hold significance for the domestic and regional audiences of emerging spacefarers.) Similarly, numbers of rockets launched or satellites deployed do not indicate leadership unless they contribute to increasing humanity's knowledge and capabilities or build infrastructure that paves the way to accomplish these things in the future. Nationalistic statements and actions that appear designed to flex muscles are likely to clash with foreign policy, trade, and technical collaboration imperatives and be seen as undesirable and anachronistic.

Investing in space leadership-by-the-numbers has opportunity costs: Could the resources be more productively applied elsewhere? For example, is having the largest launch vehicle more or less important, for operational and prestigious reasons, than having the ability to assemble, repair, and refuel on-orbit assets? Similarly, are the historic accolades and scientific and technical advances to be obtained from putting the first humans on Mars worth more or less than the economic, scientific, and technical advances gleaned from investing the

"The long-term health of a nation is probably shown most clearly by the time scale of the programs it undertakes. The willingness to commit to ventures of many years' duration, with potential very large returns, is the hallmark of a nation confident of its own future. The fear of any commitment beyond one or two years is the symptom of disease, signaling a fundamentally hopeless view of the future and the intention to cut the losses and get out of the game."

—Gerard K. O'Neill
2081 (1981)

same resources in the development of cislunar space? The late physicist John Marburger succinctly summarized this concern shortly after he completed his tenure as science advisor to President George W. Bush:

> If the architecture of the exploration phase is not crafted with sustainability in mind, we will look back on a century or more of huge expenditures with nothing more to show for them than a litter of ritual monuments scattered across the planets and their moons.[15]

For examples of how old metrics still hold some influence in today's space community, we need to look no further than reactions to the Chinese achievement of becoming the first country to land on the moon's far side in January 2019. This event did not provoke the same level of panic as did Sputnik in 1957, but some analysts sought to portray it as a demonstration that the United States is losing a new space race. A commentary in the *Washington Post* at the time correctly identified the harvesting and use of space resources as a critical element in the next generation of space development but lapsed into Cold War rhetoric in statements such as this one:

> China is best placed to win a space race, given its well-coordinated, disciplined, technocratic system, able to set and maintain long-term goals, with a vast population and talent base. The United States is disorganized regarding space and cannot offer a serious challenge to the long-term plans China is setting in this domain.[16]

Substituting "the Soviet Union" for each occurrence of "China" in the previous statement will yield the same argument that was heard through much of the Cold War. The difference today is that China has the second-largest economy in the world and is well integrated with global commerce. This gives it a distinct advantage over the old U.S.S.R., but it does not mean that all space ambitions will be realized on schedule and with no mishaps. Nor does it mean that Chinese space leadership can be defined simply by numbers of launches or space firsts.

The successful landing of Chang'e-4 on the lunar far side was a great achievement, but it was not the only remarkable space activity going on at the time. Between late November 2018 and early January 2019, NASA landed the InSight mission on Mars, put OSIRIS-REx into orbit around an asteroid, did a flyby encounter with a Kuiper Belt object with the New Horizons spacecraft, and awarded nine contracts for Commercial Lunar Payload Services (CLPS) to support lunar surface activities.

Similarly, the hiatus in the launch of crews to orbit from the United States after the 2011 retirement of the space shuttle must be put into perspective. It was fortunate that the Russian Soyuz option was available, allowing ISS operations to continue even though the hiatus has lasted longer than expected. But does temporary dependency on a spacefaring partner constitute loss of leadership? In this case, that could be true in a micro sense because the reasons for the delay include inadequate federal funding in the early years of NASA's Commercial Crew program, followed by development delays experienced by the contractors. In the macro sense, this was a big step forward in human spaceflight: the United States has become the first country to turn to its commercial sector for human access to orbit. This provides the U.S. government—and other customers—with two commercial sources for sending humans into space, with more expected to follow. This puts the U.S. squarely into a leadership position, driving what is expected to be a trend in access to orbit. Commercial services aimed at the lunar surface and other locations in cislunar space are expected to follow in the near future.

Space leadership is a source of power in the world. It enables sophisticated collection and distribution of information that can yield real economic and national security strength. Pride in space accomplishments promotes national prestige. This implies that failures of space leadership can diminish the strength of major powers. In a world that includes ongoing geopolitical rivalry, space competition in its various forms will continue and grow.

Updating the Metrics for Space Leadership

If leadership measures of the early space age are no longer valid—or at least, have lost some of their significance—then development of new measures for the twenty-first century is required. Some generic national leadership characteristics applicable to politics, economics, and science can be applied specifically to spacefaring efforts:

- Reputation as a respected partner with whom others are eager to team—the partner of choice, not just necessity
- A proactive, not reactive, approach to programs and investments aimed at innovation and development
- Substantial global market presence in key hardware and services industries
- Prime mover in establishment of procedural norms and technical standards

Based on these generic indicators, a country's concerns about loss of leadership should be focused on factors such as declining partnerships, inadequate forward-looking investment, shrinking global market share, and reduced influence in standard-setting bodies. These factors are far more important than which country had the most launches last year. Global space players, as they evolve, inevitably seek independent capabilities and ways to maximize their own economic benefits. That is part of a healthy competitive environment, so shifting markets should be no surprise. The difficulty arises when a country finds itself sidelined or excluded from international activities in which it formerly exercised influence.[17]

Leadership measures for the twenty-first century can draw from scholarship of the last century. Dr. Sally Ride's 1987 report to the NASA administrator gives excellent guidance for reevaluation of leadership indicators. Although the report was written more than three decades ago and speaks from a U.S. perspective, it contains several

insights that have lasting value for a broader community. The essential points are summarized here [emphasis added]:[18]

- **Leadership cannot simply be proclaimed—it must be earned.**

- **Leadership does not require preeminence in all areas and disciplines of the space enterprise.** In fact, the broad spectrum of space activities and the increasing number of spacefaring nations make it virtually impossible for any nation to dominate in this way.

- Being an effective leader requires that a country **have capabilities which enable it to act independently and impressively** when and where it chooses, and that **its goals be capable of inspiring others**—at home and abroad—to support them.

- Leadership results from both **the capabilities a country has acquired** and **the active demonstration of those capabilities**; accordingly, a leading country must have, and also be perceived as having, the ability to meet its goals and achieve its objectives.

- A space leadership program must have **two distinct attributes**.

  - First, it must contain **a sound program of scientific research and technology development**—a program that builds the nation's understanding of space and the space environment, and that builds its capabilities to explore and operate in that environment. A country will not be a leader in the 21st century if it is dependent on other countries for access to space or for the technologies required to explore the space frontier.

  - Second, the program must **incorporate visible and significant accomplishments**; a country will not be perceived as a leader unless it accomplishes feats which demonstrate prowess, inspire national pride, and engender international respect and a worldwide desire to associate with the nation's space activities.

- Perhaps most significant, **leadership is also a process. That process involves selecting and enunciating priorities for the civilian space program and then building and maintaining the resources required** to accomplish the objectives defined within those priorities.

Dr. Ride recognized long ago that the space operating environment would become simultaneously more collaborative and more competitive. She emphasized the continuing need for scientific research and technology development. She repeatedly identified capabilities (not destinations) as a strategic driver and acknowledged their importance in demonstrating to other nations why they should be eager to partner with the United States.

Dr. Ride's vision of space leadership overlaps and is compatible with the generic leadership characteristics listed at the beginning of this section. Merging the two yields a robust framework for an updated paradigm of space leadership for any nation that aspires to it:

- The continuing quest for scientific knowledge

- Development of advanced technology and the ability to use it

- An ongoing record of achievement based on proactive government and industry investments

- A cooperative posture that prompts other nations' willingness and eagerness to collaborate on programs as well as the establishment of standards, norms, and rules

Although counting missions and tallying budgets will always play a role in measuring achievement, the new paradigm should not be "leadership by the numbers." Technologically, it should be capabilities-driven and business-savvy. Politically and strategically, it should embrace both collaboration and competition but shun space races and other short-term, resource-depleting endeavors that do not contribute to long-term collective goals and objectives. By embracing this approach, leading spacefarers can become far better at answering the question: Why spaceflight?

Reconsidering Rationales, Rebranding Spaceflight

Two respected polling organizations each conducted national polls on the U.S. space program in 2018. Their results were very similar. Both found that a strong majority of respondents believe NASA continues to play a vital role in space exploration, even as private sector organizations demonstrate greater capabilities and ambitions. In a Pew Research poll, 72 percent agreed that "it is essential for the U.S. to be a leader in space exploration."[19] A poll by Bloomberg asked about the level of investment rather than leadership, and 76.6 percent said that U.S. government spending on space exploration was either "just the right amount" or "too little."[20] These two polls appear to document resounding public support for the United States as a space leader and for NASA as a key element of that leadership.

"We could fill books with problems of fundamental importance to the human race which can be solved only by spaceflight, more easily by spaceflight, or more probably by spaceflight."

—Dandridge Cole
Beyond Tomorrow (1965)

However, the poll results regarding priorities tell a different story than the message typically heard from U.S. leaders and the space community, who often portray human exploration as NASA's core mission. In both polls, respondents' top two mission priorities by far were climate change research and monitoring of asteroids that pose impact threats to Earth. Both polls placed human missions to the moon and Mars at the bottom of the list. A more recent poll (May 2019) placed asteroid monitoring at the top of the priority list and scientific research (all types, including climate research) in second place, with human missions to the moon and Mars at the bottom once again.[21] Altogether, these polls seem to suggest a substantial disconnect between the preferences of U.S. citizens and the projects and rhetoric promoted by their elected leaders.

Spaceflight enthusiasts, and even seasoned professionals, too often do a poor job of justifying space investments in a way that resonates with uninvolved citizens. Writing and rhetoric on the subject tend to lean heavily on national prestige, scientific discovery, technological spinoffs, inspiration of youth, and our "destiny" or "nature" to explore. While each of these rationales has merit, some have weakened considerably in our post-Cold War, high-tech world. Collectively, they may no longer be sufficient to justify the associated cost and risk in the minds of the general public.[22] It is debatable whether we can unambiguously achieve all of these aspirations as effectively as we did in the 1960s with the Apollo program.

Nationally and globally, there is insufficient agreement on prioritization of the *primary* drivers of

current and future spaceflight efforts. Space offers an array of worthwhile *secondary* rationales (e.g., spinoffs and inspiration), but investments and risk assessments should be made based on primary rationales. A brief assessment of the traditional justifications demonstrates the altered circumstances that have developed in the twenty-first century.

- **National Prestige.** Emerging spacefaring nations undoubtedly are hoping for a boost in prestige from their growing space activities. However, it seems unlikely that exploration and development efforts by a country acting alone, no matter how successful, would win hearts and minds in the international arena to the extent experienced in the Apollo era. In the absence of large-scale benefits shared generally, resentment or suspicion of the lone actor may result. This could dramatically alter the calculus for a nation seeking leadership status.

- **Scientific Discovery.** Science is obviously the primary goal on dedicated missions, but it has always been secondary in human spaceflight. In either case, the science community's investment decisions will tend to favor robotic systems for anything beyond cislunar space and perhaps for many lunar investigations. As the sophistication and productivity of robots improve, there will be no scientific motive for a rush to send humans to distant destinations given the added risk and expense. This perpetuates the tension and resource competition that has existed between science and human spaceflight efforts for decades.

- **Technology Spinoffs.** Spinoffs are not a sufficient justification for a space exploration program. They are secondary applications, and an investment of this magnitude must be justified on its primary applications. Any attempt to argue that spinoffs provide the rationale for spaceflight is easily countered: direct investment in technology development in the absence of a space program would bring similar results at less cost.

- **Inspiration to Youth.** Inspiration is a very positive *side-effect* of the space program, but it is not a primary rationale for going into space or a justification for expending substantial resources and taking on exceptionally high risk. Post-baby boom generations, who did not grow up watching Project Apollo unfold, tend to take spaceflight for granted. Space-related news and information struggles to rise above the noise level amid the multitude of distractions that draw attention in twenty-first century society.

- **Human destiny.** Not all individuals and cultures embrace exploration, so if it is human destiny to explore, this is only true for some humans. At the national level, a society that seeks to grow, enrich itself, advance its technology, and stimulate its creativity must explore in some manner.[23] However, that does not necessarily mean space exploration will be the first choice, even if the technological capability to do so exists. Analysis of opportunity costs is inevitable: If a society invests substantial resources in space, what other investments are sacrificed?

A healthy appreciation for history is clearly important. However, critical analysis of that history should reveal the importance of inflection points that re-vector human efforts toward a new plateau. As noted earlier, humanity is now facing such an inflection point in space development, if it chooses to engage and to persevere.

To reach the new plateau, decisionmakers must resist pressure to be hidebound by historical experience that lacks applicability to the future. Nations that aspire to space leadership in the twenty-first century must revisit their fundamental goals as they plan the transition to the next plateau: What do

we want to accomplish *that space can contribute to*? Presumably, the answer will include some combination of the following: expand human knowledge and resources, improve the economy and the quality of life, and increase chances for survival.

To achieve these goals—indeed, to determine the extent to which space activity can contribute to these goals—leading spacefaring nations must take on these five challenges:

1. **Conduct cislunar development** that advances science, commerce, and security.
    a. Fund and perform early-stage, high-risk research and development.
    b. Build or sponsor key infrastructure elements.
    c. Become an anchor tenant for promising new space industries and/or facilities.

2. **Address the two greatest physiological challenges** to long-duration spaceflight: microgravity and radiation exposure.
    a. Pursue development of rotating variable gravity habitats and determine the minimum gravity level needed to maintain health.
    b. Experiment with shielding and medical countermeasures to mitigate radiation exposure; plan for solar flare scenarios.

3. **Demonstrate that humans can "live off the land"** in space.
    a. Optimize reuse of space systems.
    b. Learn how to routinely use extraterrestrial material and energy resources.
    c. Develop the means for extraterrestrial production of routine supply needs.

4. **Increase efforts on planetary defense and human survival**, encompassing both the outsider threat and the insider threat.
    a. Outsider threat: Detect, categorize, and track solar system bodies that may pose a collision threat for Earth. Develop countermeasures and response plans.
    b. Insider threat: Expand the spatial, spectral, and temporal observation of Earth and its atmosphere to detect and report anomalies and identify trends. Beyond the scientific benefits of such activities, the systems should be designed to rapidly deliver results that are useful to national and international decisionmakers, space operators, and other relevant responders.

5. **Transition to a new generation of science missions** that include humans and robots working together on planetary surfaces and deep-space robotic probes that are assembled in orbit, which may allow for much more ambitious missions.

These five challenges address major aspects of the learning curve for reaching the next plateau, and cislunar space is the proving ground (for the human components in particular). However, it may also be a disproving ground. Along the way, we may discover that certain key capabilities will take far longer to become viable than we had anticipated (e.g., mining water ice on the moon or minerals on asteroids). Even negative findings are important, however, as they will compel us to adjust the pace or priorities of space development.

Conclusion

The challenges awaiting us on the next plateau of space development require *transforming* leadership (in pursuit of higher collective goals) not simply *transactional* leadership (incremental actions that satisfy specific individuals or groups).[24] For generations to come, national leadership in space may be defined and judged chiefly by how nations and their subnational entities advance the development of cislunar space and reap (and share) its benefits. In such a scenario, cislunar development will be justified on its own merits, not simply as a stepping-stone to points beyond. International and industrial collaborators will be true partners and investors, not simply contractors providing hardware or services.

Future space "firsts" will be cheered, and traditional by-the-numbers measurements will continue to be promoted, but topping the list of metrics for space leadership will be steady technological advancement, contributions to enduring space infrastructure, willingness to partner and share, and concerted efforts to address highest-salience global challenges.

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