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The Case for Managed International Cooperation in Space Exploration

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Introduction

International cooperation in space exploration has the potential to provide significant benefits to all participants, particularly if managed well. Benefits in the form of monetary efficiency, programmatic and political sustainability, and workforce stability will accrue to those partners who choose to approach space exploration as a mutually beneficial endeavor. Furthermore, international cooperation must be explicitly incorporated as an aspect, and goal, of a modern space exploration program to enable coordination prior to the construction of new hardware. Such coordination can happen on both the government and industry levels and allows for advance planning and standardization that can enhance the strategic use of redundancy through interoperability. Finally, the promotion of a set of industrial standards for cooperation in space exploration will enable the exercise of leadership in future stages of the Vision for Space Exploration (VSE). If the vision is to succeed, the United States, in particular, must engage its partners by reaffirming and strengthening its commitment to the International Space Station (ISS) to maintain its diplomatic credibility for future exploration endeavors.

International cooperation must be an integral part of the way in which the United States, and all space-faring powers, approach space exploration. Management of this cooperation up-front can have high payoffs in terms of both political and programmatic sustainability, diplomatic benefits, and ultimately, the development of free-market forces in space. The first step toward making the most of international cooperation in space exploration is the completion and utilization of the ISS.

The ISS program is not complete. Therefore, the program's utility has not yet been fully realized. To the extent that a completed ISS is beneficial, the program will deliver positive utility. Nevertheless, for each passing year that these benefits are delayed, their perceived probability of delivering value is decreased, concomitantly decreasing their expected utility. Given that the ISS program is significantly over budget, 10 years behind schedule, and far from complete, we may expect that the practical benefits of ISS utilization may not be a major factor in current utility calculations. Similarly, many space exploration endeavors promise practical benefits that can only be delivered on time scales that are significantly longer than what is required to make an adequate business case. As such, we may assume that the purely economic benefits of space exploration are not the primary driver for exploration in the short term. Rather, space exploration is an activity that delivers immediate value in noneconomic areas, while allowing for longer-term practical and economic benefits. As will be demonstrated below, each of these benefits can be strengthened through correctly managed international cooperation.

Why Do Nations Choose to Cooperate in Space Exploration?

The case for international cooperation varies between nations, depending on their needs. For example, most nations lack the budgetary resources to carry out their space exploration goals alone. As such, international cooperation is a must for these nations. The United States, on the other hand, nominally possesses the budgetary resources to carry out the VSE but is under a presidential directive to engage in international cooperation for diplomatic reasons. If cooperation between nations is to be successful, each nation must have an incentive to cooperate (i.e., each nation must derive

positive utility from the partnership). The remainder of this section presents four reasons why nations might choose to cooperate in space exploration. As such, international cooperation can occur where these nations possess complementary needs.

Reason #1: International Cooperation Saves Money

It is common knowledge that international cooperation in space exploration has the potential to reduce a partner's costs by spreading the burden to other nations. Although additional overhead costs increase the overall cost of any international cooperative endeavor, these costs are spread among partners. As per-partner cost decreases, per-partner utility increases. Space exploration has proven to be an expensive activity. Indeed, the more that any given administration and Congress must spend to maintain and/or expand the functionality of a program like the ISS, the less utility will be derived. Therefore, a nation will have an incentive to engage in international cooperation when doing so can reduce that nation's costs. This is particularly true for nations whose space exploration budget is insufficient to execute their space exploration goals. Aside from the United States, and possibly China, international cooperation is necessary for all other space-faring nations simply due to the large costs involved.

Reason #2: International Cooperation Generates Diplomatic Prestige

The ISS program, along with most international civil space endeavors, carries with it an element of diplomatic cachet and control. The participation of other nations in the program increases the diplomatic influence of participating nations and, therefore, the diplomatic utility derived from cooperation. In general, the more countries participate, the higher will be the utility. Nevertheless, not all countries are equal, and their individual utility value depends on world politics. For example, the utility of having Russia join the ISS program increased significantly after the breakup of the Soviet Union, when relations with a new Russia were at the forefront of United States foreign policy. To the extent that a symbol of cooperation with a given nation is valuable, utility will be delivered. As such, Indian participation in joint space exploration would send a strong signal to the world of good U.S.-Indian relations. This would simultaneously increase Indian prestige by demonstrating their technological prowess. Similarly, Chinese participation in joint space exploration would signal growing cooperation between the two nations. The use of the ISS for a partnership between either of these nations would drastically increase its utility to those who support friendly relations. On the other hand, those who oppose closer U.S. relations with India or China are likely to oppose their entrance into the ISS program or into any other joint space exploration program. These diplomatic incentives may come at a cost for the cooperating nations; for example, China would likely have to make concessions in the form of more stringent technology export controls and/or better observance of human rights standards. If space exploration is successfully used as a diplomatic tool to exert such "soft power," its utility increases in proportion to the degree that it is successful in implementing a policymaker's agenda. Similarly, the departure of a particular nation (or, if the United States chooses to cease participating, of all nations) will reduce U.S. utility to the extent that the aggregate symbol of cooperation is valued.

Reason #3: International Cooperation Increases Political Sustainability

International cooperation is valuable to a given nation in that it tends to increase political sustainability. Within the United States, a program is made safer from cancellation to the extent that Congress and the administration are not willing to break international agreements. Indeed, the integration of Russia into the ISS program may well have saved the program from cancellation (consider that the year before Russia was introduced as a partner, the ISS was saved by one vote in Congress). Once cooperation has commenced, canceling a program becomes inconsistent with political sustainability as long as the utility cost associated with the loss of diplomatic benefits and the negative effects on reputation of terminating an international agreement is larger in magnitude than the utility cost that must be paid to maintain the system. In the case of the ISS, international cooperation does provide a rationale for sustaining the program, because canceling the program would result in a net loss in utility. The corollary to this is that there is a high cost to be paid by any nation that chooses to unilaterally withdraw from an existing cooperative endeavor. This cost comes in the form of damage to the departing nation's reputation or credibility. In general, any unilateral action sends a signal that the actor is an unpredictable and therefore an unreliable and possibly disrespectful partner. This tends to sabotage the possibility of future cooperation. As such, there is a long-term benefit to maintaining cooperation, even

when the immediate cost may seem to call for terminating it. If cooperation has never occurred (as is the case between China and the United States), the advent of cooperation is a significant event, likely delivering a lot of diplomatic utility. On the other hand, if cooperation is the norm (as is the case between Canada and the United States), it is to be expected. The diplomatic utility of maintaining this cooperation is often not recognized. Nevertheless, the diplomatic utility cost of terminating this cooperation is large, because it would alienate a key ally. If it were necessary to cease cooperation, a mutual choice to do so would likely mitigate many of the negative reputation effects, because there would be no unilateral actor to whom one could assign blame. Indeed, if both parties choose to cease cooperating simultaneously, this would mitigate the negative-reputation effect—rather, there would be a "mutual divorce." Such a mutual decision would be significantly more tenable, in a diplomatic sense, because each party might outline a set of grievances and conditions for the termination of cooperation. Furthermore, since the agreement would be terminated in a spirit of mutual understanding, the possibility of future beneficial cooperation would be more likely.

If the ISS were unilaterally terminated, the result would be a blow to the credibility of the United States, concomitant with the loss of trust of the foreign partners. A U.S. withdrawal could send the message that the purpose of the program is simply to divert resources from other nations' space goals in order to prevent competition. This, in turn, would have a profoundly negative effect on any future U.S. leadership in space exploration. If possible, international cooperation must be terminated in such a way as to avoid portraying the terminating nation's actions as unreliable, disrespectful, or malicious. As such, if the ISS is to be terminated, such a termination should be phrased as a joint decision made among all partners, in such a way as to leave open the possibility of future cooperation.

Recommendation #1: The ISS should not be unilaterally terminated

Reason #4: International Cooperation Enables Workforce Stability

One way politicians measure the benefit of a large program is in terms of the number of jobs and amount of revenue brought to their constituency. As such, the politician's perception of change in these sorts of benefits is of the utmost importance. For example, both the Space Shuttle and ISS programs employ workers across the country and serve as a source of revenue to the districts of many members of Congress. The program also employs enough people to attract the attention of the president. The loss of these jobs and revenue streams would constitute a large loss in utility for both the administration and Congress; nevertheless, the aerospace industry must continually engage in advocacy activities to ensure that politicians are made aware of this fact. Similarly, simply continuing a program is unlikely to increase its utility for any of the stakeholders, because the jobs and revenue streams already exist. It is only when these benefits are put under threat that political salience is achieved. As such, if either the Space Shuttle or ISS programs were to grow to employ more people, an increase in the perceived utility lost in the event of a cancellation of the program would only result if the growth were significant enough to attract political attention. This is different from an expected utility gain; a proposal to grow the program prior to its execution is unlikely to increase utility as much, because future employees will not engage in advocacy to keep jobs that do not currently exist. This means that established programs are more sustainable than are programs that have not yet begun. In addition, the incumbent advantage means that members of Congress are generally satisfied with the status quo. If it should happen that a program is approved and seems likely to be implemented in a particular district, individual members of Congress may lend their support in the expectation that they will gain utility. Thus, positive utility for programmatic expansion only exists when a supporting coalition may be identified. As such, additional employment does not strictly deliver positive utility; rather it can increase the perception of utility loss in the event of program cancellation. Similarly, once jobs are lost and utility is decreased, there is no additional positive utility to be gained from reinstating those jobs. Rather, the threat of the loss of utility inherent in the loss of employment can only serve as a deterrent. Such employment programs therefore act in a manner similar to an addiction, wherein the removal of employees causes "withdrawal symptoms" manifested as a loss of utility. Nevertheless, when the metaphoric addict becomes accustomed to the additional employment, the prospect of a marginal increase does not increase utility.

On first analysis, international cooperation might seem to decrease employment in the United States, because foreign nations are building components that might otherwise be constructed in the United States. In practice, those who are employed may see more stability in their jobs due to the twin utility losses associated with employment termination and diplomatic prestige loss. In effect, employment has no impact on utility unless it changes. The stability provided by international cooperation will ensure that the associated utility is at least less likely to decrease.

How Should Cooperation Proceed?

Given that international cooperation can provide positive utility to participating nations, we must examine how best to cooperate to ensure that each participant is maximizing the utility obtained through cooperation in space exploration. The following section presents recommendations for new cooperative modalities.

The Critical-Path Problem

International cooperation inserts an element of programmatic dependence into the architecture of a system, requiring that all partners deliver what they promised on time and within the agreed-on parameters. These concerns give rise to the dictum that international cooperation is best for a nation when its partners are not on the system's "critical path" (i.e., the nation's partners' contributions are not required to complete the system; instead, they merely present an additional noncritical capability). For example, the ISS has two partners on the "critical path" for crew transport and station resupply—the United States and Russia. Other nations, such as European Space Agency (ESA) member states and Japan, currently provide modules whose absence would not prohibit the station as a whole from functioning. This approach would suggest that, from a programmatic standpoint, there is little incentive to cooperate with a nation that cannot contribute a unique capability or that is not able to provide an existing capability at a lower cost than can be domestically produced. For example, a programmatic basis for cooperation between the United States and Japan is that the Japanese Kibo module is provided to the United States for free on a no-exchange-of-funds basis. In return, the United States is flying the module and attaching it to the ISS. This paradigm removes strong incentives for nations to collaborate since the noncritical-path nation (e.g., Japan) depends entirely on the goodwill of the critical-path nation (e.g., the United States). On the other hand, the critical-path nation (the United States) may operate independently and therefore view cooperation under this paradigm as providing extraneous benefits that, although desirable, can be dispensed with in an emergency. As such, the benefits of maintaining the critical path within the purview of one nation are clear—by preventing multiple participants from participating in this area of the architecture, coordination costs are reduced. A nation will not be "held hostage" by the policy, schedule, or budgetary difficulties of its partners. Too many cooks spoil the broth.

Nevertheless, there are diplomatic drawbacks to insisting on sole control of the critical path. By restricting international partners to noncritical-path items, a nation is sending a signal indicating a lack of trust and confidence in the partner's capabilities and unwillingness to rely on that partner. Rather than committing to work through problems, the nation is hedging bets in case the partner "fails." This sort of partnering is, in effect, not truly cooperative, because the requirement that one nation possess all of the critical-path capabilities is an implicit statement that such a nation can complete the system under its own power and therefore does not need its partners. As such, there is no true programmatic incentive for the cooperation to happen. From a practical standpoint, this structure endows the nation that maintains the critical path with all of the decisionmaking power, thereby making the partner nations utterly dependent and essentially irrelevant. For example, a decision by the United States to cancel the ISS program could not be credibly opposed by the other partner nations. Although these partner nations may choose to participate for nonprogrammatic reasons, such as economic and diplomatic incentives, there is no programmatic reason for them to do so. Similarly, the argument that international cooperation reduces cost must also be seen within the context of the critical path. A partner who provides a component that is off the critical path is not genuinely reducing the cost for the integrator nation. On the other hand, such cooperation does not negatively affect the employment associated with the space exploration system. Instead, this nation is providing a capability that is, by definition, unnecessary to the minimal operation of the system. It is an extraneous capability. For example, the United States is not saving money by cooperating with Japan and the EU; rather, it is receiving a capability that it would not have had otherwise. This form of cooperation therefore creates a natural hierarchy of partner nations among those who have the most control of the critical path; the

most de facto decisionmaking power; and those who provide the extraneous capabilities but have little in the way of programmatic utility and contribute little in the form of decisionmaking.

It is unlikely that the noncritical-path partner nations, having experienced dependence during the ISS program, will be eager to leave the future of their space programs in the hands of a foreign power. How, then, can cooperation occur in such a way as to maximize the value of each partner's contribution without needlessly driving up coordination costs?

Given concerns regarding the outsourcing of U.S. jobs, the optimal way to allocate sections of the ISS, or other international cooperative endeavors, to foreign nations would be to choose elements that cannot be built in the United States or do not otherwise displace a large number of U.S. citizens, such that the political benefits do not conflict with the interest of the U.S. worker. In a project as large as the ISS, the marginal benefit of building an additional module in the United States, for example, is small, particularly if no supporting coalition may be identified that would advocate for its construction. If the module is built in an underserved district (i.e., one that has a number of unemployed skilled workers who are able to complete the task), the representatives from that district are likely to undertake advocacy, increasing the utility of keeping the module in that district. International cooperation aimed at promoting programmatic redundancy avoids adverse effects on domestic employment. A probable view of the role of international cooperation can be informative. For example, following the loss of the shuttle Columbia, the ISS program was only able to survive because of the transportation provided by the Russian Soyuz craft. Without this capability, the ISS program would have failed in the wake of the shuttle's stand-down. We may conclude, from this example, that **international cooperation can provide a strong benefit in the form of programmatic redundancy. In particular, this redundancy should be provided in critical-path capabilities**. In this way, no nation is entirely reliant on any other nation, because the critical path lies entirely within one nation. At the same, in the event of a critical subsystem failure, the presence of these redundant backups will ensure the survival of the system. One may even argue that programmatic redundancy can reduce per-partner cost by creating a higher net reliability that would otherwise impose a heavy cost burden on one nation. Finally, if one nation's system fails, other nations can temporarily move in to fill the gap in capability, thereby preventing a potentially debilitating hiatus in the human spaceflight activities of that nation.

Recommendation #2: International cooperation should create critical-path redundancy

The Case for Interoperability

Designing for programmatic redundancy provides a strong argument for interoperability between nations' space exploration assets, as this would allow nations to substitute each other's critical capabilities with relative ease. It is nevertheless a stated goal of the United States to exercise leadership in space exploration. How may it do so without alienating its partners?

International cooperation is often visualized as a big-government-to-big-government endeavor, requiring high-level diplomatic contacts and an associated overhead cost. Indeed, the ISS was the archetype of this modality. Although, in its implementing agreement, Memoranda of Understanding (MOUs) were signed between the National Aeronautics and Space Administration and corresponding national space agencies in Russia and the European Union, NASA signed an MOU directly with the Government of Japan. This type of cooperation creates programmatic risk for each nation involved. In particular, all other nations are dependent on the critical-path nation. Although this allows the critical-path nation to assume the role of "leader," there is little incentive for the other participating nations to engage in this sort of cooperation again.

International Cooperation through Industry

International cooperation does not always require the explicit involvement of direct government-to-government interaction. Instead, industry liaisons that are regulated by their respective governments can also occur. For example, the U.S. Atlas V rocket uses Russian-derived technology for its engines. Such cooperation allows for great flexibility as the governments can explicitly recognize it, creating an element of diplomatic cachet, or can ignore it, as is the case

with the Atlas rockets, allowing for the best market advantage due to the incorporation of potentially superior foreign technology. Industrial international cooperation could potentially be a convenient method of creating programmatic redundancy by allowing the prime contractor responsible for the critical path to fund the construction of a redundant backup that is interoperable by design. This interoperability allows entrepreneurs the flexibility to "mix and match" the components from many national industries in such a way as to sell commercial services in a more efficient manner.

Similarly, many types of collaboration between the government and the private sector (i.e., public-private partnerships) can be treated in a manner analogous to international cooperation, particularly in the case of creating critical-path redundancy. Interoperability on an industry-to-industry, rather than a government-to-government, basis would allow international cooperation and collaboration to develop with market mechanisms. This removes some of the diplomatic uncertainty from international cooperation, as it essentially allows for an exchange of funds at a set market rate. In effect, money would be infused into the system, moving international cooperation from strictly a barter activity to either a market or barter activity. Conversely, the diplomatic cachet inherent in cooperative activities, along with the consequent penalty for withdrawal, would be reduced if it were not explicitly sanctioned by the governments involved.

Leadership through Standardization

Given the U.S. position as the de facto superpower in space, the United States is currently in a position to develop a space exploration architecture whose legacy components will create a "lock-in" effect for decades to come. More generally, for any nation that commits to space exploration, this "lock-in" will occur regardless of which architecture is constructed. The utmost care must be taken to ensure that what is "locked-in" is something that participants can live with for decades to come. Given the extreme uncertainty surrounding budgetary and policy environments of the National Aeronautics and Space Administration (NASA), over the long time spans implied by the VSE, design for flexibility must be the rule.

The United States, or any other nation or group of nations, can exercise leadership in international industrial cooperation in space exploration by defining standard interfaces between the space exploration systems of the major spacefaring nations. Rather than envisioning the architecture of the space exploration system as a series of "forms"—objects to be built (e.g., a space shuttle, an Apollo capsule, or a heavy-lift launcher)—the architecture should be a set of interface specifications designed to maximize flexibility. Once these interface specifications have been defined, any participant who wants to engage in space exploration with the leading nation would be required to adhere to these standards. As such, the originators of the standards-creation process would be in a position of de facto leadership. The standards documentation would be released to those partners with whom these nations wish to cooperate, thereby enabling cooperation without overtly risking national security objectives through the uncontrolled transfer of technological information. The corollary to this is that those nations who choose not to abide by the standards of the leading nations will find themselves becoming increasingly isolated on the world stage. Up-front coordination can be a prudent measure to avoid the creation of competing standards.

Focusing on interfaces rather than on objects also allows national space agencies to dictate "functions" rather than forms. For example, instead of procuring a heavy-lift launcher, an agency like NASA would procure the ability to send a certain amount of mass to orbit in one contiguous piece. This scheme has twofold benefits. First, it allows for innovative new solutions that will be evaluated, not based on adherence to a preconceived solution, but on sheer effectiveness in meeting the goal at hand. Requiring a body, such as NASA, to think explicitly in terms of functions rather than forms forces this body to define its goals clearly rather than allowing it to prematurely focus on tools. This has the added benefit of decreasing the likelihood that goals will change, as an explicit goal may only be formed with a supporting coalition that is likely to be willing to advocate for it. Finally, in the event that goals or priorities change, the standard remains adaptable and the architecture does not need to be redefined. Rather, new components may be added or removed in a modular fashion.

Recommendation #3: The primary space-faring nations should exercise leadership through the creation of standards for interoperability in space exploration

Conclusion

International cooperation in space exploration has the potential to provide significant benefits to all participants, particularly if managed well. Benefits in the form of monetary efficiency, programmatic and political sustainability, and workforce stability will accrue to those partners who choose to approach space exploration as a mutually beneficial endeavor. Furthermore, international cooperation must be explicitly incorporated as an aspect, and goal, of a modern space exploration program to enable coordination prior to the construction of new hardware. Such coordination can happen on both the government and industry levels and allows for advance planning and standardization that can enhance interoperability through the strategic use of redundancy. Finally, the promotion of a set of industrial standards for cooperation in space exploration will enable the exercise of leadership in future stages of the VSE. If the Vision for Space Exploration is to succeed, the United States, in particular, must engage its partners by reaffirming and strengthening its commitment to the International Space Station to maintain its diplomatic credibility for future exploration endeavors.

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