The Future of International Relations in Space:

Recommendations for the United States Department of Defense

Written for the J-5 Directorate of the Joint Chiefs of Staff

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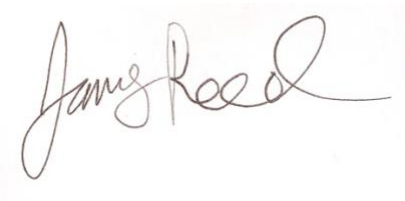
Honor Pledge: On my honor as a student I have neither given nor received aid on this report.



EXECUTIVE SUMMARY

The U.S. military, along with the rest of the U.S. Government, faces an unclear future of international relations in space. Questions surrounding the future of international relations in space result from developments in space technology, and reflect the dynamic nature of the expanding space industry. In order to provide context for different strategic approaches to this topic, I provide some brief background on the history of space activities, current issues facing both spacefaring nations and private industry, and a discussion of some of the parties involved.

I consider possible alternatives along a spectrum of more versus less international collaboration. The alternatives I consider are (1) to accede to the current international order and let present trends continue, (2) to establish a new multilateral body, (3) to engage in bilateral negotiations, or (4) to unilaterally pursue space activities. The level of collaboration for each alternative can vary, whether by operating under the current international structures in place (i.e., the UN) or by establishing new organizations or groups headed by the U.S.

To examine these alternatives, I use the criteria of (1) promoting U.S. national security, (2) ensuring access to space resources for the U.S. public and private sector, (3) minimizing the costs to taxpayers, and (4) minimizing anticipated risk. After using these criteria to evaluate the alternatives, **I recommend the second alternative be pursued, to establish a new multilateral body**.

Establishing a new multilateral body to govern space activities would have two major considerations to address: first, how to leverage the DOD and rest of the U.S. Government, and second, what nations should be included in this new multilateral organization. Establishing a new multilateral body to deal with space issues could occur through a variety of paths, all falling into two broad paths of either having this body be initiated by DOD and then extended to other parts of the U.S. Government, or it having the body be established through a multidisciplinary team consisting of individuals from the DOD and other sectors. With respect to what nations to include in this new multilateral body, there are two primary groups of nations that could be considered: (1) space-capable nations, whether limited to domestic-launching capabilities or any established space resources (satellites); and (2) nations that generally agree with the U.S. on major policy matters.

The recommendations and discussion in this report are limited due to the recent COVID-19 pandemic, and could be subject to change depending on the medium- and long-term effects that the pandemic has on the global economy, international organizations such as the UN, and U.S.-China relations.

(Word count: 8,960)

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PROBLEM STATEMENT AND BACKGROUND

The U.S. military, along with the rest of the U.S. Government, faces an unclear future of international relations in space. Questions surrounding the future of international relations in space result from developments in space technology, and reflect the dynamic nature of the expanding space industry. In order to provide context for different strategic approaches to this topic, I will first provide some brief background on the history of space activities, particularly since the Cold War ended. Following this I will discuss some of the current issues facing both spacefaring nations and private industry, and I will conclude with a discussion of some of the parties involved.

Part I: History of Space Activities

The Cold War and Space Race

The earliest American efforts in space came about with the founding of the National Aeronautics and Space Administration, better known as NASA, in response to the USSR's successful launch of the first manmade satellite, Sputnik 1, on October 4, 1957. Since 1915, the U.S. had relied on the National Advisory Committee for Aeronautics (NACA) to address aeronautical research, but did not have any cohesive approach for activities in space. Following Sputnik, the chair of NACA, Hugh Dryden, established a Special Committee on Space Technology to provide recommendations about how the U.S. could respond to the success of the Soviet satellite. As a result of this committee, Dryden stated the following in a research and development plan:

It is of great urgency and importance to our country both from consideration of our prestige as a nation as well as military necessity that this challenge [Sputnik] be met by an energetic program of research and development for the conquest of space… It is accordingly proposed that the scientific research be the responsibility of a national civilian agency working in close cooperation with the applied research and development groups required for weapon systems development by the military. The pattern to be followed is that already developed by the NACA and the military services… The NACA is capable, by rapid extension and expansion of its effort, of providing leadership in space technology. (NACA, 1958)

Following Dryden's research and development plan, James Killian, the Chair of the President's Science Advisory Committee, recommended to President Eisenhower that NACA be redesigned and reorganized as NASA. President Eisenhower was cautious about founding NASA, and repeatedly emphasized that NASA's purpose would not be to engage in a 'race' with the USSR despite public concern about Soviet ICBM capabilities prompted by the success of Sputnik I (Erikson, 2005).

Subsequent administrations did not share President Eisenhower's hesitance towards engaging in a Space Race, and during the time of the Apollo missions NASA's budget reached a peak of over four percent of the federal budget from 1965-1966 after initially receiving 0.1 percent of the federal budget in 1958 (McCarthy, 2019). Such substantial funding allowed the U.S. to reach significant milestones in the 'Space Race,' culminating with the first (and still only) manned missions to the moon.

Nearly 15 years after the success of Apollo 11, President Reagan delivered a speech in March of 1983 that would serve as a cornerstone of the U.S. approach to space militarization. President Reagan advocated for the Strategic Defense Initiative (SDI) to develop satellites capable of targeting and destroying incoming intercontinental ballistic missiles (ICBMs) to protect against a Soviet first-strike attack. This announcement, which later became known as the 'Star Wars' speech, advocated for the SDI in order to make nuclear weapons "impotent and obsolete" (Reagan, 1983). Obviating the utility of nuclear weapons would be achieved through the deployment of robust ground- and space-based defensive systems in order escape the mindset of 'Mutually Assured Destruction' which arguably prevented the Cold War from breaking out into open hostilities (Glass, 2017). Even though this 'Star Wars' initiative did not develop as planned, the SDI evolved into the still-operational Missile Defense Agency (MDA).

The Post-Cold War Era and the Global War on Terror

Prominent disasters such as the loss of Space Shuttle Challenger on January 28, 1986, and Space Shuttle Columbia on February 1, 2003, led to a post-Cold War cooling towards space activities. Despite weakened confidence in NASA, efforts to bolster military spending on space-based activities persisted. The Report of the Commission to Assess United States National Security Space Management and Organization, chaired by Donald Rumsfeld in 2000, advocated for employing "space systems to help speed the transformation of the U.S. military into a modern force able to deter and defend against evolving threats directed at the U.S. homeland, its forward-deployed forces, allies, and interests abroad in space" (Rumsfeld, 2001). Though the report was finalized in January 2001, the September 11 terrorist attacks that same year curbed efforts linked to the militarization of space and required the military to focus on the 'Global War on Terror' (GWOT).

During the GWOT some space-based expenditures continued or grew up to present, specifically the National Missile Defense program through the Missile Defense Agency (MDA). Such expenditures to counter perceived threats of WMD attacks have generally received bipartisan support, as evidenced by how Congress has supported increased funding for MDA above the amounts requested by President Trump for FYs 2018-2019 (Reif, 2019). Alongside these recent appropriations, the 2019 Missile Defense Review outlined some efforts for the DOD to pursue, to include "a new and near-term examination of the concepts and technology for space-based defenses" (Shanahan, 2019).

On December 11, 2019 the U.S. House of Representatives passed a $738 billion military spending bill that authorized Space Force to be established as the sixth branch of the military (Edmondson, 2019). Space Force has its origins in proposals made during the administration of President George W. Bush with Secretary of Defense Rumsfeld, which in turn came out of thinking during the administration of President Reagan with the SDI. The total cost of standing up Space Force is estimated to be $15 billion, with an estimated annual additional cost of $500 million, which would be in addition to the approximately $10 billion the Department of Defense already spends annually on unclassified space programs (Gruss & Mehta, 2019).

Recent Commercial Sector Advances and Consequences for International Relations in Space

Civilian and governmental funding for space programs has been increasing, as technological advancements have 'democratized' space access (Kim, 2019). To contextualize this democratization of space, the cost to launch a kilogram to low earth orbit (LEO) was approximately $18,500 from 1970 to 2000, and now with a SpaceX Falcon 9, the cost is approximately $2,800 per kilogram (Cobb, 2019). This reduction in cost has contributed to what is now a worldwide $350 billion industry (as of 2019) projected to grow to $1.1 trillion by 2040 (Morgan Stanley Research, 2019). Morgan Stanley's estimates of space industry growth project moderate increases in the currently active sectors of consumer TV, consumer radio, ground equipment, and non-satellite industry. Additionally, these estimates of the future of the space industry project substantial increases in the sectors of consumer broadband, mobile satellite services, and second-order impacts (2019). The extent of space-based technologies in everyday lives is considerable, with 96 percent of Americans owning a cell phone, and 81 percent owning a smartphone ("Mobile Fact Sheet," 2019).

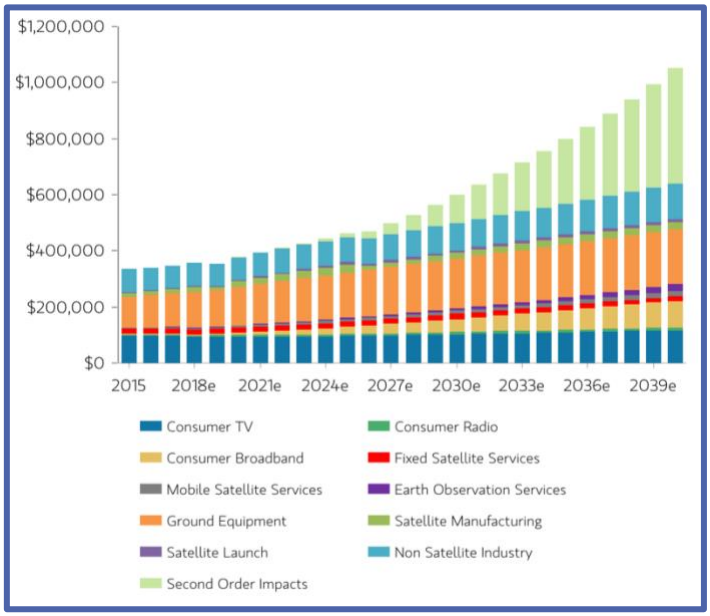

Figure 1. Projections of Worldwide Space Industry, from Haver Analytics, Morgan Stanley Research forecasts (2019)

Although there has been a strong defense-oriented industry with companies such as Northrup Grumman producing satellites, there is also the set of 'next-gen' companies striving to expand the market and provide private manned flights into space, including SpaceX, Virgin Galactic, and Blue Origin. Unlike the generally cohesive Cold War period of commercial involvement in American space activities that involved typical defense-oriented companies, the current climate is more inclusive and competitive, with NASA Director Jim Bridenstine recently highlighting that 14 different companies have received contracts for the Commercial Lunar Payload Services program (Hautaluoma & Kraft, 2020).

Part II: Current Issues and Considerations

Basics of Orbit

Although some expeditions have sent probes to other planets or out of the solar system, the vast majority of activities in space currently involve maintaining orbit around the Earth. To reach orbit a satellite has to travel at a great enough velocity to achieve equilibrium with the forces of gravity attracting it towards the Earth's surface. This velocity varies with the distance away from the Earth, and results in different characteristics for each type of orbit. See screenshot below of an animated demonstration (url: https://upload.wikimedia.org/wikipedia/commons/b/b4/Comparison_satellite_navigation_orbits.svg) which illustrates the relationship between orbital velocity, altitude, and orbital period ('Cmglee,' n.d.).

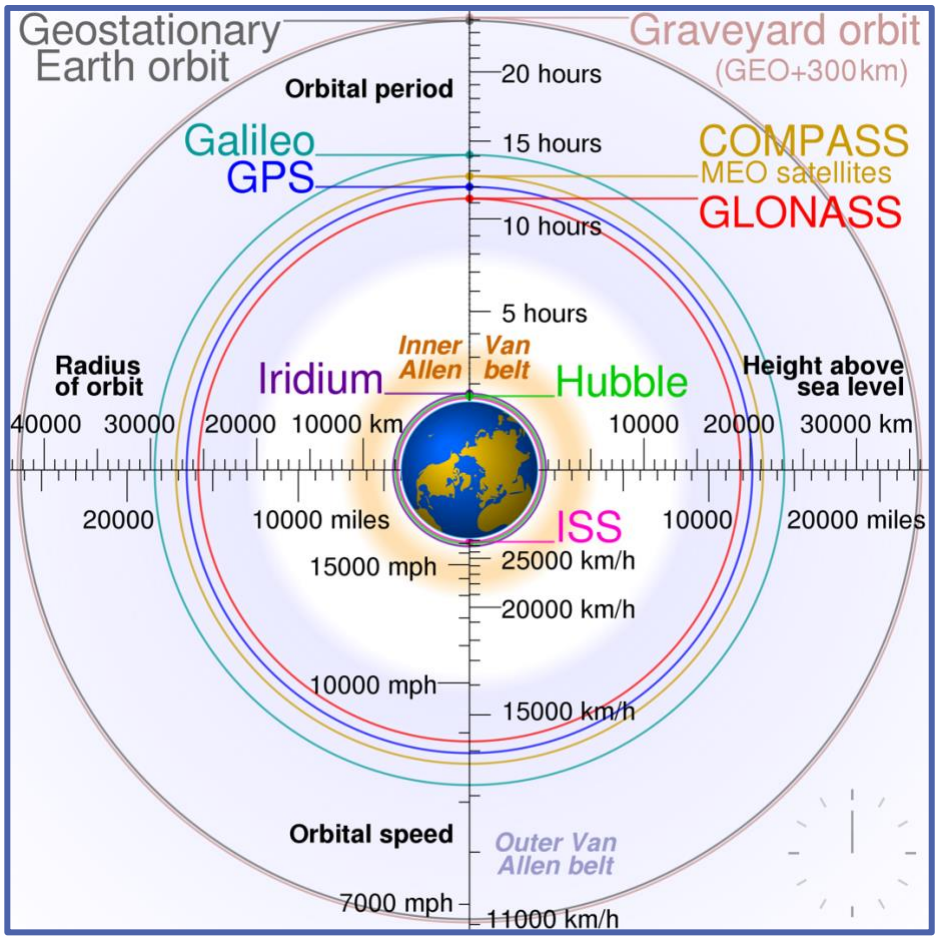

Figure 2. Demonstration of Orbital Dynamics. Source: 'Cmglee,' n.d.

The most commonly used orbit is Low Earth Orbit (LEO), from approximately 160 km to 1,000 km in altitude, and involves the greatest speeds-approximately 19,000 mph (30,000 km/h), and results in satellites passing around the Earth in as few as 90 minutes per each orbit ("Basics of Space Flight," n.d.). LEO satellites allow for imaging and the use of other sensors to make observations for services such as weather prediction, Medium Earth Orbit (MEO) extends above LEO up to 35,786 km, which is an altitude that allows for satellites to maintain a Geostationary Orbit (GEO). Although less common than LEO satellites, MEO satellites include those for GPS

and other positional systems, while GEO satellites can achieve similar functions. Aside from these orbits which generally operate along the equator is the polar orbit, which is highly elliptical and results in a larger amount of its orbit over a polar region. A specific type of polar orbit is known as a sun-synchronous orbit (SSO), which allows for a satellite to always traverse a specific location at the same time of day. Each type of orbit allows for different applications, and also results in different technological requirements depending on the satellite's purpose ("Types of Orbits," n.d.); similarly, each orbit presents different challenges in terms of the availability and congestion of useful orbits for different tasks, particularly for surveillance and communication.

Basic Technological Considerations

Due to the specialized requirements of establishing and maintaining an object in orbit, the extreme velocities involved, and the costs of such efforts, space technology is largely very fragile. Satellites operate in an environment where even a small piece of debris can be a catastrophic projectile for even our most sophisticated and costly technology in space such as the International Space Station. Current tracking technology is limited to objects larger than approximately four inches (10 centimeters) across, yet anything larger than one-half inch (one centimeter) across would defeat current shielding technology (Garcia/NASA, 2019).

Crowding of Space

Even though space is literally the largest area humanity is aware of, crowding of useful orbits is becoming a problem. As of March 2019, the United States accounted for 901 of the 2,062 operating satellites in orbit, followed by 299 from China, 153 from Russia, and 709 from other nations (Union of Concerned Scientists, 2019). Of these operational satellites, the majority (1,338) were in low earth orbit (Union of Concerned Scientists, 2019). This count does not include the number of non-operational satellites or the pieces of debris, some 500,000 of which the Space Surveillance Network (SSN) tracks (Garcia/NASA, 2017).

The decreasing cost of technology required to access space orbit has allowed more countries and private enterprises to begin launching satellites, particularly in the relatively easier to reach and versatile LEO. From the mid 1960s to approximately 2010, the average number of satellites launched annually has been between 100 and 200, but since 2013 there have been more than 200 satellites launched each year, peaking at 453 launched in 2017 ('Andy,' 2019).

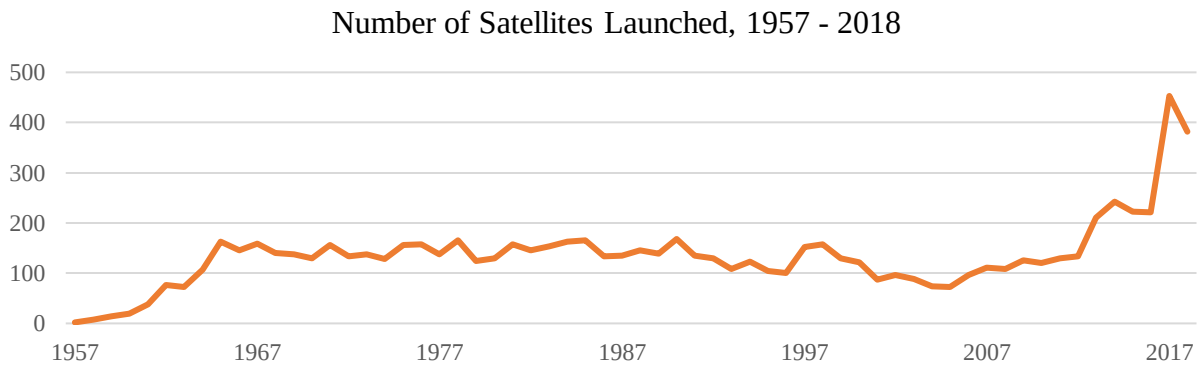

Figure 3. Satellites Launched 1957 – 2018. Data source: pixalytics.com ('Andy,' 2019)

The Economic Importance of Space

In addition to the near-term projections of the global space industry, the prospect of mining celestial bodies, such as asteroids, presents immense opportunities for profit. Looking to the asteroid belt between Mars and Jupiter, NASA estimates that the value of resources available there could exceed $700 quintillion. If the value of these resources were divided equally among every person alive today, they would contribute $100 billion to each person globally (Desjardins, 2016). The prospects of such mining ventures led to a short-lived 'asteroid-mining bubble.' Despite failing to produce any viable companies, these attempts resulted in governments addressing salient questions regarding resource extraction rights in space (Abrahamian, 2019). The U.S. Congress has passed or proposed various bills to this effect, including the *U.S. Commercial Space Launch Competitiveness Act* (enacted into law 2015) and the *American Space Commerce Free Enterprise Act* (passed in the House in 2018).

Despite the democratization of space technology and the potential economic benefit from ventures such as asteroid mining, launching assets into space remains costly and difficult. SpaceX's Falcon 9 costs $62 million per launch, and its recently deployed larger counterpart - SpaceX's Falcon Heavy - costs $90 million per launch (SpaceX, n.d.). Rocket failures are also an obstacle, with a recent SpaceX test of an emergency escape system failing catastrophically in April of 2019 when testing the craft for possible future manned expeditions (Koren, 2019). This points to an economically complex scenario, one that could provide wealth beyond measure available on Earth, but one that is difficult to accomplish at present.

The Strategic Importance of Space

Developed nations' use of space-enabled or space-benefited technology has grown considerably in recent years, with GPS tracking, satellite entertainment (television and radio), and communications' societal proliferation. In 2019, 81% of Americans owned a Smartphone, with 96% owning any cell phone regardless of whether or not it is 'smart' (Pew Research Center, 2019). The proliferation of such GPS technology in everyday life permeates from beyond the 'space-only' sector. Beyond the public use of traditional space technologies, space-based or -enabled technologies has extended to the military sector, with some identifying the 1991 Persian Gulf War as "The First Space War" (Lang, 2016). Information collection and communications technologies are arguably the most advanced militarized technology currently in space, dating back to the first satellite photos of Earth collected by *Explorer 6* on August 14, 1959. In that same year, the U.S. launched the first *Corona* satellite, starting a reconnaissance program that lasted until 1972 and was declassified in 1992 (Lavers, 2013). Some analysts argue that the successful application of space-based or -enabled technologies has not been entirely positive and has led the U.S. military to become dependent on space-based technologies (Lamrani, 2016).

Underscoring the tangible technological applications of space-enabled technology are more philosophical considerations of space constituting "the ultimate high ground" (Lambeth, 2003). President Trump's decision to establish a Space Command as an independent combatant command echoes this line of thinking, as does his plan to establish a Space Force under the Air Force similarly to the structure of the Marine Corps and the Navy. The fact that Space Force is the newest branch of the military underscores the importance of accessing space resources to the DOD, when military thinkers had anticipated that a "Cyber Force" might be the next branch created in order to address the changing landscape of warfighting in an increasingly

interconnected world. In fact, China's recent development of its Strategic Support Force (SSF) combines space, cyber, electronic, and psychological warfare capabilities in a cohesive command (Costello & McReynolds, 2018), and analysts from RAND have called for the Space Force to work closely with other services to ensure clarity of its space warfighting mission (Spirtas, et al., 2020). This enthusiasm for further developing militarized use of space is not without its detractors, who urge caution and argue that preparing for potential disruptions of space-based or -enabled technologies is prudent to avoid possibly catastrophic outcomes (Black, 2018).

Antisatellite Technology and Threats to Space Assets

Beyond conventional uses of space-based systems, which are 'positive' technologies to support some activity, the development of 'negative' space technologies - such as systems to disrupt or destroy satellites - have developed in order to target and neutralize space-asset satellites. The 21st century has seen an increased emphasis on anti-satellite technology, particularly in the Indo-Pacific region. The four nations with a proven capability to deploy a kinetic strike against a satellite (the U.S., Russia, China, and India) all are located in - or hold significant interests in - the Indo-Pacific region (Urrutia, 2019). The development of kinetic antisatellite technology poses extreme risks to space technology which increase as the number of other satellites increases. Attacks against a satellite that produce debris could in turn lead to damage or destruction of other satellites, and in a worst-case-scenario could result in a snowball effect of debris disabling satellites and creating more debris to disable even more satellites in nearby orbits (Rogoway, 2017). As an example, in 2007 China conducted an antisatellite test which resulted in thousands of pieces of debris capable of catastrophic damage to satellites, of which the majority are still in orbit (Grego, 2019).

Although only four nations have successfully destroyed one of their own satellites in orbit, this capability presents a clear danger to all spacefaring efforts of humanity. A comparable indiscriminate debris attack could be achieved with the use of a ballistic missile spreading debris in LEO (Rogoway, 2017), and would require significantly less sophisticated technology to successfully carry out. If there were enough debris then a given orbit could become unusable, and possibly even too dangerous to risk traversing through (Grego, 2019).

In addition to kinetic strikes, satellites are also susceptible to denial and deception, electronic warfare, cyber-attacks, ground site attacks, directed energy weapons, nuclear detonations, and other orbital threats (National Air and Space Intelligence Center, 2018). Some of these threats (such as using space-based weapons to attack other satellites with kinetic kill vehicles, radio frequency jammers, lasers, chemical sprayers, high-power microwaves, or robotic mechanisms) are limited to countries with advanced space programs, while others such as nuclear detonations could be relatively easier to accomplish by a nation with a nuclear warhead and an ICBM or other rocket capable of reaching LEO (National Air and Space Intelligence Center, 2018).

Regardless of the method of disrupting or destroying a satellite, any major attack or destructive accident involving satellites could lead to a cascade/snowball effect, with one damaged satellite breaking up into more debris, which could hit other satellites that could break up and hit even more satellites and so on. Disruption of even one satellite has been shown to cause myriad secondary effects across various sectors of both civilian and military operations (Black, 2018), so significant disruptions of space assets would indubitably have even wider-reaching effects.

Part III: Groups of Interest

There are four primary groups of interest for the DOD to consider for space-based activities: (1) nations capable of engaging in great-power conflict with the U.S., primarily Russia and China; (2) other space powers (aspirational or successful) which may or may not have adversarial intent towards United States, such as India; (3) private entities involved in launching and maintaining satellites, and (4) multinational organizations including the United Nations and European Union/European Space Agency.

Potential Great Power Competitors

Russia's current program built upon the heritage of the USSR, and maintains the third-largest number of satellites in orbit behind the U.S. and China, as well as robust efforts in anti-access/area denial capabilities (Luzin, 2020). In spite of this competitive history based in the 'Space Race,' the U.S. space program has collaborated with Russia on joint projects such as the International Space Station (ISS), and had used Russian launch vehicles to send American astronauts to and from the ISS since the Space Shuttle was permanently grounded in 2011 (Howell, 2019). However, events in 2020 have indicated that the collaborative spirit between the U.S. and Russia may be cooling; for example, on April 17, 2020, it was announced that NASA would use a SpaceX CrewDragon spacecraft to launch astronauts on May 27, 2020 (Clark, 2020), and on April 16, 2020, it was announced that Russia had tested a direct assent-antisatellite (DA-ASAT) missile, following earlier reports in 2020 that two Russian satellites had engaged in on-orbital maneuvers that "reflected characteristics of a space weapon" according to a statement from the U.S. Space Force (referenced in Gohd, 2020).

Distinct from how Russia's program historically competed directly against the U.S., China's program started out as a 'secondary player' but has risen in recent decades to reach significant milestones, such as being the first nation to execute a soft landing on the dark side of the moon (Wall, 2019). Similar to how the U.S. program developed from technology related to ballistic missiles, China traces its space program to the early Cold War when Chairman Mao announced a ballistic missile program on January 15, 1955. Chairman Mao wanted to develop strategic weapons as a counter to the perceived threat of American nuclear weapons, particularly after the Korean War (Reed & Stillman, 2010). Although the early period of China's space program enjoyed collaboration with the USSR, relations between the two nations soured in the 1960s and China's space program had to develop with little assistance, resulting in China being only the fifth nation to launch a satellite in 1970 (de Gouyon Matignon, 2019). China's manned program also was delayed around this time period, and did not successfully launch a crewed mission until the early 2000s (Jones, 2018). In the past two decades China has continued to make advances in its space program, including a successful experimental space station (Tiangong-2) with plans to build another in coming years (Howell, 2020). Unlike the Russian space program which has had recent periods of collaboration with their American counterparts, since April 14, 2011, the U.S. Congress has banned NASA from engaging bilaterally with China, with a clause in the appropriations bill known as the 'Wolf Amendment' after Representative Frank Wolf (R-VA) who originally introduced it (Foust, 2019).

Other Space Powers

As has been mentioned previously, India last year (2019) joined the ranks of nations that had proven a capability to carry out a kinetic strike against one of their own satellites. Unlike the 2007 Chinese ASAT test, India carried out its test in a way that resulted in fewer pieces of potentially damaging debris (Urrutia, 2019), and this demonstration is paired with the fact that India has launched over 300 satellites for other nations ("India crosses 300 foreign satellite launch mark," 2019).

Other nations with nascent space programs such as North Korea also should be considered since even if they do not have highly sophisticated launch capabilities, since even with standard ballistic missile technology they could still disrupt satellites in LEO (Rogoway, 2017).

Private Industry

Among the private entities involved in space, there are well-established companies such as Northrop Grumman which contract with military and civilian satellites, and there is also the group of 'next-gen' companies striving to provide private manned flights into space, including SpaceX, Virgin Galactic, and Blue Origin. Chief among these companies is SpaceX, which in the first quarter of 2020 launched a clear majority of payload delivered to orbit (61,284 kg, followed by China National Space Administration with 21,182 kg; Sheetz, 2020), and also just announced a planned launch of NASA astronauts in May of 2020 (Clark, 2020) As discussed in the section concerning recent private sector developments, the projections from Morgan Stanley Research emphasize the diversification that is expected in space-based and -enabled activities which would result in a growing number of industries and companies for the DOD to consider with respect to space activities (2019).

International Organizations

The United Nations has mixed influence over space activities; as a result of the Convention on Registration of Objects Launched into Outer Space (1976), the UN is involved with tracking objects placed in orbit with a Register of Objects Launched into Outer Space and as of October, 2019, over 88% of satellites were registered with this system (UNOOSA, 2019). With each nation operating under its own satellite regulation regimes, there is no clear norm or rule to follow concerning how orbits are established or claimed by each nation, and private launches of satellites (such as with the Starlink constellation which has been approved for 12,000 satellites) only compounds these issues of possible conflict between states. The major international laws regulating space activities are limited in enforceability-particularly with respect to questions about resource extraction and interpretations of 'the common heritage of all mankind' (Alshdaifat, 2018). These isolated areas of regulation reflect how various UN initiatives have largely resulted in failure, for instance with the Moon Treaty of 1979 (Listner, 2011), and highlights the dearth of strong multinational organization for space activities.

Space and Other Forms of International Relations

Even though space presents unique operating conditions and constraints, commentators sometimes compare it to the high seas with respect to how states interact with one another. Rooted in the principle of dominion over waters postulated by Van Bynkershoek in the 18th century, laws of the high seas have generally set aside neutral waters as a consequence of a

state's inability to control them (1923/1702-1744). However, this respect for free use of the high seas came after a series of conflicts and competing claims, particularly during the Age of Discovery, and these conflicts were resolved through various agreements, papal edicts, and treaties (e.g., 'The Treaty of Tordesillas,' 1494). This system of using treaties and agreements between conflicting parties continues into the modern era, with the U.S. and USSR agreeing to the 'Agreement Between the Government of The United States of America and the Government of The Union of Soviet Socialist Republics on the Prevention of Incidents On and Over the High Seas' in 1972 in order to try and prevent potentially aggravating behaviors on the High Seas to escalate into all-out conflict. Of note, this agreement between the U.S. and USSR explicitly excluded discussion of satellites or other orbital craft, and was limited to sea vessels and aircraft operating at sea. Despite the long history of establishing norms for behaviors at sea, current disputes still exist (e.g., in the South China Sea), highlighting some of the challenges to diplomacy that come with Westphalian Sovereignty.

CRITERIA FOR EVALUATION

The history of space exploration, current considerations for space-based activities, and groups of interest to spacefaring all inform how the future of international relations of space could develop. In order to bridge these considerations with current decision-making, I have decided to use four evaluative criteria: promoting U.S. national security, ensuring access to space resources, minimizing the cost to taxpayers, and anticipated risk. Although these criteria are related, particularly with risks and potential increased cost to taxpayers, I decided to use each criterion as a way of highlighting the ways in which some of the same factors can be relevant from different perspectives.

Criterion 1: Promoting U.S. National Security

The first criterion of promoting national security is especially salient given the dependence that the U.S. military has on space-enabled technologies and methodologies of waging war (Lamrani, 2016). This criterion will focus primarily on DOD activities related to promoting U.S. national security, and I will also examine the predicted second-order effects of civilian activities on national security. Some possible such second-order effects of civilian activities could include the promulgation of openly available satellite telemetry that could be used by adversaries to acquire greater information about American assets domestically and abroad, as well as anticipated interference with national security activities due to civilian use of space assets such as civilian satellite constellations crowding out government satellites at important orbits for surveillance or other national security uses.

I will measure this criterion using a relative scale for how much each alternative promotes national security:

- Positive—anticipated to increase promotion of national security compared to present;
- Neutral—comparable promotion of national security to present; and
- Negative—anticipated to negatively impact national security compared to present.

Criterion 2: Ensuring Access to Space Resources

Ensuring access to space resources is a priority for the DOD both for military-specific uses of space technology as well as public-benefit services such as the GPS constellations of satellites. Ongoing access to space resources has clear importance across the whole of DOD, highlighted by the current process of standing up the USSF, as well as the commercial/private sector which has continued to increase their use of space-based and -enabled technologies.

To measure access, I will use a relative scale of likelihood to increase/maintain access or result in a decreasing ability to access space resources:

- Positive—anticipated to increase access;
- Neutral—anticipated to maintain present access; and
- Negative—anticipated to decrease access.

Criterion 3: Minimizing the Costs to Taxpayers

Similar to the second criterion of ensuring access, minimizing the cost to taxpayers relates to both military-specific and public-oriented activities in space, from the costs associated with maintaining military satellites to the potential costs if there are disruptions to civilian space technologies. As a Congressionally funded entity that receives roughly 3% of the U.S. GDP, the DOD faces substantial scrutiny for any unnecessary or wasteful spending, and the relative lack of 'cheap options' with space-based technologies means any expenditure will need to be clearly justified. Even if some elements of DOD activities in space do not impose direct costs (i.e., a no-cost change to the use of a currently deployed satellite) there could also be indirect costs imposed on taxpayers through second-order impacts. Particularly with the advent of mixed-use satellites, other nations' reactions to DOD activities could conceivably result in increased costs to carry out a wide variety of activities such as the use of satellite telemetry to enable weather forecasting, optimizing agricultural development and harvesting, and commercial media broadcasting (Black, 2018).

I will be using a relative scale to assess the potential costs to taxpayers both by anticipated direct costs and by anticipated costs of second-order effects of each alternative:

- Positive—anticipated cost savings;
- Neutral—no anticipated change in costs; and
- Negative—anticipated increasing costs.

Criterion 4: Anticipated Risk

For the final criterion of anticipated risk I will account for both the likelihood and severity of a negative outcome. Although some activities could have clear benefits in some areas, a greater degree of risk could cause such activities to be less palatable, particularly for a risk-averse organization such as the DOD.

As with the other criteria, I will use a relative scale to evaluate risk:

- Positive—reduction in overall risk;
- Neutral—comparable risk to present; and
- Negative—greater level of risk than present).

ALTERNATIVES TO CONSIDER

Alternative 1: Accede to Current International Order and Let Present Trends Continue

This alternative would have the U.S. maintain its current relationship with the international order involving space, namely through the UN. The main structures of the UN to deal with space are the United Nations Office of Outer Space Affairs (UNOOSA, 2019), as well as resolutions passed by the General Assembly. Although the U.S. collaborates with the UN with the registration of orbital objects, it also has elected not to sign on to certain treaties involving preventing weaponization of space. This role of collaborating at times and selectively not agreeing at others would enable the U.S. to maintain its present position in space discussions without any need for assertive action or buy-in from other nations.

Alternative 2: Establish a New Multilateral Body for International Collaboration

This alternative would have the United States set about establishing a new international regime through which to negotiate and plan international relations in space, turning away from the current systems of the UN were many non-spacefaring nations currently have a voice and a vote in the General Assembly. Establishing a multilateral body would allow the U.S. to change the way it operates in space, by serving as the organizer and presumptive head of this new international body which would establish standards of behavior for activities and space. This multilateral body could be established in a variety of configurations, to consist only of nations which the U.S. considers allies or close partners and who are capable of engaging in space-based activities, or to include all nations who have a given degree of capacity for space-based activities. This sort of multilateral approach could fit into a 'spheres of influence' approach to international relations, allowing for the U.S. to set norms among its close partners and having a more standoffish, adversarial, or uninvolved stance towards other nations outside of the U.S.-led multilateral body.

Alternative 3: Engage in Bilateral Negotiations

This alternative would have the United States pursue multiple bilateral negotiations or bilateral relationships with other nations with respect to space, moving away from large collaborative bodies such as the UN and instead trying to establish norms and procedures with other nations on a case-by-case basis. This approach aligns with President Trump's general approach to international relations, favoring one-on-one talks as opposed to engagement through large multinational groups. The U.S. could establish and maintain strong relationships with specific spacefaring nations, ensuring that other nations best uphold its policy interests.

In addition to the number of functioning satellites currently in orbit, there are some 500,000 additional objects tracked by the Space Surveillance Network consisting of nonfunctioning satellites or pieces of debris (SSN; Garcia/NASA, 2017).

Alternative 4: Abandon International Cooperation, Unilaterally Pursue Space Policy

This alternative would have the U.S. pursue unilateral policies in space, and consists of three main approaches of aggressive, protectionist, or passive policymaking. Since the U.S. still has a prominent presence in space in terms of accomplishments and number of satellites, it might be possible for this alternative to allow the U.S. to pursue its policy initiatives with relatively few

avenues of recourse available to other nations. Depending on the type of unilateral policies the U.S. pursues, negative responses by other governments could be more or less likely, but these need to be considered in any case since three other nations have demonstrated an ability to carry out kinetic strikes against satellites (Urrutia, 2019). Aside from this direct way of disrupting satellites, any country with nuclear weapons and the ability to launch one into space (e.g., with ICBM technology) could potentially devastate the whole sector of space (Plait, 2012).

An approach of aggressively pursuing unilateral policies in space could allow the U.S. to assert space dominance of defensive and offensive technologies, which could help achieve General Raymond's stated goal of deterring other nations from engaging in a space conflict with the U.S. (Pope, 2020). Slightly different than these aggressive policies could be protectionist policies in space, having the U.S. primarily be concerned only with defending its own assets, and not asserting dominance over other nations. Such an approach could align with a generally 'America first' approach to pursuing U.S. interests as best serve the American people without trying to exert dominance over other nations. Yet another plan of passive unilateral policies in space could allow the U.S. to take a 'live and let live approach' to space. While this policy is similar to the 'America first' approach in protectionist approaches to a unilateral policy, it does differ significantly by not emphasizing protecting U.S. assets as much. With the steady growth of private industry in space (e.g., Morgan Stanley Research, 2019), such a passive approach could leave our companies vulnerable to aggression by other nations. Across all of these unilateral approaches, the process of deconflicting with other spacefaring nations would need to be considered, so even in the absence of a shared international order, the U.S. would still have a standard procedure for contacting other nations or spacefaring organizations as-needed.

Comparison of Alternatives by Evaluative Criteria

	Alternative 1: Accede to International Order	**Alternative 2: Establish Multilateral Body**	Alternative 3: Engage in Bilateral Negotiations	Alternative 4: Pursue Unilateral Policies
Promotes National Security	Neutral	**Positive**	Positive	Neutral-Positive
Ensures Access to Space	Neutral	**Positive**	Neutral-Positive	Neutral
Minimizes Costs	Neutral	**Neutral**	Neutral	Neutral-Negative
Anticipated Risk	Neutral	**Neutral**	Neutral	Negative

Evaluation of Alternative 1: Accede to International Order

Acceding to the current international order would generally reflect a continuation of the status quo, with the U.S. operating in space according to the governing structures set up by the UN on most issues. The extent of 'buying in' to existing international structures could vary, from the current status quo of generally agreeing on most issues, or it could include a shift in American policy to agree to all measures put forward by majority of nations when it comes to space issues (regardless of whether those nations are space capable or not).

On the criterion of promoting national security, Alternative 1 is neutral because it would not substantially change how the U.S. currently operates its business in space, and would not substantively enhance or hamper the effectiveness of DOD's activities in space.

On the criterion of ensuring access to space, Alternative 1 is neutral, reflecting the fact that maintaining the status quo and possibly agreeing to international norms of spacefaring would not substantively change either for better or for worse governmental and private American efforts in space from the current extent of access.

On the criterion of reducing the cost to taxpayers, Alternative 1 is neutral because it does not substantively change either the DOD or the rest of U.S. government programming to either increase or decrease costs.

On the final criterion of risk, this alternative is neutral because it does not significantly alter the current level of risk.

Evaluation of Alternative 2: Establishing a Multilateral Body

On the first criterion of promoting national security, establishing a multilateral body is positive. Unlike with the status quo, a new multilateral body founded and headed by the U.S. would enable the U.S. to set norms and standards of behavior that are most beneficial to promoting national security and the efforts of the DOD, while having these norms and standards backed by the this multilateral body and not just advocated in isolation by the U.S. In other words, this body could serve to amplify and validate efforts favorable to U.S. national security instead of having those policies only promoted by the U.S. in a unilateral fashion.

On the criterion of ensuring access to space, Alternative 2 is positive, as the multilateral body would ensure that norms and acceptable behaviors are constructed in such a way that the DOD and rest of U.S. government, as well as private enterprises involved in critical industries would best be able to function without hindrance or impairment from other nations.

For the criterion of reducing cost to taxpayers, Alternative 2 is neutral, because it does not substantively change any of the spacefaring efforts which are costly, and the nominal costs of setting up international meetings pale in comparison to the scale of the budgets for space activities overall.

On the criterion of risk, Alternative 2 is neutral due to possibility of conflict breaking out between the members of the U.S.-led body with other adversarial nations, or the establishment of separate spheres of influence that might constrain some activities. Depending on how this body is established it could be constructed in such a way to minimize the number of nations excluded from it, particularly if different types of membership and association are considered. This selective inclusion could help avoid deadlock for the organization's decision-making process, but it also could fail if there is a lack of interest from other parties or if other nations opposed to such an organization leverage their own diplomatic and economic efforts unilaterally (or through other organizations such as the UN) to increase costs for other parties to join it.

Evaluation of Alternative 3: Bilateral Negotiations

The alternative of engaging in bilateral negotiations with other spacefaring nations would allow for a flexible, agile way to engage in diplomacy and negotiation with nations instead of operating under a potentially more rigid multilateral body. On the other hand, these bilateral negotiations could prove difficult in light of the crowding of space. As of March 2019, there were 2,062 operating satellites in orbit, with nearly half (901) owned by the U.S. or American companies (Union of Concerned Scientists, 2019). The number of satellites is also only projected to increase, with SpaceX alone already having approval to launch 12,000 satellites for its space broadband Starlink satellite constellation (Young, 2019).

On the first criterion of providing national security, Alternative 3 is positive because it would allow the U.S. to have stronger bargaining positions with nations in the one-on-one context instead of operating with a group if enough members of the group disagree with the U.S. on a given issue.

On the criterion of ensuring access to space, Alternative 3 is neutral-to-positive because it would enable the U.S. to address issues as they arise, but it may simultaneously hamper U.S. efforts as new nations develop their own space capabilities. In other words, as new nations become spacefaring it could be the case that a whole new set of talks would need to occur between the U.S. and that nation, whereas with a multilateral body having the new spacefaring nation sign on might require less negotiation to buy in to that system instead of having all topics potentially on the table in a negotiation with the U.S.

On the third criterion of reducing cost to taxpayers, Alternative 3 is neutral because the sort of negotiations involved would likely not drastically increase or decrease any costs currently being spent on diplomacy and other forms of international relations.

On the final criterion of risk, Alternative 3 is neutral because it would enable the U.S. to maintain a great degree of collaboration with other nations, but also carries some risks of requiring many negotiations with different nations as opposed to communicating with one cohesive body. This disparity of communicating with one body or many individual nations could result in inefficiencies or delays of communication which could have operational impacts if such a delay could lead to some damage to space-based resources.

Evaluation of Alternative 4: Unilateral Policies

Unilaterally pursuing space policies would consist of the U.S. largely abandoning the current structures in place provided by the UN for dealing with space related issues and activities, and would allow the United States to have a greater degree of autonomy on how it conducts space activities. However, this alternative could pose a risk if other nations are able to overcome some of the U.S. and DOD's space situational awareness (SSA) capabilities.

On the first criterion of promoting national security, Alternative 4 is neutral-to-positive because it would enable the DOD to act essentially without limitations on space activities, with the only limits being imposed by Congress as opposed to having to act according to standards set by international bodies such as the UN. Despite such liberty in how the U.S. acts in space, the lack of coordination or cooperation could hamper national security by not providing a clear way of deconflicting competing activities with other nations.

On the second criterion of ensuring access to space resources, Alternative 4 is neutral because the United States is still considered to be the most powerful and advanced spacefaring nation, however, the relative power of these capabilities could change with other nations' ongoing development of their own efforts in space.

On the third criterion of reducing cost to taxpayers, Alternative 4 is neutral-to-negative because although it would provide a greater degree of autonomy, it could potentially lead to the DOD spending more money on space and is currently allocated.

On the fourth criterion of risk, Alternative 4 is negative because of the potential for causing greater degrees of conflict if there is not agreement between the US and other nations.

Overall Recommendation: That the DOD pursue alternative 2, establishing a multilateral body for space governance.

Although alternatives 2 and 3 both score positive on the criterion of promoting national security, alternative 2 is the only one to be fully positive on any other criterion. Alternative 1 is neutral on all criteria since no drastic changes are expected if the status quo is maintained, while alternative 4 is neutral-to-negative on minimizing costs to taxpayers and fully negative on the criterion of risk. This leaves the 2nd and 3rd alternatives as the most viable ones to consider, and given neutral scores on minimizing costs and risks the question comes down to which alternative better ensures access to space. While bilateral negotiations would likely provide some benefits, the potential for inefficiencies undercuts any possible benefits of the one-on-one format instead of establishing one cohesive body.

Although not listed as a formal alternative, it is important to consider the possibility of the DOD and rest of U.S. government abandoning activities in space, whether by choice or losing access to space altogether due to another nation's actions. Considering the consequences of losing any access to space-based or -enabled resources includes identifying what actions can be taken to maintain activities enabled by space by other means, and what sort of 'hedges' should be pursued presently to have some redundancies or fallback systems. If access to space were lost entirely, American military assets worldwide would be affected, needing to resort to alternative methods of communication and navigation, not to mention the effects on modern weapons systems with precision guided munitions.

IMPLEMENTATION

Establishing a new multilateral body to govern space activities would have two major considerations to address: first, how to leverage the DOD and rest of the U.S. Government, and second, what nations should be included in this new multilateral organization. Determining the 'how' of setting up this multilateral body would impact offices across the DOD and rest of Government, and would require intentional processes to ensure that all relevant stakeholder needs are addressed.

How to Leverage the DOD and Rest of U.S. Government

Establishing a new multilateral body to deal with space issues could occur through a variety of paths, all falling into two broad paths of either having this body be initiated by DOD and then extended to other parts of the U.S. Government, or it having the body be established through a multidisciplinary team consisting of individuals from the DOD and other sectors. The advantages of a 'DOD-first' approach would be that the ways in which information is shared would be done from a security-focused perspective, with a clear chain of command and established set of oversight regimes over all aspects of this body from its inception. On the other hand, setting up the body through a whole-of-Government approach would allow for a greater diversity and richness of ideas to be included in foundational discussions, but could also lead to blind spots in terms of how space activities are discussed if the DOD does not have a pivotal role in determining how activities move forward. See table below for a list of potential considerations for establishing such a multilateral body:

Topic:	Notes:
Credibility	Domestically and internationally the multilateral body would need credibility for government and public support.
Military-civilian balance	Domestically and internationally the balance of military and civilian personnel involved in the multilateral body would impact perception and acceptance of the body's decisions
Organizational structure	Questions of how the body would fit within the executive branch could affect its perception, particularly depending on whether or not it is headed or includes senior officials (such as the President or officials requiring Senate confirmation)
Congressional oversight	Collaboration with relevant oversight committees in both the House and Senate would be crucial, particularly if the body promulgates international treaties that would require Senate confirmation to adopt

Regardless of the pathway, the eventual end result would be similar in that ultimately the multilateral body will need to address defense/national security, economic, diplomatic, and informational concerns, and would require top-level participation from heads of departments and agencies across the U.S. government, in close coordination with the President to ensure that there is a coherence and clarity of mission. These concerns will extend to private industry as well, which in an increasingly multinational world will require particular attention. The Department of State, Department of Treasury, Federal Communications Commission, Federal Aviation Administration, and potentially other agencies/organizations such as the Department of Energy (particularly the National Nuclear Security Administration), Department of Commerce, and others would all have a stake in how future space activities are regulated. Due to the widespread use of space-based or -enabled technologies, predominantly through use of global navigation satellite systems (GNSS), regulation activities for such technologies will pertain to a broad swath of the public sector.

Inclusion Criteria to Consider for Multilateral Body

With respect to what nations to include in this new multilateral body, there are two primary groups of nations that could be considered: (1) space-capable nations, whether limited to domestic-launching capabilities or any established space resources (satellites); and (2) nations that generally agree with the U.S. on major policy matters. In order to ensure that any new multilateral body doesn't simply become a 'UN 2.0,' the former of these two groups would need to be emphasized due to changing dynamics of alliances, and the possibility of other nations such as China 'turning' nations to favor closer relations with them over the U.S. in the near future. Given this priority for including space-capable nations, there are a few benchmarks to consider as qualifiers: (1) having the ability to fund and manage some space capability, such as sustained orbit of a satellite regardless of how this satellite reached orbit; (2) having the ability to domestically place a satellite in orbit; or (3) having the ability to disrupt satellites on-orbit. The latter two of these possible qualifiers would have some necessary overlap, but the possibility of ground-based systems disrupting orbiting systems means that there could be a greater number of nations who have the ability to disrupt as opposed to establish or maintain space-based or -enabled systems. Separate from this question of capabilities as a qualifier for inclusion is the question of how each nation's space-activities align with U.S. interests. An additional consideration also is the raw capacity of each nation, whether in terms of volume or sophistication, and a related question of how capable private industry is within each nation. The question of 'who' would impact a similar if not greater range of offices across the DOD and rest of Government, and would similarly need to have a clear organizing structure to support the decisions that lead to setting inclusion criteria in this new multilateral body. See table below for a list of possible criteria to consider:

Criterion:	Notes:
Current space capabilities	Current capability could be a key consideration for inclusion to ensure that all parties in the organization have a clear vested interest in space activities
Stated space goals/aspirations	In addition to current capabilities, intended future space activities could also help determine what role nations could play in the organization; those with more substantial programs planned could take on a larger role even if their current capabilities are judged to be less developed than other nations'
Status of diplomatic relations	Diplomatic relations with the U.S. should be included in any discussion of whether a given nation should be included in the multilateral body, particularly if there are standing sanctions against that nation related to space activities
Other aspects of IR	Current political climate both within the U.S. and on the global stage could also affect the ideal makeup of the multilateral body, especially in light of possible great power competition

Potential Negative Outcomes of Implementation

In terms of a 'worst-case scenario,' various potential failure points need to be considered. First, changing politics could hamper the ability of the multilateral body to include the nations needed to best achieve the goals of international collaboration in space that is the most beneficial to U.S. interests. International relations with some nations, particularly Russia, China, Iran, and North Korea, can become politicized in such a partisan way that even a preferable policy option might not be viable due to dynamics between disparate branches of government. A similar failure point could be a 'black swan' event that drastically disrupts space activities so as to destabilize the broad balance of international relations as they are today (for instance a technological leap that allows a nation to unilaterally pursue a new form of activities in space). Another concern would be if nations that do not align well with U.S. interests find it in their best interests to proliferate space (or counter-space) capabilities to their allies and partners, to bring other nations into the multilateral body to dilute American influence over that body.

While some of these issues could be considered at the time of establishing the multilateral body, others would need to considered as they arise. The DOD and other parts of the U.S. Government involved with this body would need to maintain a keen awareness, not just 'Space Situational Awareness' in terms of active assets and capabilities in space, but also 'Space-Related Situational Awareness' for upcoming assets and capabilities, and regularly convene working groups comprised of a diverse set of experts to ensure that the opportunities for unexpected challenges to present themselves are minimized. In addition to traditional working groups, other alternatives methods such as using the Hacking/Innovating for Defense framework and employing the services of the Defense Innovation Unit and DARPA/IARPA could help ensure that this multilateral body has a 'finger on the pulse' of space activities going forward and that outside perspectives are brought into DOD and whole-of-Government discussions relating to the activities of the recommended new multilateral body to handle space affairs.

LIMITATIONS

A major potential limitation to the findings of this report is that it was conducted primarily prior to the COVID-19 pandemic, and forthcoming impacts of this pandemic were not considered as a possibility for these analyses. Chief among the possible unanticipated complications to the world economy is how the pandemic has resulted in a halt to China's nearly 50-year run of growth (Bradsher, 2020), and has caused NASA to delay work on some projects such as the James Webb Space Telescope (Bartels, 2020).

As discussed under the potential negative outcomes of implementation, a 'black swan' event could drastically undermine the recommendations of this report. This report assumes that international relations in space will continue roughly in the same fashion as international relations have in recent history, and cannot account unanticipated events that could disrupt the space industry or international relations writ large.

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