The ability to maneuver is as critical a capability to military operations in space as it is to any other domain in which the military operates. Maneuver provides the ability to engage an adversary at a place and time of your choosing while minimizing the opportunity for the adversary to observe or predict your movement. "Cislunar space offers a vast maneuver space that is difficult to surveil and for which surprises can then emerge, analogous to deep-sea submarine warfare."[16] Expanding operations into cislunar will provide the U.S. military a maneuver capability in space that it currently does not possess. The refueling capability that this system would provide would free space-based assets from the restriction of continuously operating in single, predictable earth orbits. Instead, space vehicles would be free to alter orbits on demand or transit between lunar and earth orbit making their movement much less observable or predictable.[17] This freedom of maneuver could provide military capabilities to defend assets in predictable orbits from adversary interference or offensive capabilities that deliver both kinetic and non-kinetic effects against other space vehicles, onto the Earth's surface or even on the Moon or other celestial body.

The cost benefit to the military associated with maintain a permanent cislunar presence is one that would take more time to achieve, but would potentially provide the greatest benefit. As was previously mentioned, the ability to refuel assets in space will have the effect of reducing the cost of launching space assets from Earth. This savings could be reinvested in other space-based capabilities or used to offset costs in other areas. Additionally, a natural derivative of reduced launch costs would be the increase in number of and variety of space-based capabilities. This increase in asset volume should theoretically reduce the unit cost of particular capability. For instance, the cost associated with data transmission could be reduced if, for a given unit of data, there were 4 satellites capable of transmitting that data versus two. A final, more far-reaching cost benefit would be the utilization of Moon derived resources to manufacture military assets either on the moon or in orbital factories. Producing and deploying space-based military assets in and from space would eliminate the high cost associated with launching space assets out of earth's gravity well. Production of assets in space could also benefit from the ability to produce novel materials in low gravity that would either be prohibitively expensive or impossible to produce on the earth's surface.

Beyond the military benefit, there are also significant scientific and economic benefits to expansion of space operations into cislunar space. The obvious benefit to science will be the increased access for scientists to cislunar space, to include the lunar surface. This access will undoubtedly lead to scientific discovery and advancements in our knowledge and understanding of the earth-moon system. Furthermore, the access to fuel, resources and a manufacturing capability outside of Earth's restrictive gravity-well will provide a convenient and efficient jumping-off point for further exploration and scientific discovery in the solar system beyond cislunar space.[18] In fact NASA's current plan for extending manned exploration beyond the Earth-Moon system includes a Lunar Gateway that will make use of lunar produced fuel and other resources to equip planned exploration missions.[19]

The economic benefits of operations in cislunar space have already been alluded to and are natural extensions of the military and scientific benefits. Today, analysts have determined there is an approximately $75M/year demand for a spaced-based refueling capability enabled by the production of moon-based propellant.[20] While this figure does not warrant a profit-making venture by commercial interests, it is predicted that once in-space refueling capabilities are fielded, the market could grow "…by at least an order of magnitude in the foreseeable future."[21] Additionally, access to cislunar space will facilitate the extraction of resources from near earth asteroids and potentially the outer planets. Access to these resources will enable not only space-based manufacturing but could lead to economically feasible alternatives to our current reliance on fossil fuels in the form of space based solar power or the development of clean fusion power utilizing elements such as helium-3 harvested from the moon's surface or from one of the outer planets.[22]

Recommendations

This paper has only scratched the surface regarding the benefits associated with the United States' pursuit of cislunar space-based capabilities, while making the case that having those capabilities will serve the United States' interest in maintaining its leadership while promoting its expanded utilization and exploitation of space. Fortunately, the two principal U.S. government stakeholders in space-based operations, the Department of Defense and NASA, have started to implement plans and policies that are moving each of these organizations in the right direction. NASA has committed to return to the Moon within the next decade as part of a planned Lunar Gateway capability that would utilize cislunar resources as a springboard to manned exploration of the solar system. For its part, the Department of Defense has created the Space Force which, in theory, will place the planning, development and employment of all military related space capabilities under a single military service. While these moves are certainly steps in the right direction, more can and should be done to fully integrate the resources and capabilities of NASA and the Department of Defense in order to maintain U.S. leadership in space. The following paragraphs will offer recommendations and propose milestones that the United States might implement in the pursuit of an integrated approach to cislunar exploration and exploitation.

Pursuing an endeavor as broad as the development of a cislunar space operating capabilities is one that will require significant investment on the part of the United States and expertise derived from multiple government and private entities. The size and scope of this endeavor necessitates the utilization of a deliberate process for outlining objectives and assigning stakeholders, both within government and industry, to efficiently and effectively achieve the objective. The Department of Defense Unity of Effort Framework is one such method that would effectively coordinate the efforts of all stakeholders toward the goal of developing a National Space Strategy and developing a plan of action that would prioritize the United States' pursuit of a permanent cislunar presence.[23] This paper will not attempt to outline the entire framework approach it will provide some recommendations on how it should be structured. First, an overall lead integrator for the effort should be identified. This would be the organization assigned responsibility for coordinating among all stakeholders, facilitating the development of a plan of action and ultimately held accountable for achieving the objective. For the purpose of planning and executing the development of a cislunar space capabilities, the Department of Defense, and more specifically, the Space Force would be the best candidate for two reasons. First, the military has more resources, in the form of manpower, materiel and budget, than any other branch of the federal government. Leveraging these resources to the greatest extent practicable will be necessary to achieve this objective. Secondly, the military necessity outlined previously will be the most compelling justification for fielding this capability and will make the vast expenditure of necessary resources to achieve the objective more likely. There is an added benefit to identifying the Space Force as the lead integrator for this effort. In much the same way that the strategic bombing campaigns of World War II confirmed the legitimacy for a separate independent Air Force, assigning the pursuit of a pure space-based capability such as the development of cislunar space capabilities to the Space Force will provide much needed credibility to a nascent independent space service.

While the Space Force should be considered the natural choice to lead the development, integration and implementation of a new National Space Strategy focused on the development of cislunar capabilities, this would in no relegate NASA to the role of junior partner within the national space enterprise. The fact is, NASA has, and will likely continue to carry the preponderance of the burden associated with developing the technology and procedures necessary to exploit cislunar space. Placing the Space Force in the lead for developing and implementing the National Space Strategy would not change NASA's role, but would base the rationalization and prioritization driving the development of cislunar capabilities on the needs and objectives of the United States' national security with scientific discovery becoming a secondary benefit of this endeavor. Beyond the lead integrator, the identification of other stakeholders will also be necessary to effectively plan and execute the development of a cislunar transportation and logistics system.[24] This would obviously include other relevant government agencies such as the Departments of Transportation and Commerce who already exercise significant responsibility and authority within the space enterprise. Additionally, it will be necessary to leverage the resources and creative talent resident in private industry for this endeavor to be successful. Capital investment in the form of research and development of the cutting edge technologies necessary to achieve cislunar space objectives would be the primary benefit derived from private industry. While the risks for private industry are understandably large, the potential profits associated with cislunar resource exploitation will likely be persuasive enough to ensure their willing participation.

With the Space Force partnered with NASA, other relevant government agencies, and private industry, the stage will be set for much detailed planning necessary to successfully develop a National Space Strategy that prioritizes the exploration and exploitation of cislunar space. It is not possible in the space of this paper to produce a complete outline for this planning endeavor. However, there are two milestone recommendations that should be near-term priorities for achieving the United States' cislunar objectives. First, the United States must get a manned mission to the moon, and more specifically, the lunar poles as soon as possible. These future manned lunar missions should not be one-off publicity stunts, but should be part of an iterative plan that will expand our understanding and capability to operate in the cislunar domain. The Artemis program currently being pursued by NASA has objectives that appear to mirror this recommendation. Every effort should be made to adequately resource the Artemis program and integrate national security objectives to include the assignment of Space Force personnel within the Artemis program as soon as possible. Beyond Artemis, the United States should commit to developing the technologies and the processes necessary to harvest lunar resources, produce propellant on the moon, and transport that fuel back into earth orbit or to fuel depots stationed at the Earth-Moon Lagrange points. Developing, testing and fielding these technologies and procedures will provide the necessary framework for a cislunar transportation and logistics network that will lay the foundation for all future cislunar and deep space endeavors.

Second, the United States must rapidly expand its population of astronauts and develop the astronaut skills necessary to develop cislunar resources. One of the key enablers to this recommendation will require a significant paradigm shift in how the United States selects, trains and retains its astronauts. To this point, astronaut candidates are selected based on their physical fitness, ability to pilot aircraft or for their scientific, medical or engineering expertise. In most cases, astronauts possess advanced degrees in the physical sciences, medicine or engineering prior to their selection and then are placed through years of intense training before they are deemed capable of operating in space. While robotic capabilities will likely play an integral role in the day-to-day operations within cislunar space, it will be necessary to put people into space with varying technical skillsets to achieve the necessary level of development on a reasonable timeline. For the purposes of building bases on the moon to accommodate resources extraction, fuel production and manufacturing operations, something akin to a Space Corps of Engineers will be needed with expertise in designing, constructing and maintaining lunar facilities. Similarly, technical expertise will be needed to operate propellant plants, fuel depots and satellite maintenance stations. These manpower requirements lend themselves to personnel credentialed with classic trade skills such as heavy equipment operations, refinery technician or HVAC repair rather PhD's in astrophysics or aeronautics.

Similarly, the scale of cislunar operations will require significantly more operators and technicians capable of sustained in-space operations than NASA's current astronaut pool or training program could likely accommodate. As was previously mentioned, the primary purpose behind the expansion into cislunar space will be national security related. Consequently, the majority of the personnel that will be responsible for manning these efforts in space should be members of the Space Force. Initially, the Space Force will need to leverage NASA's training experience to produce skilled space operators, but a Space Force specific training program will need to be quickly developed and implemented to ensure projected space operations are sustainable. Initial efforts should be focused on identifying the skills necessary to establish and sustain the variety of cislunar missions and capabilities. Next, a manpower model should be developed that accounts for such variables as realistic duration for manned space activities and the length of a space operators' career in order to quantify the number of trained personnel necessary to accomplish planned cislunar objectives. Armed with the appropriate manpower requirements, planners will then be able to design a space operator training pipeline that equips personnel with the necessary skills in a timeline that ensures sufficient manpower is available to accomplish required missions.

Conclusion

For the United States to maintain its position of leadership in space and to facilitate the peaceful and just expansion of human activity into cislunar space, a new space strategy is needed that emphasizes an integrated, whole of government approach to planning, developing and implementing new space-based capabilities. These capabilities should be focused on extending space operations beyond Earth's orbit into cislunar space in order to capitalize on the numerous resources available for exploitation and the strategic advantage associated with a deep-space presence. Implementation of this strategy will enable the United States to outcompete its adversaries and lead its partners and allies to enjoy the full military, scientific, and economic benefits that cislunar space has to offer. In so doing, the United Sates will preserve its current position of leadership in all space-based endeavors and will be poised to lead the further expansion of mankind throughout the solar system and beyond.

Notes

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