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EXOTIC SPACE WARFARE: MILITARY IMPORTANCE OF SUSTAINED MANEUVER

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with Introduction and Conclusion by Katherine Melbourne of The Aerospace Corporation

Debates on national security space topics often do not penetrate the public conversation. Too often, these debates are limited to specialists within the space community. This paper is part of a series published by the Center for Space Policy and Strategy called "The Debate Series." Each of these papers includes two essays written by analysts and pundits external to The Aerospace Corporation that hold different positions from one another. After having written their essay, the external authors had the opportunity to review the opposing essay and offer a rebuttal. Although these essays do not necessarily reflect views of the Center for Space Policy and Strategy, the center is publishing these essays to clarify debates on national security space issues and to try to make them accessible to a broader audience.

Introduction

Katherine Melbourne

"Maneuver" has been in the military lexicon for centuries, but only in the past few years has "sustained space maneuver" become a public topic of conversation amongst U.S. military leadership. Increasing competition and emerging threats in space have incited an increased sense of urgency for finding nontraditional solutions that protect space assets. Sustained space maneuver (SSM) is one possible exotic space warfare tactic to gain advantage in space. SSM can be distilled down to the ability to move satellites "without regret" and without fear of losing fuel or mission time; SSM may be used to evade attacks and to threaten adversarial satellites if necessary.[1]

Maneuvering in space is not a new concept and is a necessity for collision avoidance and stationkeeping, both considered routine functions in satellite operations. Sustained space maneuver would go beyond these standard maneuvers, making frequent movement—and even orbital regime changes—integral to the concept of operations of certain satellite systems. Building on a foundation of the joint doctrine definitions for maneuver and sustainment, SSM has been proposed to achieve in-domain military effects, while many Earth-facing and commercial systems continue operating on traditional, predictable orbits.[2]

While leadership in U.S. Space Command, among others, has publicly advocated for SSM as an essential warfighting capability, questions remain about the concept and its potential implementation.[3] First, is frequent maneuvering, accompanied by the changes in space operations and logistics it will necessitate, the most effective way to achieve stated U.S. Department of Defense (DOD) goals in a contested space environment or in a potential space war? Second, is SSM, as envisioned, feasible within the limitations of orbital physics? And finally, would SSM be integrated into most military space systems or be reserved for specialized missions?

The following essays address these questions by offering contrasting views on sustained space maneuver as an essential warfighting principle for the U.S. Space Force. Benjamin Staats, an Army Space Operations Officer assigned to U.S. Space Command and a graduate of the Schriever Space Scholars Program, argues in his personal capacity that sustained space maneuver uniquely allows the United States to gain and maintain positions of advantage in space. Therefore, the U.S. Space Force should include SSM in its theory of success, a set of guiding principles to follow to achieve U.S. security objectives for in space. Mr. Staats has written extensively on space weaponization and related U.S. gaps in space strategy, proposing technologies to improve persistence, resilience, and responsiveness in space.[4] He pulls on themes from his previous work that focuses on security risks posed by rendezvous and proximity operations (RPOs)—one manifestation of SSM capabilities—by describing how movement must supplement space domain awareness to properly address new challenges in the space operating environment.[5]

Taking the opposing stance, Thomas González Roberts, a postdoctoral fellow at the Georgia Institute of Technology and adjunct fellow at the Center for Strategic and International Studies, argues that sustained space maneuver should not be central to U.S. Space Force strategy, as implementing limited "strategic or tactical" maneuvering would be a more effective and practical warfighting tactic. Looking through a technical and strategic lens and drawing upon his research of noncooperative RPOs, Dr. Roberts focuses on space security in addition to coordination and sustainability.[6] He provides quantitative assessments of time and fuel costs for proposed SSM capabilities. Dr. Roberts also points out that prioritizing SSM would present roadblocks to implementing current U.S. Space Force plans and hinder space domain awareness efforts, extending his previous research on developing sustainable norms in space.[7]

These authors were selected to contribute to this debate because of their unique perspectives as a warfighter and an astrodynamicist, both of which are key to a holistic understanding of sustained space maneuver. This analysis was accompanied by a live national security space debate between the authors, cohosted by the Center for Space Policy and Strategy at The Aerospace Corporation and the Space Policy Institute at George Washington University in August 2024.[8] Their written arguments are presented here in no preferential order, followed by their rebuttals.

◂◂ Argument that Sustained Maneuver Should Not Be a Central Space Warfighting Principle for the U.S. Space Force

Thomas G. Roberts

Sustained space maneuver (SSM) should not be a central warfighting principle for the U.S. Space Force (USSF) because of the inefficiency with which it would achieve its purported strategic advantages and the threats it would pose to U.S. leadership in the establishment of responsible norms of behavior in space.

Although many satellites occasionally fire their thrusters to preserve their operators' desired orbital characteristics, SSM refers to the practice of doing so almost *all* of the time, including to migrate between orbital regimes.[9] Advocates for SSM see continuous maneuvering as a fundamental enabler of the "dynamic space operations" (DSOs) they expect to become more common, in which satellites are less likely to remain in predictable orbits and more likely to engage in frequent rendezvous and proximity operations (RPOs). While constantly maneuvering satellites could offer attractive benefits to the space warfighter—making satellites more resource-intensive to track, more challenging to target, and more capable of performing RPOs—the idea is burdened by logistical problems that prevent it from aligning with a number of the principles of joint space operations, including economy of force, simplicity, and legitimacy.[10] Most of the benefits of SSM could be achieved with far fewer burdens via what I call *strategic* or *tactical maneuver*, in which satellites change their orbital trajectories far less frequently, but in response to similar cues, such as an evolving responsibility or imminent threat. Strategic or tactical maneuvers sparingly use the same onboard propulsion systems that satellites use for stationkeeping—either chemical, electric, or hybrid—to sporadically alter their orbits in pursuit of more dynamic space operations.

The fundamental problem facing SSM is propellant use. To fire thrusters for the vast majority of their operational lifetimes, satellites would need far more fuel than what they burn for stationkeeping. Proponents of SSM have responded to this concern by outlining a vision in which USSF satellites are either refueled via on-orbit servicing (OOS) missions, accept reduced operational lifetimes, or depend on new variants of propulsion technology with significant hurdles to implementation.[11] No matter what tools you employ to combat SSM's exorbitant fuel demands, the concept requires launching enormous amounts of mass to orbit.

When satellites maneuver, they change the nature of their orbital trajectories, and with them, the foundation on which they can conduct their missions. Satellites that maneuver from one orbit to another may lose or gain critical orbital qualities—revisit rate, solar angle, and field of regard, among many others—that are only available before or after the maneuver, but not both. As the USSF continues to pursue architectural satellite defenses by fielding more disaggregated, distributed, and proliferated constellations, constant maneuvering adds undue complexities that hinder the efficient and effective execution of planned operations and intensifies the challenges of international coordination in space.[12] When maneuvers that greatly change a satellite's energy state are more rare, as in the case of strategic or tactical maneuver, mission planners can more reliably adapt to account for them while upholding the satellite's core responsibilities.

SSM represents a radical change in space operations; one, I argue, that is too costly to become a central USSF warfighting principle. As the space domain continues its trend towards DSO, the USSF should increase its fleet's maneuverability—to both pursue space superiority and protect its assets from threats—but execute infrequent strategic or tactical maneuvers to reach that goal, not SSM.

The Propellant Problem

There's no way around it: SSM requires massive amounts of propellant compared to traditional operations. Advocates for the concept do not shy away from this fact—some make it clear that pursuing SSM is about capability, not efficiency—but fail to quantify the magnitude of the propellant problem.[13]

To fulfill the requirements envisioned by SSM advocates, satellites would likely depend on an array of propulsion technologies, some with more flight heritage than others. For long-duration burns, satellites would likely make use of low-magnitude electric propulsion, as high-thrust chemical systems rapidly use propellant when fired continuously. For context, a 1-Newton hydrazine monopropellant thruster would burn on the order of 10,000 kilograms per year if fired continuously, which is more than 10 times the total mass of most low-Earth orbiting (LEO) satellites.[14] The ion propulsion system aboard *Dawn*, on the other hand—a NASA deep-space probe and one of the few satellites that has ever performed very-long-duration burns using an electric propulsion system—burned about 85 kilograms of its propellant per year when used continuously.[15] Although electric systems are tantalizingly efficient, their low-thrust output means that they cannot be used for some of the purposes highlighted by SSM advocates, such as thwarting kinetic physical counterspace attacks or performing new RPOs over the course of a few hours.[16] For a LEO satellite to raise its altitude from 400 to 1,000 kilometers to reach an RPO target using chemical propulsion, for example, about 10 percent of its mass must be propellant—or more, if its operators wish to complete the maneuver over expedited timescales.[17] Changing orbital planes is even more propellant-intensive: for a geostationary satellite to maneuver to 30 degrees inclination and back would require twice its mass in propellant for just that pair of maneuvers alone.[18] Performing these kinds of operations on a regular basis would require orders of magnitude more propellant than what satellites carry today and more frequent refueling than is ever mentioned in the public debate. Proponents of SSM aspire to an era of operations with "regret-free maneuver," where operators can always choose to maneuver without worrying about propellant consumption.[19] In reality, burning propellant at such exceptionally high rates introduces new regrets for operators: time spent waiting to rendezvous with an OOS satellite, propellant expended to reach a refueling station, or launch costs associated with replacing depleted satellites to reconstitute capability gaps.

In an attempt to overcome the debilitating nature of the propellant problem, some SSM advocates argue for the use of nuclear propulsion, which falls between electric and chemical propulsion on the traditional trade-off between efficiency and thrust.[20] Such a proposal, however, faces serious policy roadblocks that have stymied the use of nuclear propulsion in the United States for decades, including costly launch approval processes and designations for safe operations that forbid the use of nuclear propulsion in the most populated portions of the near-Earth space environment.[21]

If USSF space mission designers were allowed thousands of extra kilograms of mass on-orbit *without* pursuing SSM, they could sustain new capabilities elsewhere in the competition continuum for decades on end, including those more in line with other components of USSF Chief of Space Operations Gen. B. Chance Saltzman's vision for what he calls "competitive endurance," such as disaggregation, distribution, and proliferation.[22]

Advancing Capability While Preserving Legitimacy

Published commentary from an author team led by former U.S. Space Command Deputy Commander and USSF Lt. Gen. John E. Shaw (ret.) calls SSM an "imperative."[23] Without it, they say space operations will "become increasingly risky and dangerous, analogous to warships in port, or combat aircraft on the ground."[24] While delightfully simple, such an analogy fails to acknowledge the fundamental uniqueness of the space domain, in which satellites in natural drift are both well suited to contribute to multiyear USSF missions and already capable—without SSM—of drastically altering their trajectories with strategic or tactical maneuvers at a moment's notice. In a few fractions of a second, when fighter jets' air turbine starters would still be powering up and warships' propellers just beginning to whir, merely inching those assets forward, a satellite can perturb its orbit and begin to veer kilometers off its previous course in response to on-orbit threats or an evolving set of responsibilities. Using strategic or tactical maneuvers, the USSF can efficiently achieve many of SSM's benefits without behaving in ways that the international community could earnestly describe as anomalous compared to the rest of the satellite population and dangerous for space safety.

Because most satellites are not subject to continuous supervision, infrequent on-orbit maneuvers pose serious challenges for passive space object tracking. Well-timed one-off maneuvers can lead space sensor networks to lose custody of satellites, creating valuable opportunities for Guardian warfighters across a wide variety of scenarios both below and above the threshold for armed conflict, where every second counts.[25] While SSM would further widen space networks' custody gaps in some orbital regimes, its benefits are more limited in others: a constantly maneuvering satellite in geosynchronous (GEO) orbit, for example, may never leave a space sensor's field of view should it become its dedicated target.

As kinetic physical counterspace weapons have evolved over the course of more than six decades, the concept of using on-orbit maneuvers as a defensive mechanism has grown less obvious. The crown jewel of the U.S. anti-satellite (ASAT) program of the 1980s—the ASM-135 multistage missile launched from an F-15 jet—for example, could easily be thwarted by a well-timed maneuver, as its target's orbital elements were preloaded onto a physical tape before flight.[26] To evade a modern direct-ascent ASAT with more adaptive and precise guidance systems, an on-orbit maneuver may be a more promising strategy when paired with other kinetic physical, non-kinetic physical, or electronic active defenses.[27] Regardless of the nature of an attack on a satellite, the physics remain the same: a low-cost strategic or tactical maneuver greatly alters the trajectory of the satellite, even with relatively short notice, forming a meaningful contribution to a defensive strategy without the costs of SSM.[28]

When foreign satellite operators exercise their control authority to reposition themselves such that they can more closely inspect the behavior or physical image of U.S. and allied satellites, armed services leaders have called such behavior "unusual and disturbing" and, in at least one case, "an act of espionage."[29] As U.S. military space leadership makes an argument for responsible norms of behavior in outer space, the USSF should invest in capabilities in line with those values, including "follow[ing] trajectories that allow other space objects to maneuver in a safe manner," such as those that are largely predictable, at least over the course of collision avoidance timescales.[30] Directly investing in SSM—and not sharing the details of satellites' associated maneuver plans in the name of operational surprise—would undermine the United States' ability to legitimately advocate for mechanisms in multinational fora that guide space actors towards more responsible norms of behavior.

Adopting SSM would result in a seismic shift in military space operations. Such a change would garner enormous mass-to-orbit requirements and undermine U.S. leadership in sustainable space practices. Instead, the USSF should field improved strategic or tactical maneuver capabilities that can uniquely serve U.S. missions and complement ongoing initiatives to defend space-based assets from attack, all while preserving the stability of the domain and continuing to deter conflict.

▶▶ Argument That USSF Should Prioritize Sustained Space Maneuver as a Central Space Warfighting Principle

Benjamin Staats

The U.S. Space Force must prioritize the development and employment of sustained space maneuver capabilities to leverage the timeless value of maneuver as it becomes a key warfighting principle in yet another warfighting domain. The principle of maneuver remains an enduring and relevant principle in the practice of both warfare and statecraft, and will remain so in the space domain.[31] The ability to sustain space maneuver will enable the Joint Force to attain the necessary strategic and operational flexibility against competitors who continue integrating space and counterspace capabilities into warfighting strategies designed to challenge U.S. and allied forces.[32]

The principle of maneuver is the employment of forces into positions of relative advantage at critical times throughout competition or during conflict.[33] Gaining positions of relative advantage is an essential means to set favorable conditions and achieve desired ends. Sustained space maneuver, an element of dynamic space operations, enables space forces to continuously gain and maintain advantage over potential threats by outmaneuvering adversaries, maintaining initiative, and achieving surprise.[34]

Unfortunately, U.S. space forces do not yet possess the capacity to sustain space maneuver outside of limited space maneuver capabilities, such as the Geosynchronous Space Situational Awareness Program (GSSAP).[35] Meanwhile, strategic competitors increasingly develop and test maneuver capabilities. For example, China's *Shijian-21* satellite conducted unprecedented large maneuvers while Russian satellites *Resurs-P3* and *Luch Olymp K-2* conducted unexpected maneuvers.[36] Sustained space maneuver enables U.S. space forces to respond to unexpected activities and avoid these types of surprises.

Sustained space maneuver is a key warfighting principle that the U.S. Space Force must explicitly prioritize to drive strategic decisions on space capability development and employment. Doing so encourages commercial investment and sparks the innovation of supporting and related technologies needed to enable sustained maneuver, such as propulsion, servicing, onboard processing, sensors, and logistics. It also presents opportunities to develop new doctrine, warfighting concepts, and sustainment strategies.

The U.S. Space Force can drive and stimulate these necessary technological innovations by emphasizing the need for sustained space maneuver as part of its strategy or by revising its published theory of success, *Competitive Endurance*. Integrating sustained space maneuver as a necessary component of *Competitive Endurance* will more effectively enable the U.S. Space Force to accomplish the service's three tenets of success: avoid operational surprise, deny first-mover advantage, and prevent space-enabled attack against the Joint Force.[37] Doing so will set the U.S. Space Force towards a strategic path that better assures its desired outcome of making "the hostile use of adversary space and counterspace capabilities impractical and self-defeating."[38]

Putting Theory into Practice

First, to avoid operational surprise, sustaining timely and comprehensive space domain awareness (SDA) is essential. However, given that strategic competitors, such as China, are developing space and counterspace capabilities at a breathtaking speed, it will be increasingly challenging to maintain a complete understanding of the operational and strategic environment.[39] Even if SDA can maintain custody of every potential threat in space, an adversary can still conduct offensive preparations by posturing potential forces below the threshold of conflict to gain a position of relative advantage and threaten U.S. space forces. Further complicating matters for SDA is the inability to fully decipher the intent of adversarial satellites with multiple use capabilities and purposes; for example, China's research and development, civil, and pseudo-commercial space capabilities with a range of functions that have direct ties to the People's Liberation Army.[40]

Sustained space maneuver complements SDA to avoid operational surprise, mitigating the residual risk from SDA alone. Sustained space maneuver provides the needed flexibility to respond to unexpected threats, positions capabilities that deter hostile action, and imposes dilemmas. For example, a space infrastructure with sustained space maneuver capabilities can actively maneuver away from potential threats or maneuver protection assets into positions of advantage.

Second, to deny first-mover advantage, resilience—the ability to withstand, fight through, and recover from attacks—makes attacks against space systems impractical, but resilience alone is insufficient.[41] There is still risk that an adversary strikes first because such an attack may still enable the accomplishment of a terrestrial strategic objective. An adversary with different principles, values, perspectives, and logic may have a lower threshold of risk regarding conflict in space, particularly if initiating conflict in space is the most practical means to set conditions to achieve terrestrial-based strategic objectives. For example, Russia deliberately hacked Viasat's satellite control network as part of its 2022 invasion of Ukraine to degrade command and control in support of its strategic objectives.[42] This is a another concerning indication of Russia's willingness to target space systems throughout the competition continuum.

Here again, sustained space maneuver complements resiliency and mitigates the residual risk of a resilient architecture alone. Sustained space maneuver makes critical space systems and constellations more difficult to precisely target, further complicates an adversary's understanding of the operational environment, and enables response options against preemptive moves. For example, maneuverable capabilities can avoid attacks while other capabilities can maneuver in response, rendering the benefits of a first move negligible.

Third, *Competitive Endurance* discusses the importance of protecting the Joint Force from space-enabled attack. For example, the U.S. Space Force intends to field capabilities that prevent intelligence, surveillance, and reconnaissance (ISR) satellites from targeting U.S. forces.[43] However, the fielding of space-based capabilities without the capacity to sustain maneuver will significantly limit the number and types of options to fully protect the Joint Force.

Sustained space maneuver is again critical to fully assure space forces can further mitigate the risk of space-enabled attack against the Joint Force. Sustained space maneuver expands the types and numbers of flexible deterrence and response options and enables U.S. Space Command to confront challenges throughout the competition continuum, ultimately mitigating the risk of conflict escalation. In addition, U.S. Space Command can integrate the timing, tempo, and synchronization of such maneuver options with other Combatant Commands, further improving the effectiveness of integrated deterrence efforts.

In summary, the U.S. Space Force's theory of success is clearly incomplete without emphasizing sustained space maneuver as an instrumental component and key warfighting principle that complements SDA and resiliency. Sustained space maneuver is essential to develop a flexible and adaptable force that empowers the planning and execution of deterrence and response options. History repeatedly indicates that greater flexibility and adaptability enables greater strategic robustness and provides a stronger hedge against unanticipated strategic challenges.[44]

An Abbreviated Case Study

While no historical analogy applies perfectly to space, an example of a strategic situation with many similar geopolitical and military conditions can help put the rationale for sustained space maneuver into greater context.

As France recovered from World War I, the tragic loss of life from offensive maneuvers convinced military and political leaders that maneuver was fundamentally dead.[45] As a result, France rationally pursued a defensive strategy with the goal of making an attack against them impractical and self-defeating through deemphasizing maneuver. The logic was that a greater number of French forces arrayed across a defense would provide the necessary resilience and time for the country to further mobilize and bring the whole nation to bear in response to an attack.[46]

The strategy did not prioritize maneuver, and politicians and military leaders construed maneuverable armored forces as inherently aggressive and inappropriate for an avowedly defensive strategy.[47] Instead, their strategy emphasized fortifications and the tightly controlled methodical battle concept, and this drove how the French army organized, trained, and equipped.[48] The French army did not invest in the associated technologies needed to sustain maneuver, such as mechanization and mobility advances; supporting artillery gun upgrades;

communications equipment; and logistics capabilities and doctrine—all to enable long-distance maneuvers.[49]

What few maneuver capabilities France did develop, they passively integrated into their methodical battle doctrine without adapting their strategy. Meanwhile, German and Soviet armies prioritized and embraced maneuver to complement their own emphasis on fortifications.[50]

As a result, France's strategy was inapt against the realities presented before them and it set the army on a strategic path where it did not effectively prepare for competition and war. First, it did not have the force structure to maneuver in a way to act decisively against, or threaten, an increasingly aggressive actor throughout competition.[51] Second, because of these limitations in maneuver, it was unable to support its allies in their times of need when they were threatened.[52] And ultimately, it prepared for the wrong type of war where it was unable to respond to surprise, and reposition against a maneuverable force.[53]

Without operational and strategic flexibility, France was unable to respond as Germany began setting conditions for invasion. Once war broke out and France lost the initiative, their force posture designed around fortifications and the methodical battle left them unable to reposition and repel the German forces.[54]

France's strategic approach and absence of prioritizing maneuver during the interwar period provides insight on two strategic imperatives regarding the importance of sustained space maneuver in statecraft and warfare today.

First, it illustrates that a lack of flexibility to maneuver significantly limits alternative political and military options throughout the competition continuum. Sustained space maneuver enables a broader range of alternative political and military deterrence and response options needed to maintain flexibility and adapt to the evolving strategic environment.

Second, as a result of not prioritizing maneuver as strategic and technological conditions evolved, the French army did not develop the associated technologies needed to sustain maneuver. Thus, when the French army needed to maneuver, they did not have the capacity to do so. The same risk applies to space strategy. Prioritizing sustained space maneuver now will stimulate investments into supporting space related technologies, such as on-orbit servicing, refueling, advanced propulsion systems, propulsion efficiency, and other logistical innovations that enable future maneuver options.

In the end, the French army failed to protect and defend its nation because it did not anticipate and prioritize maneuver as the strategic and technological conditions evolved.[55] The U.S. Space Force must not make the same mistake.

Conclusion

Sustained space maneuver is a key warfighting principle the U.S. Space Force must exploit in order to assure the Joint Force attains the flexibility and adaptability it needs against evolving threats in the space domain. Strategic competitors have watched for years as the instrumental component of U.S. space strategy, resilience, has taken shape since its introduction as a concept in 2011.[56] Given that strategic competitors deliberately build forces and doctrine to exploit vulnerabilities in U.S. strategy and its military forces, one should expect they are doing the same thing against U.S. space forces and its resiliency efforts.

The concept of resilience has yet to prove its own military utility, whereas maneuver is of proven military utility in every other domain and throughout history. Prioritizing sustained space maneuver will complement ongoing resilience and SDA efforts to complete a balanced space strategy as unique as the domain itself.

The aggregate risk of not prioritizing sustained space maneuver seems clear: increased risk of operational surprise, increased risk from first-mover advantages, and increased risk from limited maneuver opportunities to prevent space-enabled attack. The opportunity to mitigate this emerging and significant aggregation of risk seems well worth the investment tradeoffs needed to develop sustained space maneuver capabilities.

◀◀ Rebuttal to the Argument USSF Should Prioritize Sustained Space Maneuver as a Central Space Warfighting Principle

Thomas G. Roberts

While Mr. Staats presents a compelling argument for how maneuvering spacecraft might be useful to the U.S. Space Force, he abstains from addressing why satellites must *sustain* their maneuvers—that is, fire their onboard thrusters more often than not—in order to achieve those benefits. Because satellites already demonstrate their ability to maneuver by regularly stationkeeping, this distinction is critical for our debate.

Mr. Staats' example of a satellite system with only "limited space maneuver capabilities"—the Geosynchronous Space Situational Awareness Program (GSSAP)—performs its mission by performing what I call "strategic" maneuvers, yet still notches the majority of SSM's purported benefits. GSSAP satellites patrol the geostationary belt by pursuing orbital trajectories above and below geostationary altitude, allowing them to drift in longitudinal space and observe other geosynchronous (GEO) satellites at very close distances relative to the terrestrial nodes of the U.S. Space Surveillance Network.[57] Because GSSAP satellites change their drift rate and direction with no discernible pattern, other GEO satellite operators may face difficulty predicting where those systems will be over the long timescales of GEO operations.[58] If GSSAP satellites were to pursue SSM, including high-magnitude plane-shift maneuvers to observe high-inclination objects as suggested by some SSM advocates, they would need to perform more predictable operations via rendezvous with an OOS satellite or a refueling station.[59]

Meanwhile, the foreign satellites that Mr. Staats described as "unpredictable" and suggested should inspire the U.S. Space Force's turn to SSM—namely Russia's *Olymp* series and China's *Shijian* (SJ) series—actually exhibit rather predictable behavior when compared to GSSAP. Although it has pursued more longitudinal-shift maneuvers than any other GEO satellite, Russia's *Luch (Olymp)* typically performs maneuvers with the same features: movement in the eastward direction with drift rates of approximately one longitudinal degree per day.[60] The behavior of China's *SJ-17*, as another example, also offers some predictability: more often than not, the satellite can be observed in regions of the geostationary belt in which the Chinese state has been assigned protected access to portions of the radio-frequency spectrum by the International Telecommunication Union.[61]

In today's current GEO environment—where SSM advocates, including Mr. Staats, harvest many of their operational examples—the United States enjoys most of SSM's benefits while shirking the costs of actually pursuing it.

▶▶ Rebuttal to the Argument that Sustained Maneuver Should Not Be a Central Space Warfighting Principle for the USSF

Benjamin Staats

While I value and respect Dr. Roberts' technical expertise as part of this dialogue, his criticisms and proposed alternatives fundamentally disregard strategic realities and anchor on faulty assumptions.

SSM—the ability to operate dynamically over time and continually gain and maintain advantage—provides the flexibility and adaptability needed to respond and adjust to the evolving space environment, and protect and defend space architectures against advancing threats. Improving the ability to defend space systems with SSM capabilities further minimizes the probability of a successful attack and disincentivizes offensive actions.

Dr. Roberts' proposed *strategic maneuver* concept will not adequately provide these same conditions. This "reactive" repositioning of satellites relabels what satellites essentially already have the capacity to perform today, but do not do so because it presents significant risk to future operations.

He also advocates to continue investing in resiliency—with which I agree. Yet as I reasoned in my argument above, the risk to space security continues to grow as counterspace threats proliferate, expand, and advance, and a resilient architecture alone will insufficiently mitigate the growing risk to operational surprise, first-mover advantages, and the ability to protect the Combined/Joint Force.

In addressing the propellant problem, Dr. Roberts fails to consider the near-future of space launch where, with systems like Starship, the USSF can launch significantly larger amounts of mass to orbit at scale—room for hydrazine and the requisite sustainment infrastructure.[62]

Lastly, Dr. Roberts' argument that SSM undermines U.S. legitimacy is unfounded as he assumes U.S. Space Command would operate SSM capabilities irresponsibly. On the contrary, U.S. Space Command operates current maneuver capabilities, specifically GSSAP, in manners consistent with its Tenets of Responsible Behavior. The United States must continue its leadership in space, and employing SSM capabilities will enable U.S. Space Command to continue reinforcing responsible maneuver behaviors that reduce misunderstandings and miscalculations.[63] Responsible maneuver norms will more likely crystallize into international law through the *practice* of responsible maneuver—not just through dialogue alone.

Dr. Roberts' status quo approach argues for the USSF to concede important strategic advantages, accept the growing risk to space architectures, and refrain from space leadership. SSM is a paradigm shift that the USSF must strive towards as its strategy evolves.

Conclusion

Katherine Melbourne

This debate captures the broader conversation about the extent to which maneuver is an essential warfighting tactic, how militarily effective frequent maneuvering would be, and by extension, how urgent it is for the United States to invest in developing sustained space maneuver capabilities. First, both Mr. Staats and Dr. Roberts agree that movement in space must serve a purpose, but Dr. Roberts argues that more limited, well-timed maneuvering would reap the benefits sought by proponents of SSM. Mr. Staats views this type of maneuvering as reactive and argues that sustaining maneuver allows it to be used more proactively. Neither author questions the importance of maneuver; rather, they disagree on the frequency and nature of maneuvers needed.

The authors also address how SSM will affect norms in space. Mr. Staats claims that the United States has an opportunity to lead international norms development on the implementation of SSM, and Dr. Roberts expresses concern that implementing SSM would undermine U.S. leadership in advancing norms of responsible behavior in space. While the U.S. may develop SSM primarily to protect space assets from attack, the capability may also be used aggressively, affecting how adversaries would interpret a U.S. focus on SSM.

Finally, the question remains as to how widespread the integration of SSM into military space assets should be to address both threats and combative attacks in space. Through historical analogy, Mr. Staats mentions that maneuver can help forces be responsive to an attack. However, his argument focuses more on the impact maneuver has on deterrence through making an adversarial attack on U.S. space assets “self-defeating.” Dr. Roberts also emphasizes deterrence and maintaining stability in space in his argument for less frequent maneuver without projecting SSM into a space combat scenario. When considering how niche of a capability SSM should be, space military leaders should analyze not only how SSM would integrate into the competitive space environment as we experience today, but how it would manifest in a potential conflict environment as well.

Deciding how important SSM is to the goals of DOD space leadership will require continued analysis of the current and future state of the space environment. It will also require clear definitions of how traditional military maneuver and sustainment will apply to space. The debate about SSM is, in some respects, part of a larger debate about how to best protect space assets while threatening and undermining adversarial uses of space. As militaries and governments increase their reliance on space, these issues—including debating and defining SSM—will continue to grow in importance.

About the Authors

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