

Space Superiority is The Prime Imperative:

Dynamic Space Operations Are but One Part of the Answer

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In the past five years, as commercial launch cadences climbed above 90–100 U.S. launches per year and China accelerated both military and civil orbital activity, a parallel surge of conceptual proposals has emerged. Many of these ideas—DSO among them—have value, but they increasingly assume that capability growth can outpace fiscal, doctrinal, and operational realities. Many of these efforts fail to capture the full complexity of DSO as part of the larger problem of gaining and maintaining space superiority, especially relative to the limited fiscal trade space available to our national security space decisionmakers.

"Space Superiority is our prime imperative... and we do not yet have the Service we need."

- General Saltzman, CSO

On this subject, a number of assertions, of varying validity, have been made. Let's take them one by one.

Space IS a warfighting domain. Yes, absolutely it is. Why? Space is already a warfighting domain because military forces actively prepare, equip, and organize for conflict in, from, and through space, and states are fielding and demonstrating capabilities designed to disrupt or destroy space systems. Multiple governments now formally classify space alongside land, sea, air, and cyber as a domain of military operations, not just a support



environment. States including the United States, Russia, China, and India have developed, and in some cases, tested a range of counterspace weapons—direct-ascent anti-satellite missiles, co-orbital systems, jamming, spoofing, cyber-attacks, and directed-energy concepts—that are

specifically intended to hold space assets at risk in conflict. The presence and evolution of such capabilities demonstrates that space is no longer regarded as neutral infrastructure but as a battlespace where adversaries prepare to contest control.

Dynamic Space Operations (DSO) are essential? Maybe... maybe not. DSO will definitely be important, but they are only one part of a broader portfolio needed to meet future space threats; resilience, deterrence, norms, and non-maneuver defenses matter just as much, and in some missions, more. DSO imagines a sky in which maneuver is cheap, frequent, and stabilizing. In reality, even adding an extra hundred meters per second of delta-v to a satellite may require structural trade-offs that reduce payload mass or mission duration. The cost is not just financial; it is architectural. DSO has its limits.

DSO—high maneuverability, on-orbit servicing, refueling, and the capability to make rapid orbital changes—helps spacecraft avoid threats and complicate targeting, but it cannot fully solve problems like cyber intrusions into ground networks, attacks on data links, or political escalation risks... and certainly not without massive expenditures. Many proliferated low-Earth-orbit constellations are designed to be short-lived and cheap, so heavy investment in refuellable or highly maneuverable platforms is not always economical or necessary for these missions. Moreover, over-reliance on maneuver also risks rapid depletion of valuable propellant and can increase operational complexity, making command & control and space traffic management more difficult under high stress situations. General Chance B. Saltzman, Chief of Space Operations, has even stated: “*Space Superiority is our prime imperative... and we do not yet have the Service we need,*” which implies that gaining and maintaining space superiority is the number one priority, and thus, DSO is but one element in a larger context to re-shape the Space Force, and the domain in which we operate, to ensure the interests of the United States.

On-orbit logistics are critical? Important, yes, but not necessarily ‘critical’. On-orbit logistics are important because they enable sustained maneuver, adaptability, and resilience, which are central to the future of dynamic space operations. However, they are not vital today because existing mission architectures and alternative strategies can still achieve operational objectives—albeit with less flexibility and survivability... but at considerably less cost. Let us not forget, OSAM-1 stands as a reminder that servicing is not yet a routine capability but a frontier of engineering challenge, cost, and risk.



Despite their advantages, on-orbit logistics are not yet indispensable for space operations because:

- **Current Architectures Can Function Without Them:** Most satellites today are designed for fixed missions with predictable lifespans. While this limits maneuverability, and thus, flexibility, it does not prevent mission success under current operational paradigms.
- **High Cost and Technical Complexity:** Programs like NASA's OSAM-1 faced cancellations due to cost overruns and delays, highlighting that logistics capabilities are still emerging and expensive to scale. These challenges make them aspirational rather than mandatory for near-term operations.
- **Alternative Strategies Exist:** Responsive launch, smaller distributed constellations, and software reprogrammability can partially offset the need for on-orbit servicing. These approaches provide resilience without requiring a full logistics infrastructure.

China is advancing rapidly? Yes, of course! Don't blink or you will miss an influx in resources from the Central Committee, a new space-focused organization, or a new technology! Many of those are focused directly on countering US advantages in space.

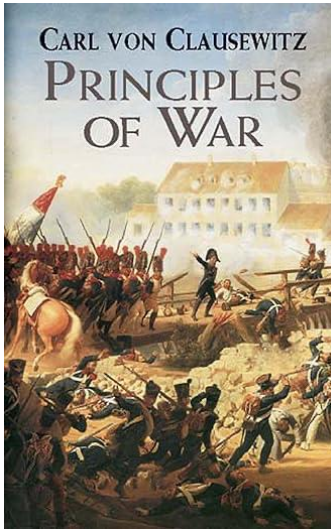
Predictable space operations are a vulnerability? In some cases, yes. In other cases, the advantages to stable and predictable orbits outweigh the risks or the need to dramatically inject DSO-like features. Injecting rapid, unpredictable maneuvers does not automatically create resilience — but it does multiply ambiguity. For many missions, predictable orbits are generally more desired because they make space operations safer, CHEAPER, and more reliable, while highly dynamic maneuvering is resource-intensive, harder to sustain, and can complicate both mission performance and space safety. While DSO is unquestionably valuable for some military and defensive purposes, they are usually the exception layered on top of a fundamentally predictable constellation or architecture.

At a time when we are trying to establish norms of behavior in space, especially with defensive and “services” constellations, predictable orbits make it easier to track satellites and model their future positions, which reduces collision risk and simplifies conjunction assessment and avoidance planning for Guardians—this equals transparency, survivability and safety for most space missions (not vulnerability). There are other missions which would naturally benefit from highly maneuverable features for surprise, flexibility or non-attribution. But, even in those cases, Guardians must balance the benefits of maneuverability against fuels costs, mission impact (or periods of mission loss), tracking burdens, and the broader traffic management and stability concerns raised above, which is

why predictable baseline orbits (think PNT, comms, weather) remain the foundation for most space operations.

Principles of warfare must be applied to space? Short answer: Yes, but adapted. After all, while the nature of war is unchanging, the character of war is constantly changing; with potential space combat as simply the latest phenomenon to be addressed. The core principles of warfare should *inform* space operations, but they must be adapted, not directly applied, to the physical, legal and political peculiarities of the space domain rather than adapted wholesale and unaltered directly from land, sea, or air warfare.

War's basic nature—organized violence for political purposes (or as we said when I was in uniform, “killing people and change when the domain foundational ideas like clear proportionality still apply. (objective, offensive, surprise, etc.) are designed political goals and to which are also central



blowing things up”)—does not shift to space. Therefore, objectives, initiative, and Traditional principles of war security, economy of force, to connect military actions to manage risk and uncertainty, concerns in a space conflict.

But these principles must be physically fragile, highly for civilian purposes, so approaches (e.g. mass

adapted for space. Space is interdependent, and heavily used unmodified terrestrial destruction of satellites) risk long-

term debris, escalation, and broad economic damage. A single destructive engagement can leave debris aloft for decades, reshaping the environment for generations (China's 2007 ASAT test created thousands of trackable fragments still circling Earth and Russia's 2021 ASAT test forced multiple crew shelter events on the ISS).

Legal regimes like the Outer Space Treaty, plus emerging norms of behavior and Law of Armed Conflict, constrain certain military uses of space and require acute discrimination, necessity, and proportionality in any use of force. Most will concede, there is a strategic paradox in space; often, finding the line between tactical, operational, and strategic missions, as well as space-derived information, for space warfighting is difficult, thus making prediction of escalation for more challenging.

Scholars and space practitioners increasingly argue for tailored “space warfare” or “spacepower” principles that reinterpret the classics in light of orbital mechanics, dependence on space services and the seemingly prioritized perspective of supporting operations on Earth. These frameworks emphasize that command of space (or Space Superiority) is meaningful only insofar as it enables or protects political outcomes on the

ground, and that seeking decisive ‘space battles’ or large-scale satellite destruction is often counterproductive in a domain that all major powers rely upon. That type of thinking is dangerous if you are the only country following the “rules”. The USSF must be prepared to gain and maintain absolute Space Superiority if and when a terrestrial conflict extends to space.

Resupply is preferable to disposable satellites? Only for some high-value missions.

The math is simple; space refueling is expensive itself and should only be considered for our most high-value assets on orbit.

Satellite refueling is attractive for certain high-value missions, but for many (most) applications, designing cheaper, short-lived, “disposable” satellites (often as part of a proliferated constellation) is currently more practical and economical. Certainly, refueling satellites extends

the life of expensive missions, improves resilience by allowing “maneuver without regrets,” and reduces debris by keeping still-healthy satellites operating instead of abandoning them when their fuel runs out. However, refueling is technically difficult: docking, fluid transfer in microgravity, and standardizing interfaces across the many satellite types are complex and remain relatively immature. There are high upfront costs: refuellable satellites, tanker spacecraft, and operations infrastructure add design and program cost, which only provides a return on that investment if the satellite itself is valuable and has a lengthy projected end of life. Moreover, there is limited benefits for many satellites because other components (electronics, fragile sensors, and complex software) age or become obsolete, so fuel is not the only, or even the main, life-limiting factor for many space missions.

Lower unit cost, smaller, mass-produced and “good enough” militarily useful satellites, can be built and launched relatively quickly, and is far less costly than adapting an entire satellite architecture to accommodate on orbit refueling.

Flexibility across all segments is key? Yes... it is.. if the Space Force is going to go “all in” on DSO at the expense of the multitude of Space Superiority planned programs across the FYDP and beyond. If one believes that “DSO must be applied holistically to orbital, terrestrial, link, and launch segments to ensure resilience and effectiveness in space operations,” then we will need to take a “clean slate” approach to the USSF budget for the next decade or more in order to afford adapting every portion of the national security space architecture, from the ground to cislunar. Even setting aside the enormous investment needed to retool infrastructure, the cultural, doctrinal, and interagency adaptations required to support dynamic operations would take far longer than the hardware itself. In reality, adapting the launch segment alone for DSO would break the bank.

Adapting US launch infrastructure for dynamic space operations—including on-orbit refueling, logistics, and rapid maneuverability—requires significant upgrades to existing facilities, new technologies, and a shift in operational paradigms. This includes not only physical infrastructure (launch pads, fueling systems, logistics hubs) but also command and control, communications, and safety

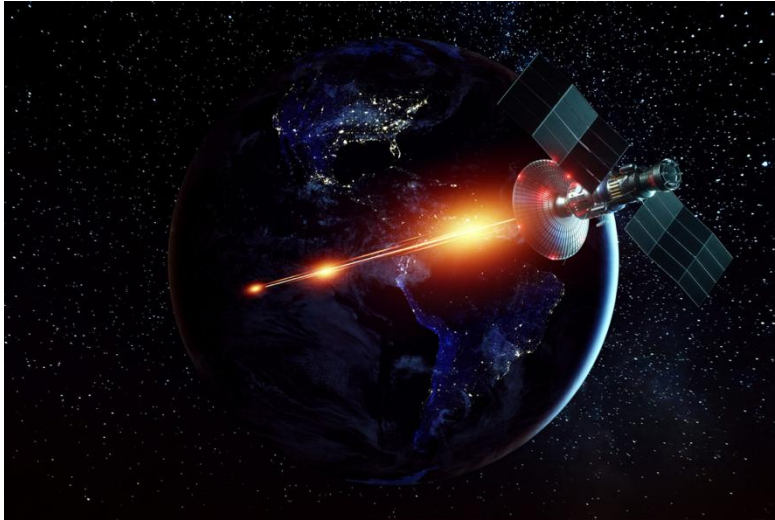


systems to support more frequent, flexible, and resilient launches. It would also entail investing in R&D for new technologies and operational concepts as well as shifting some costs to commercial partners as the government moves to a “spaceport of the future” model. The US is already spending billions annually on launch infrastructure, with at least \$18 billion planned over the next five years. Full adaptation for DSO (including refueling and logistics) would likely require tens of billions more, especially if pursued comprehensively. The government is moving toward incremental upgrades and commercial cost-sharing, but the scale of investment needed for a fully DSO-capable infrastructure is unprecedented. Many enabling technologies are not yet mature, and actual costs will depend on the pace of adoption, policy decisions, and industry participation. Further challenging are the dangers of vastly increased propellant storage, fueling on the launchpad, and moving tanks of propellant to space.

And, most importantly, the USSF can achieve Space Superiority without a full-scale buy-in of DSO.

The U.S. must act decisively? And Delaying the adoption of DSO risks ceding space superiority to China? We are...and, not true. The USSF, as the US’s youngest Service, has made the case for Space Superiority forcefully and with great success. General Saltzman, as the Chief of Space Operations, has presided over the largest budgetary plus-up in the short but storied history of the US Space Force. Most of that budget is going towards Space Superiority programs which will help re-tilt the scales in our favor in the event of a war that extends to, or starts in, space.

The supposition that the USSF must immediately buy-in, wholesale, to an extensive and complex re-engineering of the Space Force, and all its capabilities on-orbit or planned, to embrace DSO ...or therefore cede the high ground to China, is simply an exaggeration. DSO is a concept. It's a concept that has great merit and could change the way we deploy,



employ, and operate in space for the better. But its benefits are still theory. Its costs are significant. And there is no merit to immediacy in implementing it at the expense of other priorities.

Experts have made recommendations (inclusive of every space segment—from ground infrastructure to on-orbit systems) which are

founded on solid research and perspective, but are complicated, massively expensive, and beyond the realm of feasible without throwing out the entirety of USSF planning and programming for the next decade and beyond.

These recommendations aim to create a more resilient, flexible, and dynamic space architecture to maintain U.S. space superiority and deter adversaries. But the problem is this: none of these recommendations are bounded by fiscal constraints whatsoever. Nor do they account for cultural shifts required to foment a different way of thinking by our Guardians and interagency space professionals. And, perhaps most limiting, seeing this DSO “nirvana” reach fruition requires technologies and innovations which are not even on the drawing board yet. Space Superiority is THE prime imperative for the immediate future... and our space leaders have a plan to see it thorough. Doing a “crazy Ivan” right now, i.e. full court press on DSO, on our plan to secure the ultimate high ground is foolish and folly... especially without further study and robust wargaming and modeling & simulation.

As we have learned, DSO involve highly maneuverable satellites, rapid re-tasking, and resilient constellations reacting in real time to threats and opportunities. This creates complex, tightly coupled behaviors across orbits, sensors, networks, and decision-makers that are hard to reason about with static planning tools alone.

Space-focused wargames like the Schriever series let commanders and policymakers see second- and third-order effects of their decisions in a realistic but risk-free environment.

Wargames remain the only environment where the cascading effects of a maneuver, a jamming decision, or a defensive repositioning can be explored safely — and where concept becomes consequence. They help test future policies, rules of engagement, and coalition constructs for space conflict, then feed results into doctrine, force design, and acquisition priorities for dynamic operations. In these games, adjudication and scenario evolution show whether current concepts—such as rapid maneuver, cross-domain kill chains, or commercial integration—*actually* produce advantage or create new vulnerabilities. Because allies and industry often participate, wargames also expose interoperability and data-sharing gaps that are critical for multi-national dynamic space operations.

Moreover, high-fidelity M&S lets engineers and operators represent sensors, spacecraft, orbits, links, and adversary behaviors to test dynamic maneuvers and architectures that cannot be flown today. M&S supports requirement development, risk assessment, and performance trades for future maneuverable constellations, proliferated LEO, and rapid-attack/rapid-reconstitution concepts.



M&S also underpins decision-support tools: constructive simulations can rapidly generate outcomes for multiple courses of action, feeding commanders with insight on survivability, responsiveness, and collateral impacts of aggressive maneuvers or jamming. Synthetic data generated by simulations is increasingly used to train AI that can recognize and predict novel dynamic behaviors, such as frequent orbit changes or large constellation maneuvers.

Taken together, wargame and M&S, if used consistently and with rigor, can help us better understand where, at what pace, at what cost, and *how* DSO can be used to propel our national security space enterprise forward for space superiority. Modern space wargames increasingly integrate live players with constructive simulations, so human decisions drive the scenario while the simulation computes realistic orbital and network outcomes. This combination allows multi-layered exploration from strategic decisions down to tactical vignettes, which is essential for understanding dynamic operations across multiple orbits

and domains. Additionally, tools like the Space Wargaming Analysis Tool provide rapid scenario generation and execution, letting teams iterate through many dynamic concepts and courses of action in a short time. Insights from these integrated events can then be fed back into models to refine assumptions, improving both the realism of future games and the robustness of operational concepts for dynamic space operations.

To better use dynamic space operations in the future, wargames and M&S should be used to:

- Explore threshold conditions: When do maneuver, dispersion, or reconstitution meaningfully improve survivability or deterrence, and when do they just burn fuel or create collision risk?
- Test C2 concepts: How to delegate authority, automate responses, and integrate AI decision aids while staying within policy and coalition constraints.
- Co-design tech and TTPs: Use games and simulations early in the acquisition process so spacecraft design, ground systems, and tactics evolve together instead of in isolation.
- Stress-test coalition operations: Use combined wargames with partners to clarify data-sharing, authorities, and playbooks for joint dynamic maneuvers.

Used this way, wargames plus M&S turn dynamic space operations from a collection of ideas and capabilities into a coherent, tested operational approach that is technically feasible, tactically sound, and politically executable.

Achieving space superiority is the prime imperative because modern militaries, economies, and societies depend on space systems for communications, navigation, intelligence, and targeting; without control of this domain, all other forces become more vulnerable and less effective. Space is a warfighting domain where states must ensure their own freedom of action in orbit while being able to deny hostile use of space in a crisis or conflict.

Space superiority underpins the effectiveness of forces on land, at sea, in the air, and in cyberspace by protecting the satellites that provide positioning, timing, communications, and reconnaissance they rely on. U.S. doctrine describes it as a “*necessary precondition for Joint Force success*” because it “*allows military forces in all domains to operate at a time and place of their choosing without prohibitive interference from space or counterspace threats, while also denying the same to an adversary.*”

“[Space Superiority] *allows military forces in all domains to operate at a time and place of their choosing without prohibitive interference from space or counterspace threats, while also denying the same to an adversary.*”

Militaries increasingly assume uninterrupted access to space data; if an adversary can disrupt or destroy those assets, precision weapons, command and control, and global logistics all degrade sharply. The US Army, the most lethal ground force in history, believes that with space superiority, soldiers can “*deny, degrade, and disrupt the enemy’s ability to communicate, to shape, to influence, conduct surveillance, or to use their own precision guided munitions within the battlespace.*”

Strategically, controlling the space domain supports deterrence by signaling that attacking satellites will not deliver a decisive advantage and may be met with defensive and offensive countermeasures. A Space Force warfighting framework states that “*gained and*



maintained, [space superiority] unlocks superiority in other domains, fuels Coalition lethality, and fortifies troop survivability,” making it “the basis from which the Joint Force projects power, deters aggression, and secures the homeland.”

Senior leaders emphasize that space superiority is what distinguishes a warfighting space

service from a purely civil space agency. General Saltzman has called it the service’s “**prime imperative**,” defining it as the ability to defend US and allied assets in orbit while protecting forces in other domains from space-enabled attack, and stating that the force must be prepared to “*do whatever it takes*” in that domain if necessary. Space Superiority is the operational “North Star.” While DSO is an idea that has great merit and should be explored and implemented, it should be done so at a reasonable pace which does not distract us from our imperative!