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Introduction

“Space is a war-fighting domain,” […] “Ten years ago, I couldn’t say that.” […] “Broadly, from an operational concept, we are going to be ready to contest space” (Gen. Chance Saltzman, as cited in Clark, 2024, para. 8 and 40).

The adoption of the EU Strategic Compass for Security and Defence in May of 2022 embodied a “paradigm shift in the way the EU sees space and defence.” (Fiott, 2022, p. 26). Outer space, the eventual exploration frontier for humankind, has been, since it was possible, a target for military appropriation. The key difference in today’s military landscape, as opposed to ten or twenty years ago, is that existing technologies have allowed for outer space to become militarised in a more conventional sense.

The article will examine the current context of modern space weaponisation focusing on the category of military space-to-space systems. Notable developments in space-to-space technologies are redefining military warfare in space, contributing to its evolving character as an ‘operational warfare domain’. This article will also contend that the introduction of novel space-based capabilities, namely rendezvous and proximity operations (RPO) and weapons systems like manoeuvrable and reusable warfare-capable military space vehicles (MSVs), increasingly enhance military manoeuvrability and responsiveness in space. Accordingly, it is argued that the nature of the military domain in space is evolving to include active military infrastructures instead of generally passive ones. After briefly reviewing Chinese and Russian capabilities in space, the article will also look at current European projects in the fields of positioning, navigation and timing (PNT), space communications, space situational awareness (SSA) and missile interception, microsatellites and, more pertinently, space reactiveness and responsiveness. These demonstrate the concern for adversarial space-based weapons systems and the integration of infrastructure for the interception and mitigation of such threats. The conclusion is nonetheless unavoidable: space is now, for all intents and purposes, a battlefield.

1. Situational Context, Saturation of Space and Orbital Debris

Space is one of five military domains, with air, land, maritime, and cyber being the remaining four. While China identified space as an operational domain as early as 2015 (Erickson, 2024), NATO did not do so until 2019 (NATO, 2024). During the Cold War, concerns grew about the legal accountability of using space for military purposes (Tůma, 2024). The most notable legal document to serve this purpose is the Outer Space Treaty of 1967, prohibiting the stationing of weapons of mass destruction in outer space and the use of moon and celestial bodies for military purposes (United Nations Office for Outer Space Affairs, 1967).

However, it left a gap for everything in between, notably commercial enterprises (Alhamed et al., 2022). The Artemis Accords have also played a significant role in this regard (NASA, n.d.), although they are a US-led initiative and currently exclude countries such as China and Russia (U.S. Department of State, n.d.). The United States has declared and committed to a ban on Anti-satellite (ASAT) weapons testing (The White House, 2022) and the safe and responsible use of space. Nevertheless, it has reinforced its newest branch of the armed forces, the US Space Force (USSF) (United States Space Force, n.d.), along with the Space Development Agency, in response to Chinese and Russian developments but also posture in space. In April of 2024, for example, Russia decided to veto a UN Security Council resolution that would have reaffirmed all countries' positions to avoid an arms race in space and to refrain from placing nuclear weapons or other WMDs in outer space (Wood, 2024).

As of January 2025, there are more than 10,300 operational satellites in space (Cavalier, 2025); however, given the exponential growth of commercial use, projections point towards more than 60,000 satellites in orbit by 2030 (National Space Operations Centre, UK Space Agency, & Ministry of Defence, 2024). Given the dual use of many satellites and the classified nature of military space payloads, it is impossible to determine how many are military in nature and if the current statistics include all military satellites. Decades of irresponsible testing and exploration has created immense orbital trash and debris, including "an extraordinary 130 million objects between 1mm to 1cm", with additional numbers for larger object size brackets (Cacioni, 2022. para. 5). Weaponising debris makes it very hard to track the original perpetrator of the event, leaving the event in a legal 'limbo' (Blechová et al., 2024). In this sense, it is crucial to consider the potential weaponisation of orbital debris and the deliberate manipulation or redirection of orbital objects toward intended targets. Ion-Beam Shepherd satellites could function as a more mass-efficient solution by directing beams of plasma to manipulate objects' trajectories (Bombardelli et al., 2011). Orbital debris is one of many threats within the robust architecture of military systems that space assets face.

2. Military Space Environment: Space-to-Space, On-Orbit Refuelling, MSV's and Delta-V

The modern militarisation of space has led to new groundbreaking military technologies. Schumann (2023) classifies these technologies into three categories: Earth-to-space, space-to-Earth and space-to-space. Gleason and Hays (2020) further subdivide these into non-kinetic and kinetic types, which can either have a permanent or temporary effect. Although this article will not focus on the importance of ground-based space infrastructure and its strategic value is also highlighted.

Space-to-space systems use space-based assets, often integrated into satellites, and can incorporate most Earth-to-space systems, such as EW, cyber, and directed energy weapons. They can additionally include varying complexities and sizes of manoeuvrable space drones, including mission extension vehicles, cluster satellites whose use has recently evolved from just RPOs and formation flight to include stereo imaging (Erkec, 2022), nesting-doll, hunter-killer satellites, and space-based missile and projectile systems. Such technologies have already allowed for more conventional kinetic and non-kinetic warfare, as well as hands-on interference with space assets. However, new technologies, like reusable military space vehicles (MSVs), and developments in OSAM and on-orbit refuelling have allowed for more flexible, manoeuvrable and sustained military space operations.

Recent advancements in reusable MSVs, designed to launch from the ground and remain in space indefinitely, offer significantly greater manoeuvrability than traditional military satellites. However, drawing comparisons between the manoeuvrability of MSVs and that of military aircraft is impractical due to the fundamental differences between orbital mechanics and traditional aerodynamics. The more significant limitations have traditionally included Delta-v, which refers to the total change in velocity a spacecraft can achieve (European Space Agency, 2025), and the predetermined path and speed of all objects in orbit, traditionally elliptical or circular orbits (Egeli, 2021). These factors make it easier for adversaries to predict the movements of a given asset but they also make it so that the fastest route from point A to point B is hardly a straight line (Egeli, 2021). Changing a spacecraft's trajectory, performing orbit transitions or executing evasive manoeuvres requires immense energy or fuel, therefore the ability to refuel in orbit would drastically increase a spacecraft's Delta-v and its military strategic value, enhancing flexibility in more dynamic, complex military operations. The USSF has recently approved Orbit Fab's RAFT on-orbit refuelling port as one possible military platform (Sims, 2024). Similarly, China has recently successfully tested an in-orbit refuelling capability for beyond low Earth orbits with the Shijian 25 satellite launch on January 7th, 2025 (Zhuo, 2025).

The most pertinent examples of MSVs are China's Shenlong (and Tengyun) space plane (U.S. Department of Defense, 2024) and the US's X37B (Secretary of the Air Force Public Affairs, 2024), though the Russian Federation is also making new strides in this field (Reuters Staff, 2021). The key advantage of such vehicles lies in their reusability, which combines long orbital lifespans with manoeuvrability. In October 2024, the X-37B conducted a series of aerobraking manoeuvres to transition orbits while minimising fuel expenditure, showcasing the USSF's dedication to "expand our aptitude and ability to perform in this challenging domain" (Secretary of the Air Force Public Affairs, 2024, para. 5). A more manoeuvrable MSV in orbit supports sustained kinetic and non-kinetic operations in space, as these military vehicles can carry offensive weapons such as built-in EW systems, directed energy and cyber systems, extendable robotic arms, and projectile payloads.

Recently seen with Chinese MSVs, these can carry smaller payloads which they then deploy in orbit, like smaller space drones, space-to-space missiles or projectiles, or smaller military purpose-specific satellites (Engelking, 2024). These smaller payloads could include micro-satellites that can perform RPOs while maintaining proximity with the larger MSV. One of the benefits of such smaller systems is that they could hide under the larger craft's radar, electronic and optical shadow (Egeli, 2021). Deploying several space vehicles and smaller manoeuvrable assets offers the added advantage of efficiency. Having multiple weapons-capable, manoeuvrable space assets operating alongside MSVs enables the simultaneous targeting of multiple locations across the vast distances of outer space. This approach can overwhelm adversarial ISR, tracking, and interception capabilities, reducing reliance on an MSV for orbital transitions, even with the availability of on-orbit refuelling.

The US is pursuing this strategy through the SDA's Proliferated Warfighter Space Architecture (Satam, 2023), a path that both Russia and China also appear to be following (Hadley, 2024a). In May of 2024, Major General Gregory J. Gagnon stated that the number of adversarial manoeuvre alerts the USSF responded to had gone from around six or seven a month during the first stages of its creation in 2019 to around eleven thousand a month (Hadley, 2024b).

3. Recent Chinese and Russian Developments in Space

Russian and Chinese developments in space suggest rapid deployment and growing tactical complexity of military infrastructure for warfare in space, moving from a traditionally static approach to a more dynamic one. USSF Gen. David Thompson revealed in November 2021 "that the United States is dealing with 'reversible attacks' against its satellites from China and Russia 'every single day'" (Rogin, 2021, as cited in Berge & Hiim, 2024, p. 941). Although China and Russia are known to have strong ties in space military cooperation (Suess & Crawford, 2024), such cooperation is actively being deepened with Iran and North Korea as well (Hadley, 2024c). Major General Gagnon stated that China has experienced a 'strategic breakout' in space (Hadley, 2024d), given their pursuit of novel systems that will allow a more dynamic operational capability. The US Department of Defense claims China has "weaponized space and turned it into a warfighting domain" (DOD, 2020, as cited in Berge & Hiim, 2024, p. 942). Berge and Hiim (2024) explain that Chinese analysts concluded their counter-space capabilities must be able to target and, if necessary, destroy the US space-based infrared system (SBIRS) which is vital for early missile warning and tracking. They also emphasise the need to target the global positioning system. Neutralising SBIRS would allow a "nuclear second-strike capability" (Berge & Hiim, 2024, p. 942), while disrupting GPS would significantly impair Western allies' communication, positioning, and navigation systems—factors anticipated to play a crucial role in future warfare. These do not seem to be the only intended Chinese targets in space.

Manoeuvrable satellites and modern technologies like reusable MSVs have allowed the PRC to build a space capability for "inspecting, moving or damaging other satellites" (Honrada, 2024). Chinese Shijian 21 (SJ-21) and Shijian 23 satellites also exemplify new Chinese advances in the fields of OSAM (Burke, 2021). The dual-use nature of OSAM and RPO capabilities creates both strategic advantages and a legal state of limbo. As noted by the Secure World Foundation (2024, pg. 4): While certain on-orbit activities of satellites like the SJ-12 did not explicitly involve offensive actions, "the technologies they tested could be used for offensive purposes in the future". As Maj. Gen. Gregory Gagnon warned, Chinese build-up of infrastructure in space reflects "an architecture that's designed to go to war and sustain at war" (Gagnon, 2024, as cited in Hadley, 2024a, para. 12). An additional step in Chinese efforts for OSAM capabilities is highlighted recently with successful chip production (Chen, 2024a) as well as the ingredients for rocket fuel aboard their Tiangong Space station (Ling, 2025). China also currently leads in quantum communication, notably in space, launching the world's first quantum satellite, Micius (Yuan, 2016) recently establishing a quantum key distribution communications link with Russia (Swayne, 2024).

Further space initiatives also underscore major powers' plans to further operationalise space, including lunar stations and nuclear power plants (Suess & Crawford, 2024), and space-based solar power projects like China's solar station, ESA's SOLARIS and the US's SSSPIDR programme (Kehr, 2023). A significant Chinese development in space-to-space directed energy weapons systems is the converged high-powered microwave system which has already undergone military trials (Chen, 2024b). The system uses multiple microwave-emitting vehicles that converge their individual energy beams into a larger, singular beam, which can then be directed at a single target (Chen, 2024b).

Russia's 'nesting doll' satellite, which refers to the satellite's ability to host and deploy multiple smaller payloads stored inside, can be classified as a multi-payload or multi-capable space asset. One Russian nesting doll-type satellite released two sub-satellites, after which the third one deployed a projectile (Hadley & Gordon, 2024b). With enough power and velocity, such satellite-based ASAT projectiles could destroy a satellite upon impact (Clark, 2024). Additional payloads could include smaller space drones serving as mission extension vehicles, mobile autonomous radars and additional kinds of military weapons. Russia's Kosmos 2553 satellite is purportedly part of its nuclear programme, which could carry a nuclear payload. Such a payload could release an electromagnetic pulse or radiation, potentially knocking satellites out of orbit, similar to the effects observed during the US's

1962 Starfish Prime nuclear detonation in space (Chen & Singer, 2024). A notable technology that does not fit the space-to-space criteria but must be mentioned are fractional orbital bombardment systems (FOBS). Originally developed by the Soviets, and currently upgraded by China (Lewis, 2021), FOBS essentially place nuclear payloads in low Earth orbit with a rocket and re-enter to strike targets on the ground. China's contribution to this system includes introducing hypersonic glide vehicles (Gupta, 2023).

Russia's Kosmos 2558 satellite, which approached the classified US satellite-326 to within 75km, possesses similar 'inspecting' and RPO capabilities, though experts believe it may also have hunter-killer capabilities (Honrada, 2022). Furthermore, militaries are increasingly able to manoeuvre and perform RPOs within and around space debris fields with different space vehicles. Russian manoeuvres suggest military satellites can hide within debris fields to collect intelligence, launch jamming or spoofing attacks, and confuse enemy guidance and navigation systems (Honrada, 2022). These manoeuvre capabilities, alongside MSVs, nesting doll and hunter-killer satellites, weaponised debris, converged energy weapons and overall OSAM and RPO capabilities, contribute to what USSF Brig. Gen. Mastalir describes as a "paradigm-shift" in space warfare (Hadley & Gordon, 2024, para. 14). Increased bipolar military capabilities for manoeuvrability in space inevitably raises the potential for a 'dogfight in space' (Hadley & Gordon, 2024, para. 18). The continued integration of more robust military architectures in space undeniably heralds a modern arms race, with opposing military blocs strategically positioning themselves.

4. Painting the Picture: Europe Responds

European initiatives suggest the rise of rapidly evolving and complex military architectures in space, involving defensive and offensive systems from both allied and adversarial blocs. Projects like SAURON, INTEGRAL, ODIN'S EYE, DoSA, REACTS, SPRING, EPW, and TWISTER, to name a few, highlight Europe's serious commitment to protecting its space assets while preparing for ongoing kinetic and non-kinetic conflicts in outer space. The newly established European Space Information Sharing and Analysis Center (ISAC) will foster knowledge sharing between government, industry, and academia. At the 17th European Space Conference, a recurring theme was the need for European autonomy and independent access to space, particularly the capability of placing assets in space, which must also be considered.

EDIDP project SAURON (European Commission, 2020b), EDIDP project INTEGRAL (European Commission, 2020a), and EDF project ODIN'S EYE I&II (European Commission, 2022) function as space-based situational awareness platforms that will enhance European space-to-space sensor and radar networks, ISR platforms, space-based missile warning and overall space situational awareness. These will enhance the European Military Space Surveillance Awareness Network (EU-SSA-N) and the EU Space Surveillance & Tracking network (EU SST) (PESCO, 2022). Primarily defensive and dual-use, they focus on monitoring adversarial space assets and protecting European ones. Although the particulars of each project are understandably classified, the abstract description of their purpose highly implies a response to, as can be inferred, passive-tactical military architectures in space.

Notable European projects focusing on secure communications in space include the P2P-FSO platform-to-platform free space optical link and the RF shield projects, which aim to remove space link radio frequency interference (Fiott, 2022). The new European protected waveform, along with projects such as the defence satellite constellation IRIS²—incorporating quantum cryptography, the Q-Sing and QUANTAQUEST platforms for quantum-based inertial navigation and vector gravimetry will reduce European dependence on traditional GPS systems (Fiott, 2022) while enhancing resilience against jamming and spoofing. The new Galileo for EU defence system GEODE and the persistent space observation and surveillance system PEONEER will improve traditional GPS capabilities, to name a few.

Notable EDF projects include DoSA - Defense of Space Assets (European Defence Agency, 2021), which focuses on three main pillars: 'cross cutting space functions of training for space military operations', 'reactive access to space and in-space manoeuvrability' and 'space resilience'. Other important projects include REACTS - Responsive European Architecture for Space (European Defence Fund, 2022), whose goal is to provide a new 'network of Responsive Space systems', SPRING - Space Response to Risk & Integration with Ground Segment (European Defence Fund, 2021), and the European Bodyguard programme which will function as a 'bodyguard' platform for sensitive assets with defensive and offensive capabilities capable of detecting "weak-points of the threat satellite and counteract with a robot or laser" (European Commission, 2023a, p. 1). The NATO STARLIFT initiative will enhance allied responsiveness and reactiveness by creating new launch platforms for quickly deploying assets to space (Ministry of Defence, 2024). In addition, the PESCO project TWISTER (PESCO, 2019) focuses on hypersonic threats, integrating the sensor platform with endo-atmospheric mitigators, namely project HYDEF and HYDIS² (European Commission, 2023b). These combine to provide a reactive and responsive toolset that will allow for a more offensive or active posture in space. Again, although the particulars of each project are classified, their descriptions highly reflect active operational military architectures in space.

In response to growing adversarial threats in space, the US-led Operation Olympic Defender, a military alliance for cooperation in space, in addition to the work seen under NATO's Space Center of Excellence (Chapeaux, 2022), establishes a framework for "war-fighting in space", although, as of now, France and Germany are the only European countries involved (Hitchens, 2024, para. 1). These, more so than the passive-tactical, assume and understand space as an operational military domain with daily threats and the potential for kinetic/non-kinetic engagements.

Conclusion

The gamut of new Earth-to-space, space-to-Earth, but most importantly, space-to-space kinetic and non-kinetic weapons presents a new frontier in military space conduct. Current innovations in space-to-space military systems enable the implementation of a new framework of warfare in space. The flexibility, manoeuvrability and military value made possible by technologies like MSVs, multi-payload and hunter-killer satellites, but also OSAM, on-orbit refuelling, RPO and debris weaponisation capabilities, has changed the nature of military warfare in space. In addition, the complexity of military architectures in space, alongside their dual-use nature, creates an ever growing strategic-legal concern. The enhancement of infrastructural, logistical and operational capabilities in space realigns this domain with traditional warfighting, where flexibility, manoeuvrability and the capacity for sustained warfare are now a reality.As such, further EU integration into Operation Olympic Defender could prove beneficial. Equally advantageous would be an independent European MSV platform, which would greatly benefit from independent, reactive and autonomous European access to space and the leveraging of strategic collaboration with private industry.

European interoperability in space has never been so crucial, and examples like the EU Space ISAC show one potential avenue moving forward that attempts to further integrate government, industry and academia. But further practical action must ensue, and without enough legal accountability in place the challenge will be to do so with a stern moral compass. The analysis presented reveals not only that space is no longer just a military domain, but that it is an operational military environment in line with the traditional strategic, tactical and operational levels of war. As such, global militaries' recognition of space as a warfare domain, and the developments analysed in this article, signal that the capacities for engaging in more conventional conflict in outer space already exist and that major military powers like China, Russia, and the Western Allied-NATO bloc are actively positioning and preparing themselves for a potential war in outer space. It is therefore evident that space is undergoing an operational paradigm shift. In other words, space is now, for all intents and purposes, a battlefield.

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