IAC-25,A6,8-E9.1,1,x96007

The Space Triad – A Practical Space Operations Framework

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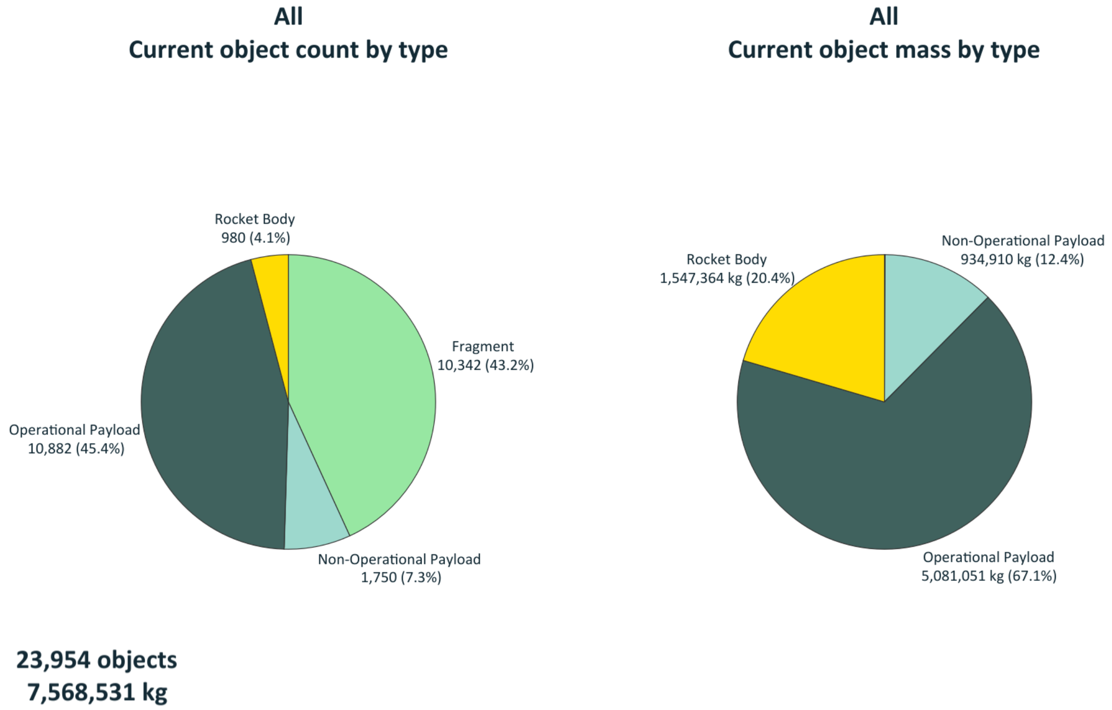
Abstract

Space security, space safety, and space sustainability are often treated as independent domains of the space operations assurance enterprise. There is a tight coupling between these areas that requires a thorough examination of use cases whereby ignoring these entanglements may put one's space operations at risk. Space safety focuses on short-term collision risk, often to operational satellites, as they attempt to conduct their missions. Many responsible behaviors for space traffic coordination are those needed to reduce tensions related to space security. Further, space sustainability focuses on long-term collision risk to all space objects and means to promote actions that reduce the possibility of deleterious growth of lethal debris. Reducing the growth of debris contributes not only to short-term space safety but, particularly when focusing on stopping deliberately-created debris, is a factor in mitigating the possibility of space conflict. Lastly, space security is a realm that is currently masked with lack of transparency for missions and behaviors of those space systems. More openness and discussions about capabilities that could be interpreted differently depending on the perception of the owner (e.g., the ability to grapple a space object can be seen as both a weapon and an enabler for cleaning up the debris environment) could reduce sparking events for space security. This, in turn, can enhance transparency of space activities that will in turn aid both space safety and space sustainability. Our hypothesis is that if you do not understand and appreciate the different perspectives of space operators you will likely make mistakes or get surprised; neither of those outcomes are good.

1. INTRODUCTION

There are currently over 90 countries operating satellites in Earth orbit. These spacefaring entities span the spectrum from university-led research cubesats to massive commercial constellations providing global connectivity and almost everything in between. This diversity of missions and diversity of space operations sophistication create natural tensions when interacting with others in space. As a result, there may be misperceptions of intent as everyone's actions do have some measurable effect on each other as the space commons is largely a persistent environment where remnants of previous missions linger for years to decades and possibly even for centuries.

Fig. 1 depicts the on-orbit population in low Earth orbit (LEO, i.e., average altitude below 2,000 km) which is the fastest growing region of Earth orbit due largely to deployment of constellations. However, the back story, often hidden by the ramp up of constellations, is the changing nature of these payloads and the massive derelicts left in their wake. Operational payload masses have more than halved in the last 25 years on average while the average derelict abandoned in LEO has increased about 35% in mass; this is largely due to the larger rocket bodies being abandoned in orbit. So, smaller operational objects and larger orbital debris are not intuitive trends to be happening simultaneously. This illustrates the complexity of understanding the emerging dynamics in LEO considering only simple bookkeeping of objects and object mass. The situation is further complicated when adding in the complex supply chains behind deployed assets, continuing explosions of hardware on orbit, and ever more complicated regulatory realities. As more and more countries see being "spacefaring" as a requirement for "first world" global status and an enabler for economic prosperity, the evolving regulatory, policy, and operational developments will have potentially massive effects on nation states. These rules and regulations will be complicated as the estimated global space economy is expected to approach $2T by 2035 [1]. Reliable, regular, and cost-effective access to space may be an enabler for addressing many terrestrial ills such as over-population, climate change, etc. to raise up all countries. A holistic framework of space operations is required to minimize accidental deleterious actions by international co-inhabitants of space and to inform all spacefaring entities about the utility of communications, cooperation, and collaboration that should contribute to responsible behavior in space.



	Before 2000	After 2000
Derelict Number	2,026	704
Derelict Mass	~1.6 Mkg	~0.9 Mkg
Average Derelict	~810 kg	~1,300 kg
Average Operational Payload Mass	~1,300 kg	~470 kg

Figure 1. The LEO space object population is now driven largely by operational payloads filling out large constellations, however, the overall demographics have changed drastically over the last 25 years. The pie charts represent the LEO space object population as of 1 June 2025 from LeoLabs.

2. MOTIVATION

Fig. 2 is provided as a strawman for a comprehensive, coherent, and compelling aperture into addressing potentially accidental detrimental actions between space operators that occur because of a lack of appreciation for this interconnected "space triad" of operations. Space security is focused on the protection of space assets that support military and national security objectives. The threats to space assets are both environmental and ~~human-based; they may~~ range from reversible disruptions of satellite operations to irreversible destruction of space assets. Space security concerns span activities from simple identification of space assets that might pose a threat to other adversarial systems to actual aggressive close approach and attack. As public research by one country details how they could "disrupt" the Starlink constellation through the use of "lasers, microwaves, and other operations" [2] it is clear that space security issues are starting to affect commercial space safety.

Space safety is assuring the reliable and safe operations of current satellites. This comprises multiple dimensions, including space traffic coordination (STC), space system reliability, anomaly resolution, radio frequency interference (RFI), cyber resiliency, fault tolerant design, etc. In the past, STC was solely providing Conjunction Data Messages (CDM) to operational spacecraft from orbital debris encounters. While this is still a large part of space safety, the rapid increase in operational satellites in LEO has made the cooperation and exchange of operator ephemeris and maneuver plans between operators (i.e., space traffic coordination, STC) a growing component of space safety.

Currently, there seems to be good coordination between a subset of constellations and single satellite operators but not between all. Part of this disparity is due to varying regulatory constructs worldwide but some of it is a more fundamental lack of trust between operators stemming from current poor diplomatic relations terrestrially.

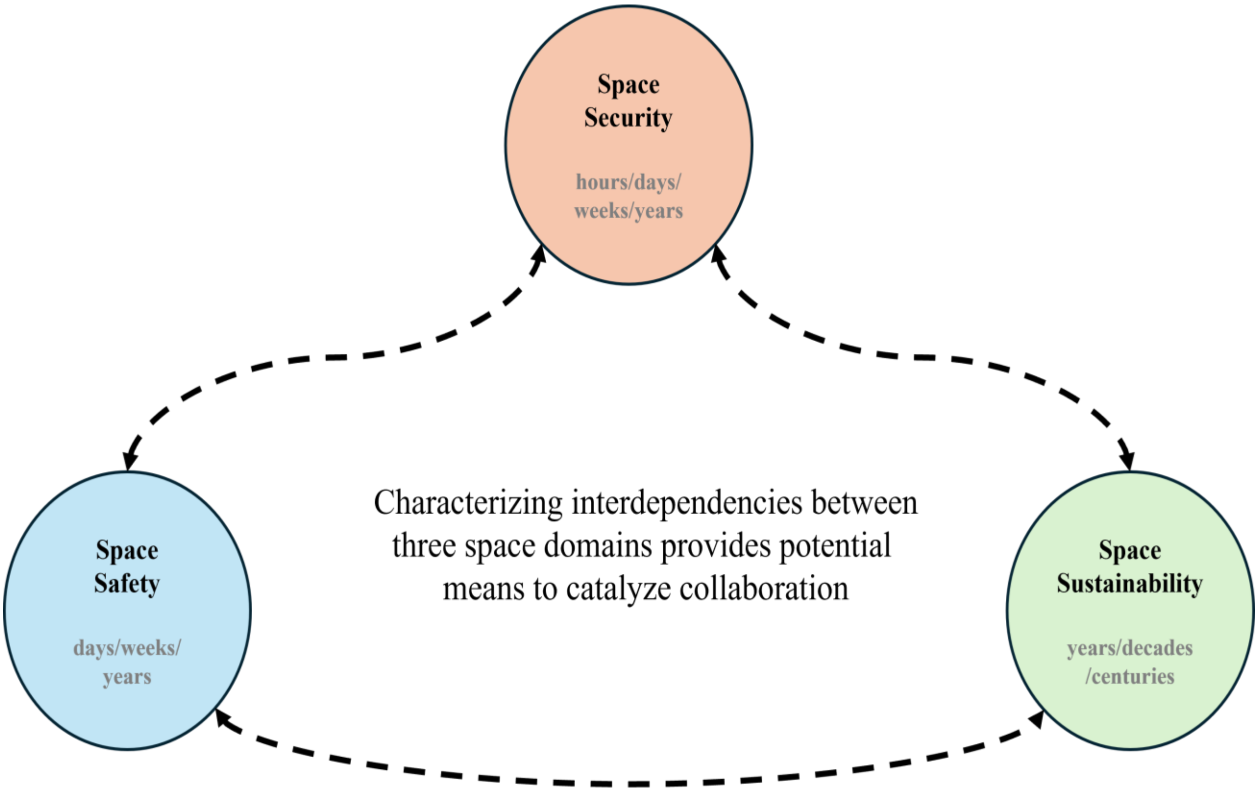


Figure 2. Space security, space safety, and space sustainability are intimately connected; if a spacefaring entity is unaware of potential linkages between these domains it may lead to increased political tension, degraded space operations reliability, and reduced economic growth globally.

Space sustainability principles strive to encourage behavior that will ensure long-term reliable space operations. These activities primarily fall into two major actions - do not create more debris (mitigation) and remove debris that is currently residing in Earth orbit (remediation). The timeline for space sustainability outcomes is often measured in years to decades and even centuries. Unfortunately, looking too far out into the future (e.g., centuries) may be counterproductive and may obscure true interdependencies with space safety. For example, current legacy guidelines for post mission disposal (PMD) remaining at 25 years puts many of the newly deployed constellations' safety at risk. Adherence to the 25-yr rule is clearly counter to sustainable space operations when it is understood that an intact object will have an orbital lifetime of 25 years if abandoned at ~615 km. Further, since many new constellations currently operate below this altitude, abandoning large numbers of massive derelicts to slowly filter through the largest constellations is unsafe long-term.

These three domains are not only different from an operational perspective, but they are also different from governance and economic perspectives. The diversity of timelines, regulations, and even culture for the international spacefaring community adds to the potential for difficulty in identifying and resolving cross-cutting issues represented in this space operations assurance triad.

3. SPACE OPERATIONS TRIAD

The interactions between the three areas of space safety, space sustainability, and space security will now be detailed separately. These two-dimensional insights and discussion will contribute to an appreciation for a holistic (i.e., integrates all three domains together) appreciation for space operations.

Further, while differences between these space domains are noteworthy to identify and address, there are key similarities. Each of these space domains are international in nature, have their origins dating back to the dawn of the space age, are rapidly changing, and require deliberate communication/collaboration to resolve issues.

3.1 Space Security - Space Sustainability

Actions taken to advance space security can impact space sustainability and vice versa. These interactions can be amplified or diminished by how a particular operation is conducted.

Case Study: Weapons testing in space may have long-term effects.

The most obvious example of a space security operation impacting space sustainability is the deliberate fragmentation of a space object. Three examples are the 2007 Chinese and 2021 Russian anti-satellite missile tests and the 2008 U.S. engagement of a hazardous reentering satellite. Each of these events was undertaken for security reasons; in the case of the Russian and Chinese activities, to test a direct-ascent anti-satellite missile, and in the case of the U.S. activity to protect people on Earth from hazardous chemicals onboard the reentering satellite. In each case, the engagement produced many fragments – debris which could have significant impacts on the sustainability of the outer space environment. The way these target satellites were engaged in each of these cases, however, significantly affected the impact on space sustainability. The Chinese test had the greatest impact on space sustainability. Because the test was conducted at a high altitude, over 68% of the over 3,500 fragments generated (i.e., 2,385 fragments) are still in orbit. Most of these will continue to pose a collision hazard across LEO for decades or even centuries. The Russian test had little impact on space sustainability but did have substantial short-term space safety effects (which will be discussed in the next section). Although it too generated over 1,800 fragments, the test was conducted at a lower altitude and, as a result, only six remain in orbit as of 1 June 2025. Finally, the U.S. engagement was conducted at the lowest altitude and with an engagement geometry designed specifically to reduce long-term orbital debris, resulting in no impact on space sustainability [3]. The longest any known fragments from this US test lingered in orbit was ~20 months.

Year	Country	Altitude	Fragments Generated	Fragments Still in Orbit
2007	China	~860 km	~3,500	2,385
2008	US	~250 km	~175	0
2021	Russia	~470 km	~1,800	6

An oft-cited example of the intersection between space security and space sustainability is the development, testing, and operation of on-orbit servicing and active debris removal spacecraft. Servicing a satellite or removing it from orbit requires technologies and techniques like capturing another satellite, deliberately modifying it, and potentially even changing its orientation and/or orbit. These kinds of space sustainability activities are essential because they can reduce the number of defunct objects on orbit, minimizing the possibility of a catastrophic collision and reducing crowding in the most useful orbits.

The same capabilities used for space sustainability missions, however, can also be used uncooperatively to harm a satellite by deliberately damaging an on-board component or modifying the satellite's operational profile so that it can no longer perform its intended mission. Satellite operators and nation states, therefore, have become concerned that a satellite whose stated mission is active debris removal or on-orbit servicing could be used as a space weapon thus creating a space security concern and raising tensions.

In the case of on-orbit servicing or active debris removal, transparency – or lack thereof – can lessen or raise space security concerns. Following industry best practices [4] such as sharing telemetry or video footage in real-time about the spacecraft's location and behavior can reduce the perception that a given on-orbit servicing mission is cover for something more nefarious. Furthermore, using on-orbit servicing technologies cooperatively is paramount to minimizing concerns.

For example, commercial company Astroscale conducted the ADRAS-J inspection mission [5] under contract with the Japanese government. The company undertook measures for safety and transparency based on Japanese government guidelines for spacecraft performing on-orbit servicing, shared video of its mission, and approached and gathered data on an approved target. This approach provided interested observers with confidence that the mission was being conducted cooperatively and not intended to hide a security purpose.

Indeed, the way technologies like ADR are used in operations has a significant impact on the extent to which a purported space sustainability activity could impact space security. This is true for any dual-use technology.

Additionally, when space security and space sustainability are broadly defined (i.e., having confidence that space operations can continue in perpetuity without interference) then in fact there is very little difference between space security and space sustainability. The long-term viability of space activities generally depends on individual operators believing that their satellites will be safe from harm whether that harm is accidental or purposeful. Very few operators will continue their space activities if space becomes so littered with debris or fraught with conflict that they lack confidence in their own mission. Therefore, space security and space sustainability are inextricably linked.

3.2 Space Safety - Space Security

Space safety and space security likewise can mutually reinforce each other or work against each other, depending on the actions taken.

A complicated space security environment can negatively affect space safety. We have seen this in the creation of debris from anti-satellite (ASAT) tests: of the sixteen ASAT tests that resulted in debris from the beginning of the Space Age to present time, 6851 pieces of trackable debris were created [6]. Of that, 2920 trackable pieces are still in orbit. It is also important to note that this is just the debris that we have been able to detect and track; there are undoubtedly fragments that are too small to detect but could have significant and deleterious impacts on spacecraft if they were to impact them.

Additionally, the debris from these ASAT tests are often kicked up to much higher orbits from the force of the impact. For example, the 2007 Chinese FY-1C ASAT test, which was conducted at an altitude of roughly 880 km, resulted in debris well over 3300 km [7]. The higher up the debris, the longer it takes to de-orbit, which means that it poses a spaceflight safety hazard for that much longer. Due to the physics of the space environment, any space actor – whether ally or adversary of the nation creating the debris – can be at risk from it.

More recently, for months after Russia's November 2021 ASAT test, which created over 1800 pieces of trackable debris, remote sensing satellites in Sun-synchronous orbit went through "squalls" where they had thousands of close approaches with debris from that test [8]. In August 2022, SpaceX' Starlink constellation had an event where those satellites had over 6000 close approaches to debris from Russia's test [9].

Rendez-vous and proximity operations (RPO) can also have long-terms effects on both space safety and security. The United States, China, and Russia have all conducted uncoordinated RPO activities near other countries' satellites; some of this may be being done to develop and enhance co-orbital counterspace capabilities, while some of it may be traced to intelligence gathering and general SSA capabilities. Noncooperative RPOs being undertaken for space security reasons can in turn affect space safety, particularly if any of the satellites being approached do not know they are being approached and maneuver in such a way that would increase collision risk.

Space security considerations also can shape how spaceflight safety actions are interpreted. For example, several times in 2021, a Starlink satellite operated near the Chinese space station such that the Chinese described in a December 2021 note verbale to the United Nations as "buzzing" it. The Chinese pointed out that, in one case, if the Chinese space station had not maneuvered, the Starlink satellite in question would have come within one kilometer of it [10].

The United States responded in its January 2022 note verbale to the United Nations that "Because the activities

Case Study: Short-term space safety effects from ASAT testing have been significant in LEO.

Tab. 2 depicts the significant short-term space safety hazard posed by the intentional destruction of the Cosmos 1408 spacecraft in 2021 despite the negligible long-term space sustainability effects reported earlier. The table summarizes the number of high probability of collision (PC) (i.e., PC > 1E-6) conjunctions from the fragment clouds of the Chinese and Russian ASAT tests for 2022, 2023, and 2024 in addition to the span of altitudes over which they occurred. It should be noted that most satellite operators will perform a risk reduction maneuver (RRM) if the PC of a conjunction exceeds 1E-4, but the most responsible operators are performing RRMs if PC exceeds 1E-6. Seeing the magnitude of the space safety effects over the three years after the Russian ASAT test highlights the need to scrutinize both space safety and space sustainability in relation to space security activities. The importance of the Fengyun 1C fragment cloud is clear with its 2022 effects worse than the worst year from the Cosmos 1408 fragment cloud (i.e., 2022 results). Note that there was no record of any high-PC conjunctions after the US low altitude destructive test and the two most energetic fragments only lingered for 20 months.

Table 2. Tally of high-PC conjunctions and span of altitudes for these events from Russian and Chinese ASAT tests in 2022, 2023, and 2024. For each year, the number of high-PC conjunctions and the altitude span over which they occurred are summarized for the last three full years.

ASAT Test	2022	2023	2024
Cosmos 1408 – Russia	#38,193	#4,645	#1,711
2021	272 km to 1,408 km	295 km to 1,230 km	289 km to 1,107 km
Feng-yun 1C – China	#43,240	#15,014	#9,874
2007	342 km to 2,213 km	328 km to 1,629 km	291 km to 1,446 km

did not meet the threshold of established emergency collision criteria, emergency notifications were not warranted in either case," and "If there had been a significant probability of collision involving the China Space Station, the United States would have provided a close approach notification directly to the designated Chinese point of contact." The complicated US-Chinese relationship on the ground and geopolitical rivalry in space no doubt affected how the actions were communicated and interpreted, and a case where greater cooperation and collaboration to ensure spaceflight safety could have had positive consequences on space security overall.

Even innocuous steps taken to improve space safety have the potential for unintended consequences for space security. For example, SSA data collecting and sharing is vital for supporting space safety by providing understanding of where an object is and what other objects it may conjunct with. SSA collection, however, used to be solely the provenance of state actors, and as such, states were able to keep the existence of extraordinarily sensitive national security assets more or less classified.

Now that SSA capabilities are proliferating globally, both in terms of the number of countries that can collect their own SSA observations and in the type of actors that can do so – that is to say, commercial SSA companies – this ability to keep certain kinds of satellites in the shadows is ebbing away. As well, actions and behaviors on orbit can be highlighted by commercial SSA providers, enabling verification of agreed-upon responsible behaviors at multilateral fora. It should be clear: this expansion of SSA data is in the end, a very good thing for spaceflight safety; it simply may also have effects on overall space security.

3.3 Space Safety - Space Sustainability

The connection between safety and sustainability is the most apparent one in the triad comprising the "space operations assurance enterprise." [11]. It is also the most acknowledged within the scientific literature for both general [12] and space-specific discussions. This connection is evident for operational, national, and international policymaking [11, 13-16]. Maintaining safety is in fact the first requirement to ensure the long-term sustainability of the space environment.

It is no coincidence that the largest portion of the UN Long-Term Sustainability (LTS) Guidelines (Guideline B.1-B.10) deals with the promotion of national and international practices and frameworks for mitigating the safety risks associated with the conduct of space activities so that their benefits can be sustained in the long run [17].

What differentiates the two pillars is mainly the time horizon and the configuration of interests of the actors involved. Specifically, safety is mostly concerned with short-term measures aimed at *preventing* specific outcomes through coordination, while sustainability is concerned with long-term measures aimed at *ensuring* outcomes that would not be accessible by individual

Case Study: Safety standards are key elements to attain space sustainability.

The LTS Guideline B.8 (Design and operation of space objects regardless of their physical and operational characteristics) recommends manufacturers and operators to design space objects "to implement applicable international and national space debris mitigation standards and/or guidelines to limit the long-term presence of space objects in protected regions of outer space after the end of their mission. This is also endorsed by the Space Safety Coalition (SSC). In its Best Practice 5, the SSC recommends designers "consider means to further improve the reliability of passivation functions, including the ability to complete passivation even after loss of command or loss of contact." As shown in Fig. 3, there is a strong consensus on the potential effectiveness and long-term benefits of these measures, if fully implemented.

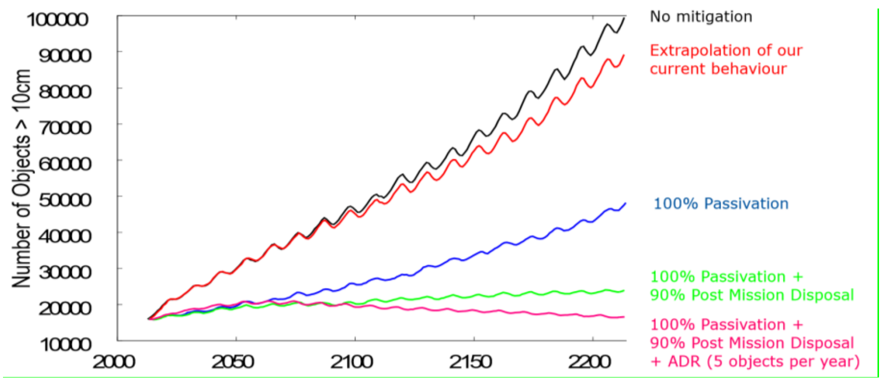


Figure 3: Effectiveness of spacecraft passivation and post-mission disposal (credit: Ref 15)

actors without cooperation mechanisms [18].

The two pillars, however, remain so closely interwoven that it is difficult to address one without affecting the other. A few examples suffice to illustrate how safety-oriented behavior (or lack thereof) can greatly support (or impair) long-term sustainability, and vice-versa. For example, performing a risk reduction maneuver in case of conjunction assessment is paramount not only to prevent possible damage, including the loss of critical functions or even the termination of a mission, but also to prevent the generation of new debris and minimize the risk of successive (and potentially cross-contaminating) break-ups events, which today represent a key source of debris. Placing any object in orbit that cannot take actions to avoid collisions with resident space objects reduces safety. Further, leaving massive derelicts at altitudes where they may linger for decades to centuries also adversely affects hopes for a sustainable space environment.

Over the years, several collisions between catalogued objects have been observed. In the case of the Cosmos 2251 and Iridium 33 collision in 2009, over 2300 fragments have been catalogued but less than 1,000 remain in orbit today. As reported by ESA in its annual space environment report, accidental collisions represent less than 1% of all past fragmentation events [19], however, fragments from these events comprise 31% of the on-orbit fragment population.

Similarly, adhering to safety standards and best practices such as the one put forward by the Inter-Agency Space Debris Coordination Committee (IADC) today continues to “remain the most effective method to reduce the long-term environmental impacts of global space activity by slowing the rate of growth of the space debris population observed” [13].Others have also recognized the nexus

Failure to adhere to safety standards and agreed-upon international guidelines is inevitably doomed to create an unsustainable operational environment. For instance, lack of adherence to post mission disposal thresholds can likely fuel long-term collision dynamics leading to future massive debris-generating collision events over the next decades.

Whereas the adoption of space debris mitigation practices at a global level has been gradually improving over the past five years, both ESA and the IADC have highlighted that compliance to the IADC space debris mitigation guidelines, “is still at a too low level to ensure a sustainable environment in the long run” [13].

According to the data presented in the 2025 IADC report to COPUOS, the combined compliance rate for non-naturally compliant satellites that reached end-of-life from 2017 onwards is estimated to be 60% [13].

The report also notes that with this current level of adoption of, and compliance to, IADC guidelines, the extrapolation of current space launch activity could lead to a doubling of the space debris population in less than 50 years [13] and a substantial increase in the number of catastrophic collisions.

Yet, even with a widespread adoption of the guidelines and recommendations, “environmental impacts cannot be removed completely, and additional steps should be taken, such as enabling the technology for active debris removal” [13].

If the long-term outlook of the space environment cannot be dissociated from the measures implemented in the short term, overlooking the requirements associated to sustainability-oriented behavior such as undertaking de-orbit or re-orbit through ADR can potentially harm short term space safety. The abandonment of massive derelicts in orbit can, for instance, pose direct collision hazards to operational satellites, as shown in Fig. 1. Accordingly, space safety miscues become more relevant as hurdles to space sustainability the more mass that is involved and the higher altitude where they occur.

4. OBSERVATIONS AND RECOMMENDATIONS

Discussions of the individual linkages of the space triad clearly demonstrate interlinkages across the triad as a whole. This interlinkage is nowadays increasingly acknowledged by scholars and policy makers alike. To illustrate, in 2020 the Journal of Space Safety Engineering introduced a new section, "Space Security, Safety, and Sustainability” with the aim to provide a platform for promoting scholarship analysing issues at the interface of the safety, security and sustainability of space activities [14].

Similarly, in Ref. 13, the concept of “space operations assurance enterprise” is discussed to show the relationships between these elements. “Space operations assurance addresses the three critical space operations aspects of security, safety, and sustainability. These issues are dependent on an underlying foundation of SSA capabilities, data, and information; in particular, space surveillance and tracking (SST). [13].

Additionally, in 2019 the European External Action Service (EEAS) launched a public diplomacy initiative called “3SOS,” which stands for Safety, Security and Sustainability of Space Activities, aimed at promoting discussions with industry, space agencies and think tanks to build a common understanding of the need for an

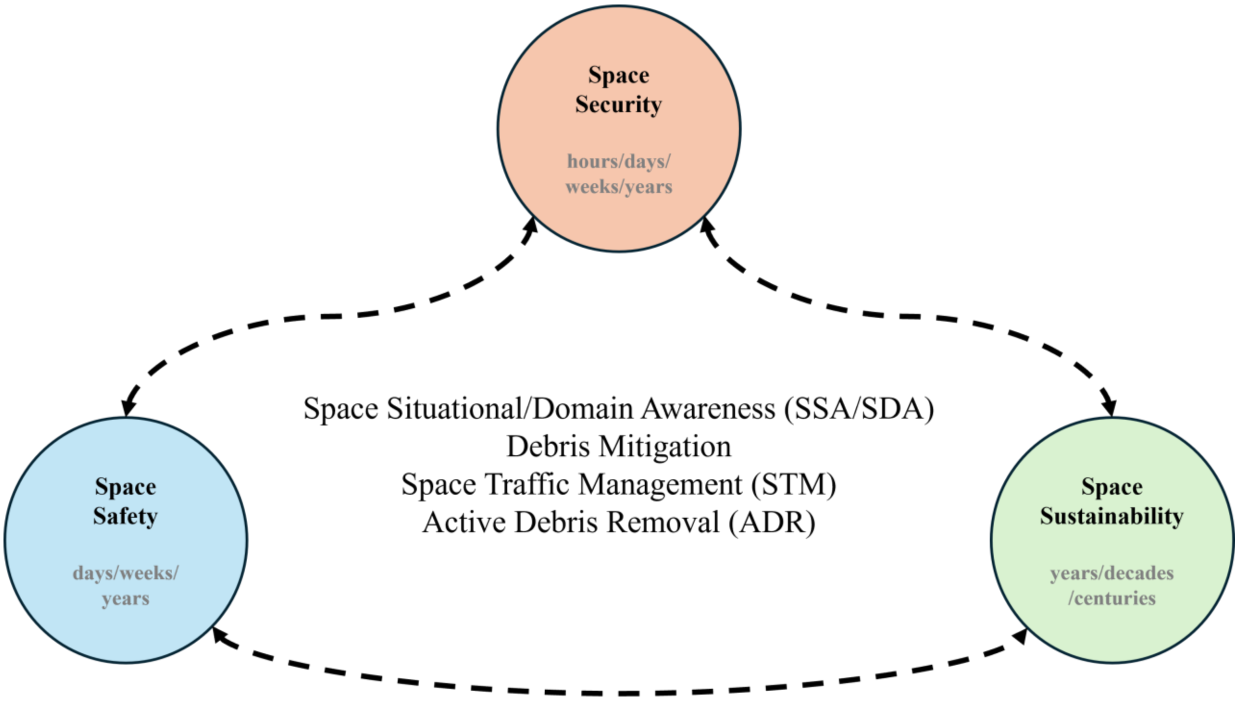


Figure 4. Four key activities (Space Traffic Management [STM], Debris Mitigation, Active Debris Removal [ADR], and Space Situational Awareness [SSA]) serve as the nexus for the space safety, space sustainability, and space security domains.

ethical conduct in space [20]. Irrespective of its ill-fated outcome, the initiative demonstrates awareness of the intimate relations between safety, security and sustainability and importance of addressing them holistically.

While the nexus amount the tree elements is already fairly acknowledged, the paper also shows that there are certain activities within the three domains of the triad that seem to be the glue that holds this holistic space operations framework together. Fig. 4 casts a new design of the space triad where the key activities in the middle cross all domains. These functions are Space Situational Awareness (SSA), Debris Mitigation, Space Traffic Management (STM), and Active Debris Removal (ADR).

Furthermore, the paper also demonstrates that how any of these activities is conducted can greatly impact the interlinkage between elements of the triad. Efforts to improve space security, for instance, can inadvertently pose harm to space safety and sustainability.

Having all operators adopt behaviours that factor in these interlinkages through shared norms and rules can help reduce unintended consequences.

Nonetheless, there remain challenges to driving operators to act in ways that reinforce positive interlinkages between all pillars. From examining the issues raised in this paper, it emerges that three key issues, if not managed properly, can result in divergence between operators: (1) time scales, (2) technologies, and (3) trust. These are depicted in Fig. 5.

Time Scales: The three space operations domains focus on distinctly different time scales. Space sustainability is the longest, on the order of decades to centuries, while space safety focuses on days to years. Space security actions may span years down to minutes. When different operators are thinking and acting at different rates and not taking into consideration how others may be thinking and acting, it is easy to forget how short-term actions may affect long-term objectives.

Technologies: Key enabling technologies are perceived differently throughout the different lenses of the three disparate space domains – resulting in different operator perceptions of impacts to the different pillars of the triad. For example, laser communications enable large data bandwidth and high reliability but may also imply an attempt to prevent being jammed. Further, RPO and grappling are critical to space sustainability to remove massive derelicts but may also be seen as a counterspace threat. Last, propulsive capability is necessary to maintain space safety to execute risk reduction maneuvers, however, a large deltaV capability could indicate a space object is a potential threat.

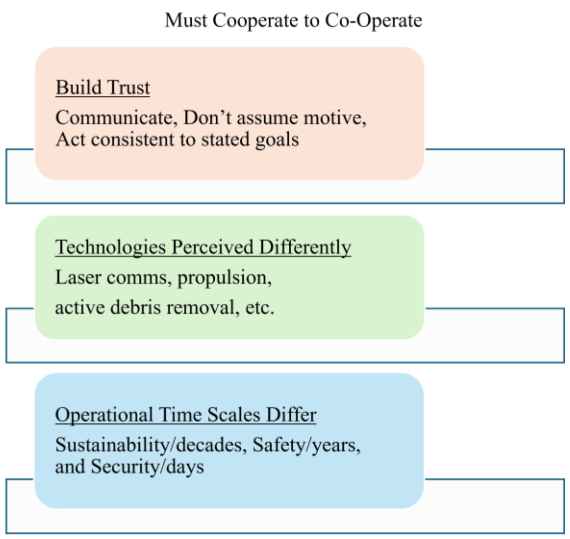


Figure 5. The strategic messaging for a holistic framework space operations can be summarized as being able to cooperate to co-operate.

Trust: Trust is a critical element in driving operators to act in ways that reinforce positive interlinkages between the three pillars. Trust, however, cannot be taken for granted. When assessing the actions of another space operator, whether there is inherent trust between the parties can affect their perceptions of the others' intentions.

The two factors that most critically hinder the necessary level of trust are:

- the dual-use and dual-purpose nature of space activities
- Rationality premised behaviour

Because the dual nature of the vast majority of space activities, determining intent is often impossible, and this compels worst-case assessments and security dilemmas. For instance, efforts aiming at space sustainability (e.g. testing of ADR technologies) can be easily interpreted as security-oriented efforts

Similarly, rationality can also undermine trust, as it inherently compels actors to depart from agreed upon norms and rules, at least in the areas of space security and sustainability. For instance, every single operator prefers that others contribute to sustainability while it contributes nothing. But if no one contributes, everyone is worse off. For this type of problems, it would be necessary not only to have a set of norms that all actors agree to, but also a mechanism for monitoring adherence, or at least building trust.

To overcome the above identified challenges, communication can be a good start if it involves a true frank discussion that identifies needs, desires, assumptions, objectives, etc. In addition, this discussion must be accompanied with the spirit of not assuming a motive for someone's actions and instead learn to ask why (maybe multiple times) to get to root values that will be useful in the future. This communication enables the cooperation that allows co-operation in space. Trust is manifested when an operator's actions are consistent with their stated objectives; this traceability is paramount to believability.

As an example of efforts to establish trust, OneWeb announced at the European Conference on Space Debris in Bonn, Germany in April 2025 that Chinese large constellations deploying to high-LEO around OneWeb had come to them to start to coordinate deploying activities with OneWeb operations [26]. This is a great positive step forward reinforcing the mantra that "we must cooperate to co-operate". As we see an increasing number of new actors and activities in space, it is correspondingly important that the nexus of space sustainability, safety, and security is well-understood to ensure that efforts to undertake each part of the triad also enhance the other two aspects of it.

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