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The space domain 2050:
Swedish security policy and the Swedish Armed Forces' operating environment

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In recent years, the realm of outer space has become increasingly important to several defence forces worldwide. The commercial use of space is also expanding. Despite this, there is limited literature within the futures studies research field that focuses solely on the space domain. There is also limited analysis exploring the relationship between the development of the space domain and Sweden's future security. The report *Swedish security policy and the Armed Forces' operating environment in the space domain 2050* is a first step in assessing what future space domain developments could mean for the Swedish Armed Forces. This summary presents the key trends identified in the report as critical to the space domain's evolution, along with the four scenarios developed based on these trends.

Each scenario is a separate vision of the future, and together they map a range of outcomes, wich should be viewed as possible futures. They may appear somewhat unlikely or even extreme, which is intentional. One of the purposes of using scenarios when exploring the future is to expand the reader's perspective and create a basis for discussion.

The study was carried out on behalf of the Swedish Armed Forces. Therefore, the report focuses on both security and defence policy, along with the future operating environment. This summary of the report starts with a brief overview of how the scenarios were created.[1] Then, the four scenarios are presented and analysed. Finally, Table 2 summarises the scenarios.

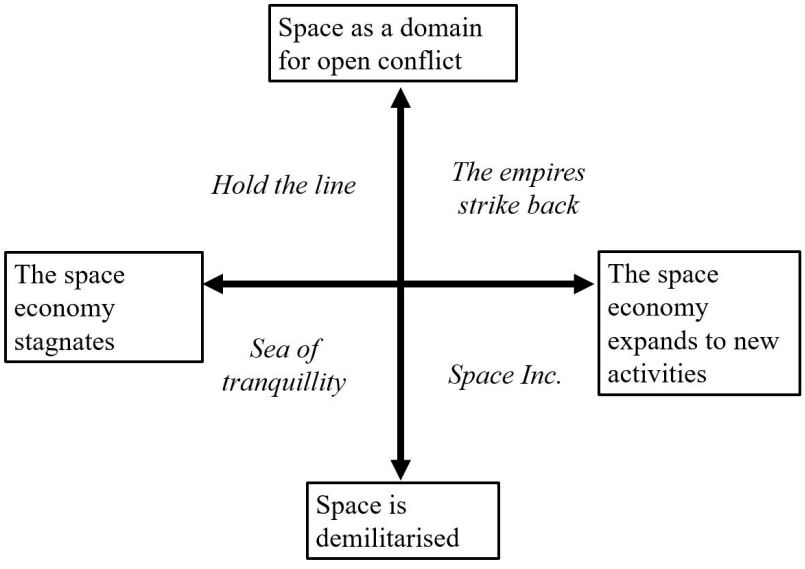

Figure 1. The scenario logic, which serves as the backbone of the scenarios.

1 For a more detailed description, see Karlsson, M., Johlander, A., Welsh, J., and Westman, J. Swedish security policy and the Armed Forces' operating environment in the space domain 2050. Stockholm: FOI, 2024.

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Table 1. Critical Uncertainties and Their Potential Development

Critical uncertainty	Potential developments of the trend
Warfare in space	• Space is a distinct domain for armed conflict • Orbital infrastructure as military targets • Satellites are replaceable • Anti-satellite weapons are present • Conflicts in space affect those on Earth and vice versa
Space as a distinct economic zone	• Space tourism • Raw materials extraction • Solar power generation • Human settlement • Issues arise concerning ownership and extraction rights • Conflicts emerge over strategically important locations in space
Human settlement	• Large-scale settlements with self-sufficiency • Limited settlement • Increased importance of situational awareness in space • Conflicts of interest between commercial, academic, and military actors • Armed conflict in space
Space-supported surveillance society	• Mass surveillance • Increased security on Earth • Societal mistrust toward the space sector • Satellites for detecting and predicting climate change
Increased environmental impact from space activities	• Limited exploration of space • Restrictions on launches • Regulatory requirements on technology • Increased costs
Space-based climate and energy solutions	• Space-based solar power • Alteration of atmospheres and surfaces of other planets to mimic Earth's • Regulation of Earth's climate by exploiting solar radiation.

The scenario development process

The scenarios were developed using a three-step process, which is common within strategic foresight.

Step 1: Trend collection

In the first step, trends were collected through a workshop that included experts, researchers, and defence-force personnel exploring the future space domain. These trends were then combined with those collected through a literature review.

Step 2: Scenario logic

The second step involved sorting the collected trends into background trends and critical uncertainties. A background trend is considered to have a very high impact on the studied area and has an outcome possible to envision. A critical uncertainty has a high impact, but there is uncertainty about how the trend's outcome will influence the space domain. Table 1 summarises the six identified critical uncertainties.

The scenarios were created with the help of nine background trends as well as the six critical uncertainties summarised above. Two critical uncertainties were selected to make up the scenario logic: *Warfare in space* and *Space as a distinct economic zone*. Two opposite developments within these uncertainties were identified, as seen in Figure 1.

Step 3: Analytical framework

In the final step, the report developed an analytical tool to understand how Swedish security and defence policy, as well as the operating environment, would take form in the scenarios. The tool is partly based on Håkan Edström and Jacob Westberg's military strategy model, focusing on several concepts: goals, which relates to survival, influence, and status; and means and methods, which can be defined into military, political, and economic categories.[2] This framework is adapted to encompass broader security policy considerations specific to the space domain. To understand how scenario developments relate to Swedish security policy goals in 2050, two guiding questions based on the concepts informed the scenario analysis:

2 Edström, H. and Westberg, J. The Military Strategy of Great Powers. Abingdon: Routledge, 2022; Edström, H., and Westberg, J. Comparative strategy—A new framework for analysis. Comparative Strategy, 42(1), 80–102, 2023.

1. *What security policy goals—survival, influence, and status—might emerge within the scenario?*
2. *What security policy methods and means—military, political, and economic—might emerge from the goals enabled by the scenario?*

In addition to analysing Sweden's future security policy in the space domain, the report also explores its eventual operating environment.[3] The scenarios were analysed based on three key aspects:

1. **Actors**, including institutions such as the UN or NATO, as well as state and non-state actors.
2. **Non-physical aspects**, which encompass culture and the virtual environment.
3. **Physical aspects**, which include infrastructure, climate, technology, geography, and the other domains of land, sea, air and cyber.

Based on these aspects, the operational environment was analysed in relation to the following questions:

1. *What actors might the Swedish Armed Forces need to consider in the scenario?*
2. *What non-physical aspects might the Swedish Armed Forces need to consider in the scenario?*
3. *What physical aspects might the Swedish Armed Forces need to consider in the scenario?*

Scenario 1: Hold the line

Scenario logic: space as a domain for open conflict and the space economy stagnates

- The space economy is stagnating and there are weak economic interests.
- There are geopolitical tensions on Earth and in space.
- Space is a distinctly military domain.
- There is low restraint in conflict and a high risk of escalation.

By 2050, global geopolitics have experienced further tensions and a steady deterioration in relations among the Great Powers. The proliferation of regional conflicts has worsened the diplomatic climate. With nearby powers exhibiting increasingly hostile and aggressive behaviour, regional security organisations have become more crucial for member states. Security cooperation between states in space closely follows pre-existing arrangements on Earth, as few states are willing to bear the cost of developing distinct arrangements for security cooperation or alliances exclusively for military activity in this domain. As a result, the credibility of and adherence to multilateral treaties concerning space, such as the Outer Space Treaty, have diminished and the treaties have consequently collapsed.

The international financial system has come under severe strain due to stalling economic growth and global instability. Volatility and risk have increased financing and insurance costs. As a result, only a few powerful states have been able to establish any presence in near-space. While the trend of decreasing launch costs has persisted, hopes for a burgeoning space economy have faded. As most commercial services in space have struggled to yield significant returns, business plans from the early 21st century have proven overoptimistic. Almost exclusively, the limited commercial space traffic remains focused on delivering replacement satellites to established constellations. Very few launches are necessary to sustain this kind of activity, and there is virtually no other commercial interest in expanding economic activity beyond the orbits currently in use.

The moderate pace for commercial launches has meant that most space industrial manufacturers and launch providers rely on subsidies to stay in business. Consequently, the interests of state actors dominate the space domain. Access to traditional military space functions, such as earth observation, satellite communications, and signals intelligence, is still essential. These services remain important despite declining demand and the stagnating space economy.

During a string of diplomatic crises in the 2030s and 40s, several public and private satellite systems were targeted in non-reversible hybrid attacks, most likely orchestrated by regional space powers. Since then, many space state powers consider themselves compelled to conduct recurring anti-satellite tests to deter any potential aggressors. Offensive and defensive space capabilities, such as ASAT missiles, direct-energy weapons, and manoeuvring satellites, are commonplace. It is considered almost inconceivable that the next great conflict on earth would not immediately involve the space domain.

Security and defence policy

In this scenario, Swedish security policy must address the looming risk that any military conflict on Earth could spill into space. There is a risk that the space domain becomes an active warfighting arena as soon as a terrestrial conflict breaks out. Sweden's military infrastructure

3 Swedish Armed Forces. Slutredovisning av Försvarsmaktens Perspektivstudie 2022; Development, Concepts and Doctrine Centre. Strategic Trends Programme: Future Operating Environment 2035, UK Ministry of Defence, 2014.

in space is highly vulnerable due to the tense situation characterised by unstable deterrence and an increased risk of escalation. At the same time, space systems are crucial for Sweden's military defence on Earth.

Sweden's security policy goals in space focus on securing infrastructure and maintaining already well-established arrangements for security cooperation. Since space is merely an arena for warfare, Sweden has limited interest or ability to act independently in the space domain. Instead, Sweden's security policy in space aligns with great-power interests and focuses on maintaining the same alliances and security providers on Earth as in space.

Sweden seeks to achieve its security policy objectives in space by deterring potential adversaries. Active participation in security alliances aims to bolster the credibility of Sweden's military capability, both for fellow alliance members and for external threats. At the same time, Sweden must uphold its obligations to these allies should a conflict spread from Earth to space.

Sweden's threshold for the use of force in space is tied to confrontations facing its security alliances. In a conflict situation, Sweden will utilise all available military means, which could be offensive or defensive depending on the requirements set by its alliances.

Sweden has little control over the development of its own space capabilities, as these are driven by the needs of its alliances rather than national preferences. As part of cooperative security arrangements, Sweden must complement other allied nations' space capabilities, which imposes specific and niche demands on Sweden's military space assets.

Diplomatic tools include bilateral relations with allied great powers, integration into allied systems, and other cooperative security arrangements. Another security-policy measure includes subsidisation of the Swedish space industry to ensure the military's ability to operate in the space domain.

The operating environment

The Swedish Armed Forces view space as a distinctly supporting domain, with increased militarisation leading to heightened demands for space situational awareness (SSA). The operating environment is dominated by alliances led by a few major and regional powers, with little room for non-state actors.

Since very few humans are in orbit, there is a culture of low restraint when it comes to armed conflict in space. As a state's interests are closely tied to its critical space infrastructure, which underpins military capability on Earth, attacks on a state's satellites elicit the same emotional response as attacks on a nation's ships or territory. Ground stations on Swedish soil are seen as military targets and constitute military interests.

Climate threats and space environmental issues, while significant, do not influence security policy considerations due to the heightened military-strategic tension. The removal of space debris has been militarised, as it is seen as a training opportunity for satellite manoeuvring.

Scenario 2: The empires strike back

Scenario logic: space as a domain for open conflict and the space economy expands to new activities

- Large commercial interests are active in and beyond Earth's orbit.
- States see the need to protect economic interests through military means.
- Space alliances form, differing from alliances on Earth.
- State and commercial interests are interwoven.

By 2050, economic activities in space has grown significantly, both in scale and scope. The activities have expanded to beyond the Earth-orbiting satellites. Profit-driven companies are starting to conduct asteroid mining and establish human presence on other celestial bodies, such as the Moon and Mars. The human presence in space is supporting commercial activities and government research initiatives.

Due to the rapid economic expansion in space, governments feel the need to protect their interests, leading to a strong military presence there. As a result, by 2050, commercial development is concentrated in nations that can credibly demonstrate military space capabilities or that are part of alliances with such capabilities. Given the varying capabilities and interests in space, these space-related alliances often differ from those formed on Earth.

This situation has resulted in a close intertwining of state and commercial interests. Governments provide police and military forces, which act as a deterrent to hostile actors, to protect commercial and state economic interests and physical commercial infrastructure in space. Space infrastructure situated near valuable resources or strategic locations becomes a major focus for protection. The establishment of such infrastructure can trigger escalating conflicts. The increasing risk of attacks on satellites and other space assets has increased the cost of insuring space operations, which deters smaller players from entering the market and further encourages the formation of alliances.

All of this space activity is made possible by lower launch costs, which, because of its complexity, however, remains concentrated among a few actors. This also contributes further to alliance formation to ensure continued access to space.

The large number of launches and re-entries of satellites is causing significant emissions at high altitudes in the atmosphere, the consequences of which remain unclear in 2050. However, for the time being, economic and military interests outweigh environmental concerns. There is a growing fear of irreversible consequences for life on earth, and the strong military presence in space has led to a negative public view of space activity in some parts of society.

Security and defence policy

Sweden's security policy goals are primarily focused on the need to protect both individuals and significant economic assets in space. The protection of Swedish citizens against threats in space is interlinked with commercial interests and international prestige. If commercial interests are threatened or attacked, there is a risk that armed conflict breaks out in space and then spreads to Earth. Sweden, therefore, in competition with other states, strives to secure continued use of space while also aiming to avoid escalating into armed conflict.

To achieve its security policy goals, Sweden seeks to form credible and distinct space alliances. These alliances do not necessarily reflect Earth-based alliances. Deterrence, often within the framework of these space alliances, is used as a military strategy to prevent escalation. Joint operational planning in space and collaboration on space infrastructure are examples of methods used to build and legitimise these alliances. Such infrastructure partnerships can provide security through a "tripwire" effect. However, since space alliances differ from Earth-bound ones, they tend to be less institutionalised, and diverging interests can hinder productive cooperation. This complicates Sweden's ability to increase its influence within these alliances. As a result, Sweden must maintain a broad range of military capabilities, both offensive and defensive. Close cooperation between the Swedish Armed Forces and major commercial actors is also a prerequisite for achieving these security policy goals.

The operating environment

Space alliances, which differ from those on Earth, create a highly complex operating environment for the Swedish Armed Forces. Space is no longer just a supporting domain but a primary arena for armed conflict. At the same time, unresolved issues remain, related to the large amounts of space debris driven by both military and commercial activities.

There are multiple state actors in space, operating within alliances. There is a significant presence of non-state actors, mostly comprised of a few larger companies, protected by state alliances. The presence of Swedish commercial actors and human habitats in space means that the operational environment requires both military and police activities. However, the economic values and human presence in space have a somewhat restraining effect on the use of violence, as any aggression would inevitably lead to escalation. While tensions are high, the shared deterrent capabilities appear stable for the time being.

On Earth, there is a growing negative perception of space activity in some parts of society. This, combined with an attractive and thriving private sector, complicates the Swedish Armed Forces' ability to recruit personnel for space operations.

Launch stations, ground stations, and strategically central space infrastructure become critical to defend, requiring defensive space capabilities. The operating environment also demands that situational awareness extends much farther into space than it does today.

Scenario 3: Space Inc.

Scenario logic: space is demilitarised and the space economy expands to new activities

- Major commercial interests dominate space.
- A few large transnational corporations dominate.
- Space is not seen as an arena for interstate warfare.
- Corporate espionage, sabotage, and terrorism are the main threats to space actors.

By 2050, the use of space is primarily characterised by large commercial interests, with major space companies and smaller private actors, rather than states, being the most important players. Space has become a well established domain for commercial activities, including space tourism, mining, and space-based manufacturing. Because of the enormous commercial value of the space economy, space has not developed into a domain for open warfare between states.

The space economy has expanded rapidly, driven by sharply falling launch costs and large private investments, making commercial players the dominant force in space.

Space tourism evolved in the 2030s from sub-orbital flights to Earth's orbit and eventually around the Moon. Small-scale attempts at mining rare metals from asteroids and manufacturing certain semiconductors in orbit proved highly successful, sparking increased commercial competition and rapid development in these areas.

Due to its enormous commercial significance, by 2050, space will have become a distinct economic zone with its own supporting activities. Autonomous and remotely controlled spacecraft handle most tasks in space, supported by a relatively large number of humans living and working in space stations orbiting the Earth and the Moon. There are mining bases on the Moon and a growing number of space tourists spend time in space.

A combination of the huge commercial stakes, heightened risk awareness, and the transnational ownership of many large space companies has led to space being seen as unsuitable for warfare in 2050. As a result, commercial space systems are generally not considered attractive targets in conflicts, even when they provide services to military users. Instead, corporate espionage, sabotage, and terrorism are the primary threats facing space actors.

The large number of satellites and space launches puts pressure on the environment, both in space and on Earth. Dealing with decommissioned satellites and space debris is increasingly seen as an economic interest. Furthermore, insurance companies are demanding that satellites are able to manoeuvre autonomously to avoid collisions. Emissions from space activities also threaten the Earth's environment and climate, but due to the immense economic interests, there is a risk that these emissions will remain unregulated.

Security and defence policy

Security policy objectives in space are constrained by and subordinate to the transnational space industry. Sweden's capacity and capabilities are entirely dependent on developments in the commercial sector, limiting the country's political freedom of action in space. The ability to influence or control the larger space companies enhances political influence, provides access to cutting-edge technologies, and generates international status. As a result, Swedish influence within the space industry becomes a national strategic interest. Sweden seeks to maintain the state's commercial interests in space companies rather than exercising independent control in the space domain.

The threats that arise in the space domain are closely tied to commercial interests and are primarily non-conventional. For example, space espionage, sabotage, andterrorism are common. Since states lack the capacity to independently address these threats, they are mostly managed by space companies themselves. Sweden limits its primary policy objectives to safeguarding the rights of its citizens and companies.

To gain influence in the space domain, Sweden aims to establish voluntary public-private partnerships between the Armed Forces and the transnational space industry. In certain areas, Sweden also seeks to influence the space industry through international regulations within various intergovernmental forums. Sweden does this by asserting the rights of its citizens and companies through formal diplomatic engagements with the states involved in those forums.

Since states are both dependent on and share the same interests as the transnational space industry, state use of force in space is considered impractical. Consequently, military means are not employed. The political tools available are limited and concentrate on increasing influence over the space industry, for instance through long-term contracts with military space-service providers. Sweden uses economic measures such as tax incentives and subsidies to entice transnational space companies to establish operations on its soil.

The operating environment

Non-state actors dominate the Swedish Armed Forces' space-operating environment. Large corporations play a more critical role than states, as the military relies on these companies for services. To protect their own economic interests from sabotage, espionage, and terrorism, commercial actors lead the monitoring and production of situational awareness in space for both civilian and military purposes. Additionally, space infrastructure is primarily civilian. Since the major companies are transnational, Sweden becomes reliant on commercial infrastructure located in other countries.

This dependency can negatively impact the availability of critical services and limit the ability to tailor technical solutions to the needs of the Armed Forces. Such dependencies may hinder interoperability and the integration of military services.

In space, the entangled economic interests of multiple actors have an inhibiting effect on the use of force. This entanglement has led to the emergence of new norms, which view the use of violence as taboo because it would result in significant costs and go against commercial interests.

Scenario 4: Sea of tranquillity

Scenario logic: space is demilitarised and the space economy stagnates

- Large amounts of space debris pose dangers.
- Strong international norms hold sway.
- Commercial interests in space have faded and development is limited.
- Space is a peaceful zone, with only limited supporting roles for the military.

By 2050, a significant space conflict has generated massive amounts of space debris, rendering certain orbits unusable. The war's devastation led to a broad international consensus on demilitarising space. As a result, the military presence in space is limited to supporting roles, with no offensive capabilities.

In contrast to the pre-war era, it is now considered unthinkable that conflicts on Earth would spread into space. The war underscored the importance of international norms, leading to the establishment of a new space treaty that is widely observed. States are cooperating in the development of additional treaties that can address potential problems that they may face in space.

Increasing environmental degradation has also limited space exploration. In the late 2030s, this led to the introduction of international regulations on emissions related to satellite launches and re-entries. Combined with heightened risks and insurance premiums due to space debris, commercial space activities have significantly declined. As a result, research and technological development in space are relatively constrained.

Activities in space now primarily revolve around research and the protection of the space environment within the framework of international cooperation. Much of the research conducted in space is state-funded, while civil interests drive development. The state-driven space research is motivated by diplomatic efforts and a desire for prestige.

A substantial portion of the work and development conducted in 2050 is related to addressing environmental and climate impacts both on Earth and in space. For example, there are major international projects to reduce space debris in orbit.

Security and Defence Policy

Sweden's main security policy objective is to maintain the established space order to avoid further armed conflict and minimise negative impacts on the space environment. Consequently, Swedish security policy focuses on preserving and advancing international norms in space. Additionally, Sweden views the restoration of the space environment through international cooperation as a critical goal. Since space is not perceived as a high-risk political domain, Sweden also seeks to use space cooperation to improve diplomatic relations on Earth. Peaceful relations in space could, therefore, intertwine with and contribute to resolving security policy issues on Earth.

To be a norm-setting player in space, Sweden works to shape the agenda within the international forums where space norms are established. Sweden also integrates environmental and peace issues into other space-related contexts to increase its influence in the domain. Furthermore, Sweden uses collaborative research projects in space to support both environmental goals in space and diplomatic goals on Earth. To achieve these objectives, Sweden leverages its membership in international organisations, committees, and research projects. Given the vast amount of space debris, maintaining sophisticated space situational awareness (SSA) is crucial for Sweden's continued presence in space.

The Operating Environment

The primary actors in the operating environment are states and regional and international intergovernmental organisations. These organisations are responsible for driving norm development, enforcing adherence to space treaties, and managing the limited space activities that are still taking place. Through these organisations, states uphold norms and foster cooperation while driving the modest levels of space activity.

The norm system in space is highly developed, and armed conflict in space is taboo. Therefore, it is unnecessary to protect satellites from destructive weapons, and maintaining offensive capabilities is irrelevant. The limited military activities in space focus on traditional support roles for other domains. However, space debris limits the available orbits, which affects the extent and quality of military support operations.

Space infrastructure and technological developments are confined to diplomatic and scientific projects, suchas the International Space Station (ISS). A prominent theme in space-related technological development and research is tackling space debris, though space is also used for climate research.

Overview of the Scenarios

Table 2 summarises the potential implications of each scenario for Swedish security policy, the means and methods used, and the physical and non-physical aspects of the operational environment in 2050. ■

Table 2. Summary of the four scenarios in relation to the analytical framework

Scenario	Hold the line	The empires strike back	Space Inc.	Sea of tranquility
How might Swedish space security policy be influenced by the conditions in the space domain in 2050?				
What security policy goals (survival, influence, and status) might emerge in the scenario?	Focusing on securing infrastructure through security cooperation. Limited freedom of action. Dependence on security partnerships restricts autonomy but enables increased capacity and capability. There is a significant risk that armed conflict on Earth will spread to space.	Focusing on protecting citizens and commercial interests. Avoiding escalation into armed conflict. Weak alliances mean limited ability to influence. Collaborations with large companies can enhance military capacity in the event of war. Increased risk that conflict in space will spill over to Earth.	Focusing on influencing space companies by being an attractive country for investment, but the ability to influence is limited. Space companies indirectly restrict autonomy.	Primary focus on status. Maintaining the existing space order.
What security policy methods and means (military, political, and economic) might emerge from the goals enabled by the scenario?	Deterrent method A niche military space capability based on the needs of security *cooperation.*	Weak space alliances for deterrence require a broad military space capability. Close collaboration with commercial actors.	Collaborations with companies. Economic measures to promote a positive business climate.	Political methods, e.g., agenda-setting and collaboration in international organisations.
What might the operational environment of the Swedish Armed Forces in the space domain look like in 2050?				
What actors might the Swedish Armed Forces need to consider in the scenario?	Alliances are the primary actors. No humans are in space.	State actors. A few large companies dominate the market These are protected by state alliances with different compositions than those on Earth. Humans are in space.	Large companies play an important role, or perhaps an even more important one than states. Human settlements in space.	International organisations. Other states. Few humans in space.
What non-physical aspects might the Swedish Armed Forces need to consider in the scenario?	Low threshold for the use of violence. Nationalism related to space.	Negative perception of space activities in parts of society.	Taboo against the use of force in space, as it can harm economic interests.	Taboo against the use of force in space. Norms regarding the use of space.
What physical aspects might the Swedish Armed Forces need to consider in the scenario	Space is a supporting domain. Ground stations considered as military targets and interests. Militarisation of space debris removal.	Space as a potential primary arena for armed conflict. Requirements for military and police presence. Infrastructure necessitates a defensive military presence. Space situational awareness is important. Large amounts of space debris.	Swedish dependence on space infrastructure in other countries. Technical dependence and need for interoperability with companies. Commercial interests are prioritised over preventing space debris.	Space as a limited supporting domain. Large amounts of space debris. Unusable orbits.

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