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Commercial Space Services for Military Use: Explaining Variation in Availability Across Mission Areas

PRACTICE-ORIENTED ARTICLES

JUUSO LIEKKILÄ
MARKO HÖYHTYÄ
*Author affiliations can be found in the back matter of this article

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ABSTRACT

While commercial space capabilities have become essential to military operations, their availability differs markedly across mission areas. Commercial providers offer launch services, satellite communications, and certain aspects of space-based intelligence. In contrast, governments retain control of capabilities such as positioning, navigation and timing, missile warning, and counterspace. These differences are typically described rather than explained. We show that they follow a structural logic: Availability rests on structural conditions that technological progress alone does not remove, serving to limit commercial provision. The article develops this argument through a framework that explains why the commercial availability of space services for military applications varies. Drawing on an integrative literature review and qualitative expert interviews, the study identifies four structural determinants that interact to shape availability: sovereignty criticality; market scalability; technological maturity; and governmental incentives. Applying this framework to major space mission areas reveals recurring patterns of high, hybrid, market-constrained, and security-constrained availability. Hybrid outcomes, where commercial provision coexists with sovereign control, represent stable structural equilibria rather than merely transitional phases. The categories themselves persist even as individual mission areas may move between them. Explaining the differences in commercial availability, the article provides an analytical tool for assessing where commercial services are available, especially for small- and medium-sized states. Rather than focusing on operational effectiveness or outsourcing risks, the study foregrounds availability as a key structural factor, framing subsequent analysis of dependency, vulnerability, and strategic consequences.

CORRESPONDING AUTHOR:
Juuso Liekkilä
Finnish National Defence University, Finland
juuso.liekkila@mil.fi

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INTRODUCTION

Commercial space capabilities have undergone a dramatic transformation over the past two decades. The emergence of so-called New Space actors, characterized by rapid innovation cycles, mass-produced small satellites, reusable launch vehicles, and private investment, has lowered barriers to entry in a domain historically dominated by major spacefaring states (Denis et al., 2020). As a result, armed forces increasingly rely on commercial providers for access to space-based services ranging from launch and ground-segment support to satellite communications and remote sensing.

This development has generated extensive academic and policy interest. Studies have addressed the benefits and risks of outsourcing military functions, the efficiency of market-driven capability development, the rise of dual-use technologies, and the changing relationship between government institutions and commercial actors.

Differences in availability are, however, striking. Commercial launch services, satellite communications, and some segments of remote sensing data products are accessible through global markets (Yonekura et al., 2022), while services such as missile warning, positioning, navigation and timing (PNT), and offensive space control are treated as core governmental functions rather than commercial service domains (U.S. Department of Defense, 2024).

While these patterns are well documented, the reasons behind them receive far less attention (Cunniffe et al., 2023; Kim et al., 2025; Yonekura et al., 2022). What is missing is a comparative and integrative explanation of why some mission areas commercialize early and extensively while others remain structurally resistant to market-based provision. The need is clearest in the middle ground, where sovereignty requirements and market conditions pull in opposite directions and provision settles into a stable division between commercial and state capability rather than moving toward either end. Although strategy documents such as the U.S. DoD Commercial Space Integration Strategy (U.S. Department of Defense, 2024) prescribe how commercial and government capabilities should be combined, they presuppose rather than explain the pattern of availability they respond to. We address this by asking: "Why does the commercial availability of space services for military use vary systematically across mission areas?" This division, we argue, is stable: It rests on conditions that technological progress alone does not alter.

Drawing on a literature review and expert interviews, we develop a framework that explains availability outcomes as the product of four interacting structural determinants: sovereignty criticality, market scalability, technological maturity, and governmental incentives. The framework explains these patterns as the results of determinant interactions rather than as isolated cases. The analysis focuses on the availability of commercially provided services delivering operational effects such as communications, positioning, situational awareness, and data-enabled decision-making, and not on ownership of the underlying infrastructure.

This article examines availability as a structural precondition for military use. It does not evaluate the effectiveness or risks of outsourcing; those questions are addressed separately (Liekkilä & Höyhtyä, 2026). By isolating availability as an analytically prior condition, the study provides a foundation for subsequent analysis of dependency and operational desirability. The aim is explanatory rather than predictive: The framework identifies structural conditions associated with different levels of availability rather than estimating future commercial availability.

The article is structured as follows. The next section provides the theoretical background by examining outsourcing in military contexts, the evolution of space markets, and the nature of dual-use technologies. The research design is then outlined, followed by the empirical findings and the development of the Availability Framework. The subsequent section discusses the implications for theory and military planning, and the final section concludes and proposes future research directions.

THEORETICAL BACKGROUND

The question of the growing military reliance on commercial space services intersects with broader debates on outsourcing, public–private partnerships, strategic autonomy, and dual-use technologies. Understanding variation in commercial availability therefore requires integrating insights from institutional, economic, technological, and strategic scholarship.

Traditionally, the armed forces of most states maintained direct control over their key capabilities, relying only marginally on contractors for tasks such as supply, maintenance, and logistics (Krahmann, 2010). Over time, economic pressures, organizational reforms, and the increasing complexity of military technology drove defense establishments to seek greater efficiency and specialization through outsourcing (Singer, 2008). Scholars have repeatedly highlighted that the motivations behind outsourcing are often pragmatic: cost savings, technological innovation, and the desire to focus scarce military resources on core warfighting functions (Cusumano, 2022). These drivers are obvious in technologically dynamic sectors where private industry can innovate at a pace beyond what is possible for state-owned industrial bases or traditional procurement systems (Singer, 2008).

However, the outsourcing literature also warns that such arrangements may entail substantial risks. When the military relies on commercial actors, its access to vital capabilities becomes dependent on the financial stability, corporate priorities, and political alignment of private firms (Wong et al., 2023). These concerns are amplified in the space sector, where assets are not only technologically complex but also highly exposed to geopolitical competition and global markets. Dependencies can create operational and strategic vulnerabilities with potential implications for national security (Defense Science Board, 2024; Kim et al., 2025). These arguments explain why states retain control over certain functions regardless of potential efficiency gains. The tension between efficiency and sovereignty, discussed in the outsourcing literature, thus becomes particularly acute in the context of space services.

To fully appreciate the continuing relevance of these concerns, it is necessary to consider the transformation of the global space industry over the past two decades. Historically, the space sector was dominated by a small number of spacefaring states operating through large, vertically integrated firms, where immense capital requirements, slow development cycles, and the strategic value of space capabilities limited participation (Ojala & Baber, 2024). However, the advent of what is commonly referred to as New Space has reshaped this landscape (Denis et al., 2020). Advances in miniaturization, cheaper manufacturing, reusable launch vehicles, and the rise of venture-capital funding have significantly lowered entry barriers for commercial actors (Bousedra, 2023). These developments have enabled commercial firms to provide capabilities that were previously the domain of states.

The dual-use nature of space technology adds further complexity (Langeland et al., 2026). Many space-based capabilities can support both civilian and military functions to varying degrees (Kim et al., 2025). In some cases, dual-use characteristics facilitate commercialization by widening the customer base and enabling economies of scale. Remote sensing satellites are a prime example: Data collected for environmental monitoring, agriculture, or insurance analytics can also support military intelligence, surveillance, and reconnaissance (Langeland et al., 2026). Due to the dual-use nature, the industry has been compelled to comply with export controls and other trade restrictions applied to space-related services and products (Rementeria, 2022).

Commercial space is becoming increasingly important in military conflicts, with growing potential to strengthen governments and armed forces, making its integration into security systems both ongoing and likely to expand further (Pražák, 2025). Private firms can justify the significant capital investment needed to deploy space-based infrastructure if they expect strong demand for the services, particularly if the technological components can be standardized or replicated across multiple satellites (Denis et al., 2020). However, commercial space capabilities cannot fully replace governmental systems as there will always be a need to maintain state-owned critical space infrastructure (Pražák, 2025). In contrast, markets struggle to develop where demand is almost exclusively governmental, highly specialized, or dependent on classified requirements (Cunniffe et al., 2023; Rementeria, 2022).

While these strands of literature offer important insights into outsourcing, market dynamics, and dual-use technologies, they do not fully explain why commercial availability varies so systematically across space mission areas. These mechanisms explain the extremes: Where demand is broad, markets develop, and where it is exclusively governmental, they do not. What remains missing is a framework that connects economic scalability, technological maturity, and sovereignty requirements to explain the space between these poles – where each mission area falls when the two pull in opposite directions. To address this gap, this article develops a

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framework that synthesizes the theoretical strands and applies them to evidence from interviews and the literature. Rather than proposing a general theory of state–market relations, the article advances a domain-specific explanatory framework tailored to military space services.

RESEARCH DESIGN AND METHODOLOGY

In this study, we adopt a qualitative, theory-building research design to explain systematic variation in the commercial availability of space services across mission areas. Given the exploratory nature of the research question and the absence of established theoretical frameworks addressing differences in the availability of military-relevant space services, the study combines an integrative literature review with qualitative expert interviews. The objective is not hypothesis testing or prediction, but analytical explanation through the identification of recurring structural patterns.

An integrative literature review was selected as the primary method for synthesizing existing knowledge. Integrative reviews allow the incorporation of diverse source types, which was essential because much of the most relevant knowledge on market structures, technological maturity, and defense-related space policy resides outside traditional academic journals. The review included academic literature, government and defense policy documents, think-tank reports, market analyses, and industry studies. Emphasis was placed on sources that assess commercial space capabilities across multiple mission areas. Rather than cataloguing capabilities descriptively, the review sought to identify recurring mechanisms, tensions, and boundary conditions that shape where commercial services emerge and where they remain constrained. The literature on commercial space availability is centered on U.S. markets, reflecting the disproportionate scale of the U.S. commercial space sector. While European and Asian markets are included where data exists, their coverage remains comparatively limited.

To complement the literature, we conducted 15 semi-structured interviews with professionals from the Finnish space sector, including representatives from industry, academia, government institutions, ministries, and the armed forces. The sample comprised six industry representatives, four from public administration and intergovernmental bodies, three from the defense administration and armed forces, and two from academia. The interviews were conducted in early 2025 typically lasting 45 to 90 minutes. They were conducted and analyzed in Finnish, and were documented through detailed notes subsequently reviewed by the interviewees, who confirmed that the key points had been recorded accurately.

The literature and the interviews served distinct analytical functions. The literature review provided the basis for assessing relative availability across mission areas (a global question requiring correspondingly broad sources) and informed the development of preliminary analytical categories. The interviews provided an explanatory logic: Respondents explained the observed availability in terms of the demand structure, sovereignty requirements, and costs, and these explanations guided the derivation of the determinants. Where interview assessments of availability itself are reported, they are treated as corroborating evidence alongside the literature rather than as authoritative market intelligence.

The analysis followed an abductive logic. Recurring factors explaining differences in availability were identified through iterative interpretation between the empirical material and existing literature and synthesized into the framework. The model did not emerge as an a priori theoretical construct but as the outcome of that process. In reporting interview material, a distinction is made between observations that recurred across respondents and those raised by individuals: Recurring observations are reported as patterns, while single observations are identified as such and treated as hypotheses rather than findings.

Several limitations must be acknowledged. The empirical basis of this study is primarily derived from Western commercial space markets. Although the interviewees were Finnish, national commercial provision covers only a small fraction of the services examined, so their assessments necessarily concerned the global market rather than a national one. The sample nonetheless reflects a small-state vantage point and is better suited to identifying mechanisms than to establishing the state of the market at any given moment. In states where commercial activity is structurally subordinated to state-owned enterprises or where market mechanisms operate differently, such as China or Russia, the determinants may manifest differently. In addition, the

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commercial space sector is evolving rapidly, and assessments of availability may shift over time as technologies mature or markets consolidate.

Another limitation lies in the study's high level of abstraction. Assessments are made at the mission-area level, and while the analysis identifies systematic variation within domains, it does not resolve it at the level of individual services. Capturing all such nuances would require more narrowly focused, mission-specific analyses that fall outside the scope of a single integrative article. As noted in the introduction, questions of operational integration, performance, and the desirability of outsourcing, pertaining to operational use rather than availability, fall outside this study.

RESULTS

The analysis reveals a highly structured hierarchy of commercial availability across mission areas. Commercial services are not distributed evenly, nor do differences reflect incremental variation along a single continuum. The analysis further indicates that availability evolves alongside developments in the commercial space sector.

The following section establishes the comparative empirical pattern that provides the evidentiary basis for deriving the determinants; it is not an exhaustive market survey. The subsequent two sections formalize these recurring patterns into the Availability Framework and then apply it across mission areas.

CURRENT AND FUTURE AVAILABILITY ACROSS MISSION AREAS

In this article, space mission areas are treated as doctrinally established functional categories commonly used in the context of military space. Remote sensing is not treated as a single mission area; rather, the article distinguishes among intelligence, surveillance and reconnaissance (ISR), missile warning, and environmental monitoring, all of which exhibit fundamentally different availability dynamics. This division is standard in military space doctrines (North Atlantic Treaty Organization, 2016; UK Ministry of Defence, 2022; United States Joint Chiefs of Staff, 2020).

Commercial availability was assessed against three qualitative indicators, derived inductively from the comparative material rather than imposed in advance and applied to services capable of meeting military requirements: (1) the presence of competing providers, such that a buyer can choose between alternatives instead of depending on a single source; (2) an operational service available to customers, not systems under deployment or in trial use; and (3) provision on standard commercial terms, meaning that the service is offered through ordinary contracts rather than depending on co-financing, anchor-customer commitments, joint development, or other bespoke arrangements (used as a qualitative judgment rather than a threshold). Together they capture the conditions under which a commercial market can be said to exist. The set was deliberately kept small, since the mission areas differ substantially in market structure and a larger number of criteria would have made comparison across them harder.

With indicators establishing whether a commercial market exists for a given military requirement, the assessment proceeds in two stages.

Where none of the indicators is met, availability is assessed as "none". Where some but not all are met – for instance, where providers exist but no operational service is available on standard commercial terms – availability is "low". Where all three are met, the assessment turns to how much of the mission area the market covers. It is "moderate" where commercial provision serves part of the requirements but leaves core military functions unserved, "high" where it covers most requirements, and "very high" where commercial provision covers the whole mission area, with sovereign capability retained for continuity rather than for functions the market cannot serve. Availability is assessed as a structural characteristic of the market, not a measure of service levels; capacity constraints such as lead times affect how readily a service can be obtained at a given moment but do not alter whether it is commercially available. Availability categories reflect relative comparisons, not an absolute threshold.

Projected availability and current availability are assessed differently. As the indicators cannot be applied to services that do not yet exist, forecasts are based on underlying factors: whether technological maturity is advancing, whether demand conditions are likely to sustain

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commercial provision, and whether sovereignty requirements constrain the mission area regardless of the other two factors. Projections are directional rather than predictive and are given as ranges where the evidence supports movement in either direction. Ranges extend downward as well as upward, since availability may decline if provider viability or public demand weakens. Projections refer to the near term – roughly the next five years. Longer horizons are not attempted as the pace of change in commercial space makes assessments beyond that speculative, and the sources on which the projections rest rarely specify longer timeframes.

Table 1 summarizes the assessments across mission areas.

Table 1 Summary of the Current Level of Commercial Availability of Space Services for Military Use and an Assessment of Future Availability, Assessed Against the Indicators Set Out Above.

Note. ENVMON = environmental monitoring; EO = electro-optical; GSaaS = ground stations as a service; HS = hyperspectral; ISR = intelligence, surveillance and reconnaissance; LEO = low Earth orbit; MW = missile warning; PNT = positioning, navigation and timing; RF = radio frequency; SAR = synthetic aperture radar; SATCOM = satellite communications; SSA = space situational awareness.

MISSION AREA	CURRENT COMMERCIAL AVAILABILITY	PROJECTED FUTURE AVAILABILITY	SUMMARY
Launch	Very high	Very high	Western states access orbit almost exclusively through commercial providers. Reusable vehicles and rideshare models have cut costs; constellation demand is growing, already visible in six-to-twelve-month lead times.
GSaaS	Moderate	Moderate–High	Commercial networks exceed national coverage, but availability concentrates on commercial frequency bands and fragmented national licensing constrains expansion. Cybersecurity, jurisdiction over data, and the need for an independent receiving capability keep part of the infrastructure sovereign.
SATCOM	High	High	Competitive market with a diverse supplier base; commercial capacity exceeds sovereign capacity in satellite numbers and throughput. Wideband well supplied, narrowband smaller but growing; protected SATCOM remains sovereign.
ISR	High	Moderate–High	EO is commercially mature and SAR increasingly available; HS and RF remain immature. Providers offer both raw data and value-added products. High-end intelligence and military-specific requirements stay sovereign, and provider viability depends on sustained government demand.
ENVMON	Low	Low–Moderate	Commercial supply covers 2 of 12 military requirement categories, with no fully commercial environmental monitoring constellation. High capital costs deter entry, and competition with free public data limits commercial demand. Growth depends on sustained state procurement.
SSA	Moderate	Moderate–High	Mature technologies and expanding provider networks support growth, but states retain the compilation of the overall picture and part of the sensor base. Free public data and dependence on government funding constrain the market.
PNT	Low	Low–Moderate	Core PNT remains state-provided. Commercial activity focuses on augmentation, and free public signals leave little room for paying demand. Whether LEO PNT will commercialize is contested.
MW	None	None	Customer base limited to military organizations; no commercial market has formed, and single-provider dependence would create unacceptable continuity risk.
Counterspace	None	None	Inherently tied to the use of force, with no civilian demand base. Constraints are political and legal rather than technological.

Space launch has transitioned into a vibrant commercial service market, with government and commercial customers increasingly drawn to launch-as-a-service offerings (Cunniffe et al., 2023). Reusable launch vehicles and rideshare models have significantly reduced costs and increased access to orbit (European Space Agency, 2024). Commercial launch has become the primary option for most payloads in Western countries (BryceTech, 2025); the U.S. military relies on commercial providers for all its launch requirements (United States Government Accountability Office, 2025). While public actors primarily drive demand for heavy- and super heavy-lift launch services, the private sector leads demand in the larger and faster-growing small- and medium-lift segments (Semanik & Crotty, 2023).

Interviewees described launch as the mission area that has moved furthest toward commercial provision, with several observing that Western states retain little launch capability outside the commercial market. Looking ahead, satellite numbers, driven by the deployment and replenishment of large low Earth orbit (LEO) constellations, are expected to increase (Organisation for Economic Co-operation and Development, 2023), which can in turn drive demand for launch services. Interviewees noted that this is already visible in lead times, with launch slots often booked six months to a year in advance. However, the literature also highlights uncertainty, as earlier projections regarding constellation deployment and market growth have not always materialized as anticipated (Cunniffe et al., 2023; Yonekura et al., 2022).

Ground stations as a service (GSaaS) offers extensive global coverage that surpasses the capabilities of purely national ground infrastructures, as commercial operators can establish stations without the intergovernmental agreements a state would require. Demand has been driven primarily by the expansion of commercial constellations, while government demand has acted as a secondary driver (Carcaillon & Bancquart, 2020). Availability remains largely concentrated in frequencies used by commercial satellites (Yonekura et al., 2022), so availability is high where services are standardized and support a broad user base, but with gaps persisting in those bands commonly required by military systems. From a military perspective, GSaaS usage is also limited by cybersecurity concerns (United States Government Accountability Office, 2023a).

Availability is further shaped by fragmented regulation and licensing: Ground-station operators must obtain national licenses in each country where they operate, and national security and geopolitical considerations may influence regulatory decisions (Rasila & Ojala, 2024). As providers expand to an internationally diverse client base, licensing burdens may intensify. Interviewees gave three reasons for retaining sovereign ground infrastructure: classified missions require it; states seek assurance that sensitive data remains under national control and jurisdiction; and several parties concluded independently that states need their own means of receiving data – at the very least as a backup system to commercial networks.

Looking ahead, GSaaS availability is likely to be shaped by the interaction between commercial scalability and sovereign control. While some providers appear increasingly interested in military customers, which could improve the availability of military-relevant services, continued financial uncertainty in the commercial remote sensing sector introduces demand-side risks for GSaaS, since both depend on the same constellation deployments (Yonekura et al., 2022).

Satellite communications (SATCOM) differs from most other space mission areas in that its commercialization began in the 1960s (Wong et al., 2023), driven from the outset by commercial investment and nongovernmental customers (Swope, 2026). It has evolved into a mature and competitive global market with a diverse supplier base and a broad range of customers (Yonekura et al., 2022). According to the U.S. armed forces' classification (United States Government Accountability Office, 2021), SATCOM is divided into narrowband, wideband, and protected systems operating in distinct frequency ranges. Narrowband supports secure voice and low-rate data, and its lower frequencies penetrate obstructions and resist weather attenuation (Gündüzhan & Brown, 2015). Wideband provides worldwide capacity for high-volume traffic and carries the bulk of high-priority communications (Office of the Chief Information Officer, 2023). Protected systems provide secure and assured communications under extreme conditions, including nuclear conflict (Wang et al., 2021).

Commercial capacity in this sector now surpasses state-maintained capabilities in many respects: There are significantly more commercial satellites than military ones in both geostationary and LEO orbits, and the capacity of commercial high-throughput satellites greatly exceeds that of military SATCOM (Wong et al., 2023). The global market is expected to continue growing steadily, but availability does not extend uniformly across all military requirements. Wideband services are the most robust, while narrowband services remain smaller (Kim et al., 2025), although satellite Internet of Things services are a significant driver of commercial narrowband development (Alves et al., 2024).

Protected SATCOM, by contrast, remains outside the scope of commercially viable services and continues to constitute a sovereign government capability (Cunniffe et al., 2023). Interviewees identified SATCOM – alongside launch operations – as one of the mission areas where commercialization is most advanced, and they expected this trend to continue; one respondent suggested that the situation may eventually be reversed, with military satellites

serving as a backup to commercial constellations. Commercial offerings thus cover the volume of military communications, with the protected tier remaining outside this scope. There is little indication in the literature or interviews that this division is changing at the strategic level.

ISR has expanded rapidly in the commercial domain, with a larger number of operating satellites, new market entrants, and significant private investment, and global remote-sensing revenues have roughly doubled over the past decade (Yonekura et al., 2022). Proliferating commercial LEO constellations provide a broad set of sensors, such as synthetic aperture radar (SAR), hyperspectral (HS) imaging, and emerging radio frequency (RF) tracking, that can be used for locating active radar and electronic warfare systems (Cunniffe et al., 2023). Availability varies significantly across these modalities: Electro-optical (EO) imaging is commercially mature and SAR increasingly available as small-satellite platforms have brought costs within commercial reach, whereas HS imaging and RF geolocation remain comparatively immature (Yonekura et al., 2022). Beyond raw data, many providers now offer value-added intelligence products enabled by advances in sensor performance and analytics (United States Government Accountability Office, 2022), and interviewees noted growing interest in pre-processed data, attributing it to the volume of imagery now available.

Commercial ISR is not seen as a replacement for bespoke high-end governmental systems but as an important part of the overall ISR architecture (Harrison & Strohmeyer, 2022); respondents named very high-end intelligence capabilities and requirements specific to military use as areas expected to remain governmental, with regulation limiting what commercial actors may provide. Despite strong growth, long-term availability is shaped by market fragility. Rapid evolution and past cycles of consolidation have demonstrated that provider viability depends heavily on stable demand (Wong et al., 2023). ISR markets emerging from traditionally governmental missions are particularly sensitive to government demand signals (Defense Science Board, 2024), and there are no signs of this dependence changing (Swope, 2026). Commercial ISR availability is expected to continue increasing, but growth in specialized or emerging modalities depends on sustained public-sector demand and the financial stability of providers (Bingen et al., 2024).

Environmental monitoring (ENVMON) covers the collection and analysis of atmospheric, terrestrial, and maritime data required for weather forecasting, space weather assessment, and broader environmental analysis. The U.S. armed forces have identified 12 distinct categories of weather-related requirements, encompassing data on cloud cover, wind conditions, soil moisture, ice conditions, and a range of other environmental variables (United States Air Force, 2016). The requirements of other armed forces can be assumed broadly similar, as such requirements reflect the operating environment rather than national doctrine. Commercial activity remains largely limited to value-added analytics based on publicly available environmental data and to global navigation satellite systems (GNSS) radio occultation services providing atmospheric and ionospheric profiling (Kim et al., 2025). Although the U.S. armed forces have contracted an experimental commercial mission to provide weather data (SSC Public Affairs, 2025), this fulfills only 2 of the 12 requirement categories, and no company currently offers a fully commercial environmental monitoring constellation (Cirac-Claveras, 2021). High capital expenditure requirements for deploying operational constellations limit private-sector entry, while customer demand uncertainty further weakens commercial viability (Borowitz, 2016).

Interviewees highlighted one further constraint, which is institutional rather than economic in nature: Environmental data is produced by established public institutions adhering to common standards, meaning the need is met through public service provision and no commercial demand consequently arises. Respondents also noted that armed forces typically receive weather information in processed form through these institutions rather than purchasing data directly. The commercial ENVMON market has remained stagnant and is strongly dependent on government funding (Kim et al., 2025). Absent sustained public investment, these constraints are unlikely to change, though there are indications that the U.S. government is considering long-term procurement of commercial weather data under substantial budgetary allocations (Werner, 2026), which could alter availability.

Space situational awareness (SSA) capabilities have commercialized rapidly, with companies operating globally distributed optical, radar, and passive RF sensors, as well as developing space-based non-Earth imaging (Duke et al., 2020). Commercial providers increasingly complement governmental SSA architectures with broader geographic coverage, diverse

sensors, and faster innovation cycles (United States Government Accountability Office, 2023b), and because commercial SSA relies on mature sensing technologies, technological risk is not expected to be a significant concern (Kim et al., 2025). Availability is nonetheless uneven across the SSA chain. At the sensor level, space surveillance radars are frequently employed not only for SSA but also as components of missile warning and missile defense systems (Lal et al., 2018), which ties part of the sensor base to functions that are not commercially provided. Governmental sensors are therefore expected to remain in operation even as commercial data sources expand (Yonekura et al., 2022).

Interviewees located the main boundary further along the chain: Individual elements can be outsourced, but states intend to retain the compilation of the overall picture. Consistent with this, commercial contributions have not been incorporated into all core governmental SSA tasks (United States Government Accountability Office, 2023b). Functions associated with military space battle management performed within military organizations include timely indications and warning, custody of potentially hostile objects, and detailed characterization of satellite capabilities (Yonekura et al., 2022). Market structure adds a further constraint.

Because orbital data and conjunction warnings are freely available from government sources, commercial firms must differentiate through higher fidelity or more tailored analytics (Young, 2021). The industry remains nascent and dependent on government demand, with several providers reporting that they cannot sustain current sensor networks without government funding (Kim et al., 2025). The direction of change depends on how far commercial sensor networks extend before the sovereign layer begins: Technological maturity and expanding provider networks support growth, while the fusion function and the shared sensor base set its limit.

Positioning, navigation, and timing (PNT) capabilities remain predominantly state-operated, with only minimal commercial availability. GNSS underpin not only military operations but also a wide range of critical civilian and infrastructural functions, including transportation, telecommunications, energy networks, and financial systems. Although several companies are pursuing PNT services through LEO PNT constellations, only one is operational, while others are only beginning to deploy their initial satellites (Rubinov, 2024); most commercial initiatives are oriented toward augmenting existing GNSS performance, in contrast to providing stand-alone alternatives (Kim et al., 2025).

Two factors constrain broader availability. Deploying and sustaining large PNT constellations requires substantial capital investment (Mayank et al., 2025). Demand also remains limited because several nations provision GNSS signals free of charge (Kim et al., 2025) – and this is not a coincidence; PNT, considered too critical to leave unprovided, is supplied by states without charge, so the commercial markets that depend on customers' willingness to pay are foreclosed. One interviewee illustrated the phenomenon using Galileo; its commercial service was ultimately offered free of charge because a paying customer base failed to materialize. LEO PNT nonetheless offers capabilities that GNSS does not, providing stronger signals from lower altitudes across a wider range of frequency bands, meaning it is less vulnerable to jamming and spoofing (Rubinov, 2024).

These systems are expected to expand over the next three to five years, and the integration of PNT into SATCOM mega-constellations such as Starlink, OneWeb, or Kuiper could disrupt the existing ecosystem (Rubinov, 2024). Respondents differed on how much this matters. Most assumed that the public PNT service would be maintained even if LEO PNT expanded, since such expansion would itself be driven by state actors. By contrast, one respondent argued that financial-sector dependence on satellite timing constitutes genuine commercial demand, and that LEO PNT will therefore commercialize. Either way, significant expansion of commercial PNT is likely to depend on sustained public-sector demand and investment (Wong et al., 2023).

Missile warning (MW) shows no meaningful sign of commercialization. U.S. policy treats missile warning as a government-primary mission (U.S. Department of Defense, 2024), and the U.S. Space Force has explicitly stated that it is not seeking commercial support for these capabilities (United States Space Force, 2024). In practice, space-based missile warning systems have been operated only by a very small number of the world's armed forces. Europe has traditionally relied on U.S. support rather than maintaining its own system, although Germany recently announced plans for a national space-based missile detection system (Hollinger et al., 2026).

Missile warning, by its nature, generates neither civilian nor commercial demand, limiting the potential customer base to military organizations. Governments have traditionally procured and owned space systems tailored to unique military requirements, particularly where sensitive technologies are involved and no viable commercial market exists (Harrison & Strohmeyer, 2022). Reliance on a single commercial provider would also create significant vulnerabilities in a mission area of this kind (Cunniffe et al., 2023). Respondents characterized missile warning as a niche capability with even less market pull than other constrained mission areas. While allowing that commercial technology might eventually contribute components without an emerging commercial service market, respondents expected missile warning to remain state-provided for the foreseeable future.

Counterspace, or offensive space control, includes actions and capabilities such as jamming, dazzling, cyber operations, and anti-satellite (ASAT) systems (Weeden & Samson, 2024). Even where dual-use technologies exist, commercialization is constrained by political, legal, and strategic considerations rather than by technological feasibility. U.S. policy treats counterspace as a government-primary mission (U.S. Department of Defense, 2024) and explicitly excludes it from current commercial acquisition (United States Space Force, 2024). Counterspace does not appear in the public assessments of commercial space service availability reviewed for this article, which suggests that the mission area is not treated as a plausible candidate for commercial provision. Because these capabilities are inherently tied to the use of force, they generate no civilian or commercial demand outside state military organizations. Together with policy that explicitly excludes them from commercial acquisition, this makes offensive counterspace capabilities likely to remain outside the commercially available services, at least in Western states – although, given that Russia has nonetheless demonstrated a willingness to leverage non-state and commercial actors in the cyber domain to conduct or support offensive operations (Sherman, 2025; Volāns et al., 2025), it cannot be excluded that offensive cyber operations targeting space systems may be commercialized or outsourced in non-Western states. This falls, however, outside the scope of this analysis.

On-orbit services were similarly excluded from this study. Although interest in commercial in-space servicing, assembly, and manufacturing has increased, current activity remains limited mainly to technology demonstrations and early pilot missions (Cunniffe et al., 2023; Kim et al., 2025; Yonekura et al., 2022). Given the low level of maturity, assessing their commercial availability in a manner comparable to more established mission areas would not have been analytically meaningful.

The current high demand for commercial space services, particularly in areas such as satellite communications and ISR, has been strongly shaped by the war in Ukraine. Once the conflict ends, demand may decline, capacity requirements may normalize, and market consolidation may follow as competition intensifies. This raises the possibility that some providers may not remain commercially viable in a post-war environment. While many assessments assume stable or growing availability, a market contraction cannot be ruled out.

Ordered by availability, as shown in Figure 1, the mission areas occupy the full range of the scale. The framework developed below explains why each falls where it does.

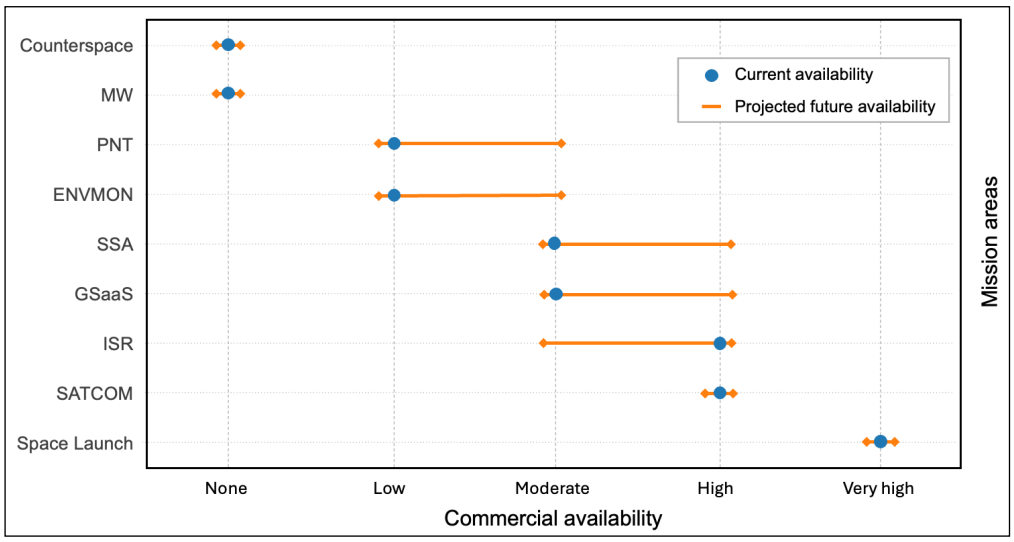


Figure 1 Current and Projected Commercial Availability Across Mission Areas.

Note. Ranges indicate uncertainty in projected availability and do not represent measured values. Ranges extend in both directions since availability may also decline.

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THE AVAILABILITY FRAMEWORK

The patterns identified in the preceding section, read against the mechanisms described in the Theoretical Background, show variation in commercial availability to be neither random nor mission-specific. A combination of market forces, technological developments, and strategic considerations shapes the availability of commercial space services. In this section, we conceptualize availability as the outcome of four determinants that operate in different ways. Sovereignty criticality and market scalability are the dimensions along which availability outcomes are distributed. Together, they define the space in which a mission area is located. Technological maturity conditions that space rather than forming part of it, determining what is commercially feasible at a given time and shifting positions as it advances. Governmental incentives operate on both dimensions rather than alongside them, influencing whether structural potential translates into actual provision. Distinguishing these roles matters analytically because it separates the conditions that locate a mission area from those that move it.

Sovereignty criticality

The term "sovereignty criticality" describes the degree to which a capability is essential to a state's strategic autonomy and the functioning of nationally vital systems. The higher the criticality, the less acceptable it becomes to rely on commercial provision, even when markets and technologies would support it. High-sovereignty functions span both military and civilian domains. The functions of strategic warning, secure command and control, classified intelligence, and core timing and navigation services underpinning transportation, telecommunications, financial systems, and emergency response must remain under state assurance: Commercial dependence could expose vulnerabilities or external leverage.

Sovereignty criticality does not necessarily require national ownership of the underlying infrastructure. Indeed, many states depend on foreign GNSS signals. What matters is who guarantees integrity, continuity, and prioritization under crisis conditions, not who operates the system. Capabilities with lower sovereignty criticality do not directly affect national decision-making or societal stability, allowing states to rely more extensively on commercial actors. Sovereignty criticality thus sets the upper bound of commercialization, regardless of market or technological conditions, functioning as a structural condition shaping whether a commercial market emerges at all rather than as a decision criterion for whether an existing service should be used.

Market scalability

"Market scalability" refers to the breadth, diversity, and stability of demand required to sustain competitive commercial provision. Markets scale when demand extends across multiple customer segments and remains stable enough to support investment and technological renewal. Such markets tend to develop competitive supply, global service reach, and stronger resilience to fluctuations in any single demand source. By contrast, mission areas that rely on narrow or predominantly governmental demand typically remain small, volatile, or dependent on single anchor customers, limiting opportunities for commercial entry and constraining technological and capacity growth. Scalability, therefore, enables high commercial availability but does not guarantee it; sovereignty requirements or technological constraints may still restrict commercial provision.

Technological maturity

"Technological maturity" refers to whether the underlying technologies are sufficiently reliable, standardized, and affordable for commercial actors to operate at scale. Below a certain level of maturity, commercial provision does not emerge, regardless of demand. On-orbit services were therefore excluded from this analysis because, where technologies remain at the demonstration stage, there is no commercial availability to assess. Once this threshold is crossed, maturity shifts mission areas' positions within the space defined by market scalability and sovereignty criticality. The rapid growth of small-satellite SAR illustrates this process: A once-specialized capability became commercially scalable as the underlying technologies matured.

Governmental incentives

Governmental incentives shape market scalability by signaling or withholding demand, subsidizing early providers, and creating predictable procurement environments. Authorization and licensing regimes also determine whether domestic commercial activity can emerge in the first place. They shape sovereignty criticality by regulating what commercial actors may provide in sensitive areas. Incentives also work indirectly through information asymmetry. Several interviewees emphasized that military requirements are difficult to articulate openly to industry because of security classification and institutional caution, leaving companies without a clear view of use cases, performance thresholds, or long-term demand. In capital-intensive segments, this uncertainty can suppress private investment even where commercial provision would be technically feasible. Policy therefore determines whether structural potential is realized, but it operates within the limits set by the dimensions of sovereignty criticality and market scalability. By itself, no level of state support can overcome sovereignty constraints where commercial provision is structurally precluded, just as restrictions may not eliminate markets sustained by strong scalability and technological maturity.

APPLYING THE AVAILABILITY FRAMEWORK ACROSS MISSION AREAS

Availability outcomes follow four recurring determinant configurations. These configurations explain both current patterns and plausible future trajectories:

- *Security-constrained availability* emerges when sovereignty criticality is high and market scalability is weak, ensuring capabilities remain sovereign even when technologies are mature.
- *Market-constrained availability* results from low sovereignty needs but insufficient demand to sustain private provision.
- *High commercial availability* appears where sovereignty demands are moderate, markets scale easily, and technologies are mature.
- *Hybrid availability* arises when determinants pull in different directions within a mission area, producing tiered markets: commercial at lower tiers and sovereign retention at higher tiers.

Figure 2 positions mission areas along the two dimensions that define the framework – sovereignty criticality and market scalability. Technological maturity and governmental incentives do not appear as axes – the former serves to condition the space in which mission areas are located, while the latter operates on both dimensions. Horizontal positioning reflects market scalability and the economic viability of commercial provision; vertical positioning reflects sovereignty criticality – that is, the extent to which a mission area requires assured national control.

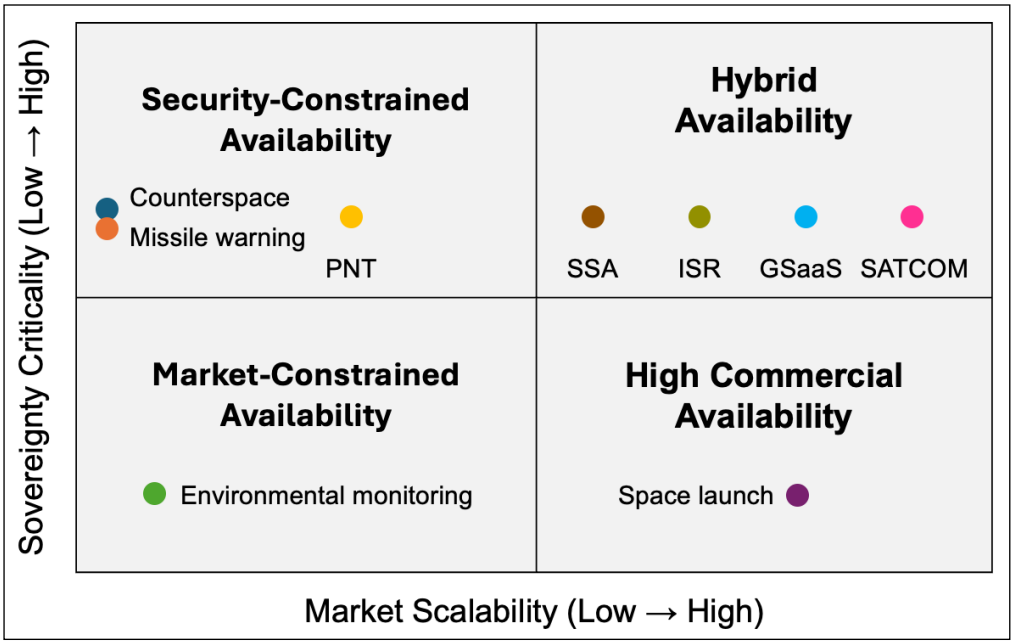


Figure 2 Commercial Availability Across Space Mission Areas According to Market Scalability and Sovereignty Criticality.

Missile warning and *counterspace* represent cases where the determinants align against commercialization: high sovereignty criticality, lack of scalable demand, restrictive policies, and limited incentives. Both are security-constrained cases.

PNT differs from the other security-constrained cases in how the constraint operates – while commercial provision is not precluded, sovereignty criticality suppresses the demand that would sustain it. Future commercial augmentation, such as LEO-based PNT constellations or satellite communications-enabled positioning, could eventually move PNT toward hybrid availability, with commercial provision alongside a sovereign core that remains state-operated because of its societal criticality.

ENVMON demonstrates that low sovereignty criticality does not guarantee commercial availability. Weak scalability, dependence on free public data, and limited demand constrain market formation despite mature technologies. ENVMON is therefore a market-constrained case: If availability increases, it will most likely result from sustained long-term public funding.

Launch exemplifies a case where all determinants align toward commercialization. Sovereignty criticality is comparatively low (arguably because launch is a discrete event rather than a continuous service, meaning dependence does not extend into operations), while market scalability is high, technologies are mature, and governmental incentives are supportive. These factors jointly explain its position in the high commercial availability configuration.

GSaaS is a hybrid case where the boundary runs through infrastructure rather than the service. Market scalability and technological maturity favor commercialization, and sovereign control is retained at specific high-security interfaces, not in the core service itself, allowing security risks to be mitigated through segmentation and access control. Fragmented national licensing further slows commercial expansion.

SATCOM is a hybrid case where exceptionally high scalability and technological maturity support extensive commercial provision in wideband (and increasingly in narrowband) services, while elevated sovereignty criticality preserves government control over protected communications.

ISR is likewise hybrid, although the boundary runs along the process rather than through the infrastructure. Commercial provision thrives at the data-collection and analytics layers due to scalable demand and mature technologies, whereas sovereignty criticality concentrates state control at tasking, fusion, and classified analytic functions.

SSA exhibits hybrid availability: scalable demand and mature technologies enable commercial sensing and analytics, while high sovereignty criticality preserves governmental control over high-end custody and characterization functions.

In each hybrid case, the boundary is drawn at a different point within the infrastructure, between service tiers, or along the processing chain. But the mechanism remains the same, with sovereignty criticality varying within, rather than across, the mission area. The four hybrids also differ in scalability: SATCOM rests on broad civilian demand, GSaaS on commercial constellation demand, while ISR and SSA remain anchored to public-sector customers and are correspondingly more exposed to shifts in government funding.

Figure 3 presents the conditional logic underlying these outcomes in simplified form; the sequence is analytical rather than temporal. The figure shows where commercial provision is structurally likely, hybridized, or constrained. It does not indicate whether commercial services should be used where they are available, which requires a complementary analysis of the advantages and disadvantages of relying on them.

Across the mission areas, no single determinant accounts for the pattern. High sovereignty criticality does not automatically prevent commercial involvement (as the use of commercial SATCOM in operationally important functions shows); nor does the position of a mission area remain fixed as technologies mature (as demonstrated by the rapid commercialization of SAR and EO smallsat constellations). Availability reflects, rather, how the determinants align – and that alignment shifts over time as technologies mature, markets evolve, and governmental incentives change. Moreover, the determinants are not independent of one another: PNT demonstrates how high sovereignty criticality can directly undermine market scalability by encouraging states to provide the service free of charge, which in turn eliminates the demand required by commercial providers. Technological maturity does not differentiate among the

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mission areas examined here, though it varies across modalities within them; its role is visible at the boundary of the analysis, not within it.

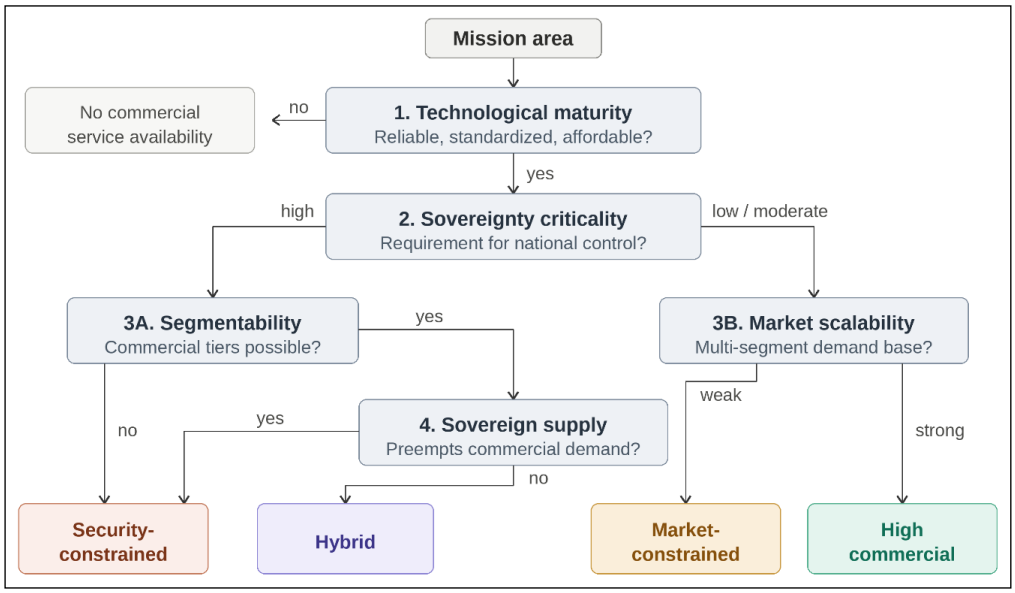


Figure 3 Conditional Pathways Shaping Commercial Availability Across Mission Areas.

The framework should not therefore be understood as a predictive causal model, but as a structural explanation that identifies the boundary conditions under which commercial markets can emerge. It explains availability as the outcome of interacting constraints that shape feasible state–market arrangements across mission areas.

One boundary is worth stating explicitly. Commercial availability determines how a capability is obtained, not how fast it develops. Where no commercial market exists, as in missile warning and counterspace, states procure from the same industrial base and operate the systems themselves, so development proceeds at the pace of public investment rather than that set by the market. Availability determines the acquisition mechanism, and with it the degree of control retained by the armed forces.

DISCUSSION

This section interprets the findings by situating commercial availability within broader debates on outsourcing, dual-use technologies, and the evolving role of private actors in security-critical space capabilities. These perspectives, while informative, overlook a more fundamental issue: Commercial availability is itself a structural condition that precedes and constrains military choice. Neither outsourcing nor dual-use dynamics alone can explain domain-specific patterns of commercialization; both implicitly assume the prior existence of a commercial provider base. The framework addresses this gap by conceptualizing availability as the outcome of four interacting determinants and showing that military choice is structurally constrained before questions of cost-effectiveness, operational performance, or resilience arise.

At the same time, availability is not independent of these operational considerations. Risk tolerance, performance requirements, and classification constraints feed back into the determinants themselves, especially sovereignty criticality and governmental incentives. High strategic or societal stakes elevate sovereignty demands, while stringent performance requirements or perceived risks limit state willingness to rely on commercial actors. Availability is thus analytically prior to, but empirically conditioned by, the security environment within which these determinants form. Availability assessments are also sensitive to timing: Short-term spikes in demand can create an exaggerated impression of market scalability without indicating a permanent structural change. This matters for how the framework is used: An availability assessment is a snapshot, and configurations built on demand that may not persist are more fragile than the assessment alone suggests.

Hybrid availability should not be understood as a transitional stage toward fully commercial provision. Respondents expected states to retain some degree of control even where commercial actors provide services, whether through ownership stakes or regulatory mechanisms. This

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reflects a structural constraint: As demonstrated above, sovereignty criticality varies within these mission areas, and with it the level of assurance required. Commercial offerings can therefore expand at tiers where assurance requirements are less stringent, but remain absent where requirements are too demanding to be met by commercial provision. As technologies mature, the scope of commercially available services may expand to include capabilities that were previously beyond commercial reach. However, market growth alone cannot eliminate the need for state involvement, because differences in sovereignty criticality, and the associated assurance requirements, persist.

The boundary can be set by the nature of the requirements themselves or, where states aim to preserve tasking authority, protected interfaces, or custody functions, by explicit policy. In both cases the underlying reason is the same: Hybrid structures are enduring equilibria rather than instances of incomplete commercialization.

The findings indicate that the structural boundaries within which military planning takes place are defined by availability. Availability indicates what can be accessed through markets, what requires sovereign or allied solutions, and where hybrid arrangements are plausible. Three further implications warrant discussion here.

First, availability defines the feasible options that shape planning assumptions. In mission areas with high availability – launch services and wideband SATCOM, for example – militaries can credibly plan for routine commercial access. In structurally sovereign areas such as missile warning and counterspace, commercial substitution is not viable, and sovereign or allied solutions remain the only realistic pathways, regardless of policy preference or budgetary pressure.

Second, availability necessitates differentiated integration models. Hybrid availability domains require architectures in which commercial and sovereign capabilities coexist. Commercial services can augment capacity, responsiveness, or geographic coverage, but they cannot displace sovereign control over critical interfaces. This implies a need for planning concepts and procurement mechanisms that accommodate tiered availability rather than assuming uniform commercial provision.

Third, availability shapes strategic specialization, especially for small and medium-sized states. Where commercial availability is high, such states can access advanced space capabilities without incurring the prohibitive costs of sovereign provision. Conversely, where availability is structurally constrained, these states must rely on alliances or limited sovereign capabilities, as commercial substitutes are unlikely to emerge. The asymmetry is sharpest in hybrid areas: States with substantial sovereign capability can retain critical tiers, whereas smaller states may depend on allied provision above the commercial tier. The framework, therefore, clarifies which capability areas lend themselves to market-based access and which require political or military cooperation.

With regard to capability planning, the implication across all three is the same: Where the structural conditions are absent, expectations of future commercialization are unlikely to be met regardless of technological progress; where they are present, availability may develop faster than procurement cycles anticipate.

CONCLUSIONS

In this article, we examined why the commercial availability of space services for military use varies systematically across mission areas, and the structural conditions determining where markets emerge, scale, and persist, and where they do not.

The findings demonstrate commercial availability to be patterned rather than incidental, a phenomenon shaped by the interaction of four structural determinants: sovereignty criticality; market scalability; technological maturity; and governmental incentives. Where these determinants align across the service chain, commercial markets flourish; where alignment is partial, hybrid availability emerges; and where sovereignty demands dominate or markets fail to scale, availability remains predominantly governmental.

Commercialization in military space is therefore neither inevitable nor universally applicable; it is structurally bounded. Hybrid outcomes are not transitional but stable, because the variation

in assurance requirements that produces them does not diminish as markets mature. The configurations themselves are similarly durable: Individual mission areas may move between them, but the conditions that define them do not dissolve.

The consequences are sharpest for small and medium-sized states, for which sovereign alternatives are often not realistic. Policymakers who treat commercialization as a universal trend risk overestimating market depth in sensitive domains, while those who assume sovereign self-sufficiency to be attainable risk planning for options that do not exist. Planning must therefore begin from an assessment of where markets exist, where they scale, and where dependence is unavoidable.

The framework is offered as an analytical proposition rather than a validated model. Its value lies partly in the questions it makes testable. Whether publicly funded infrastructure crowds out commercial development can be examined against the trajectory of the EU's publicly co-funded IRIS² secure connectivity program and comparable programs; one respondent raised this possibility, though the present data cannot assess it. And whether a mission area can migrate between configurations as market conditions change is testable in PNT, where respondents were divided: Most expected core services to remain public, while one argued that financial-sector dependence on satellite timing may generate genuine commercial demand in LEO.

If full sovereignty is unattainable, the central question becomes how dependence can be governed rather than eliminated. Future research could therefore examine how states respond to structural availability through procurement strategies, provider diversification, alliance-based access, and regulatory mechanisms, and how they incorporate such constraints into doctrine. Reframing the question in this way moves the debate from whether commercialization is occurring to how structurally constrained states can navigate it.

DATA ACCESSIBILITY STATEMENT

The interview material underlying this study is not publicly available. Participants were assured that their responses would be reported in anonymized form. The literature on which the analysis draws is listed in the references.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR AFFILIATIONS

Juuso Liekkilä orcid.org/0009-0002-0709-3038
Finnish National Defence University, Finland
Marko Höyhtyä orcid.org/0000-0001-9088-1566
VTT Technical Research Centre of Finland, Finland

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