Hosted Satellite Payloads

NATO's Strategic Pathway to Space Resilience

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Introduction

Acting alone in the space arena is difficult and may not always be the best strategy for nations. Space is a costly domain to operate in, and requires significant investments in research, development, and operational resources. Additionally, the vast expanse of space presents numerous opportunities for international collaboration and joint defence, especially within alliances like NATO.

Through cooperative efforts in space, NATO member countries can combine their resources, knowledge, and capabilities to strengthen their collective defence posture. Space collaboration encompasses a range of activities, including satellite communications, early warning systems, navigation, and ISR.

NATO member states can enhance their presence in the space domain through *hosted payloads*. The term hosted payloads refers to using available capacity on satellites by allies, partner nations, or companies to accommodate additional transponders, instruments, or other equipment.[1] Hosted payloads provide additional resources, resilience, and contingency capabilities, enhancing the robustness of NATO's space assets by diversifying NATO members' space-based capabilities.

This article provides a concise overview of hosted payloads, the benefits and drawbacks associated with this concept, the role they play in enhancing resilience and deterrence, and offers recommendations for NATO countries to pursue collaborative space initiatives.

The Evolution of Hosted Payloads

A satellite bus, also known as a spacecraft bus or satellite platform, constitutes the fundamental and standardized structural framework for a satellite. It encompasses and supports the critical systems and subsystems required for the satellite's operational functionality. Concurrently, the payload, customized to fulfil the satellite's precise mission objectives, is integrated onto the bus.

Hosted payloads, also referred as *satellite-as-a-service, hitchhiking,* or *piggybacking,* are becoming more appealing for space missions. The idea is to share the spacecraft bus platform with other payloads and still achieve mission success.[2] This timely solution clearly supports the concept of collaboration and collective defence in space. Such an approach enables multiple NATO nations or entities to distribute the costs and advantages associated with space missions, capitalizing on pre-existing infrastructure and reducing overall cost.

Examples of Hosted Payloads

The following examples illustrate the diverse approaches to the concept of hosted payloads and highlight the different strategies adopted by various stakeholders.

US-Norway: The US and Norway have a partnership in which Enhanced Polar Systems-Recapitalization (EPS-R) Flight One and Flight Two payloads are scheduled to launch in 2024 onboard two Arctic Satellite Broadband Mission (ASBM) space vehicles on a dual launch from Vandenberg Space Force Base, California. EPS-R is an Extremely High Frequency (EHF) MILSATCOM system designed to extend EPS services into the early/mid-2030s. Its mission serves to provide 24/7 protected satellite communications for US polar forces operating in the Arctic region. This marks a historic collaboration between Norway and the US Department of Defense (DoD) on a hosted payload where the US is entrusting a Norwegian bus to support strategic missions.[3]

Government/Commercial: Government and commercial partnerships for hosted payload initiatives are becoming increasingly popular. Notable examples include:

- Skynet 5, a United Kingdom (UK) government/commercial enterprise communications satellite that also provides bandwidth for critical NATO missions involving ISR.[4]
- The collaboration between Intelsat and the Australian Ministry of Defence (MoD), which launched 22 telecommunications satellites to extend internet routing into space.[5]

Two of the EPS-R satellites built through the cooperation of the US and Norway go through testing at the Northrop Grumman facility prior to their launch on 15 August 2024.

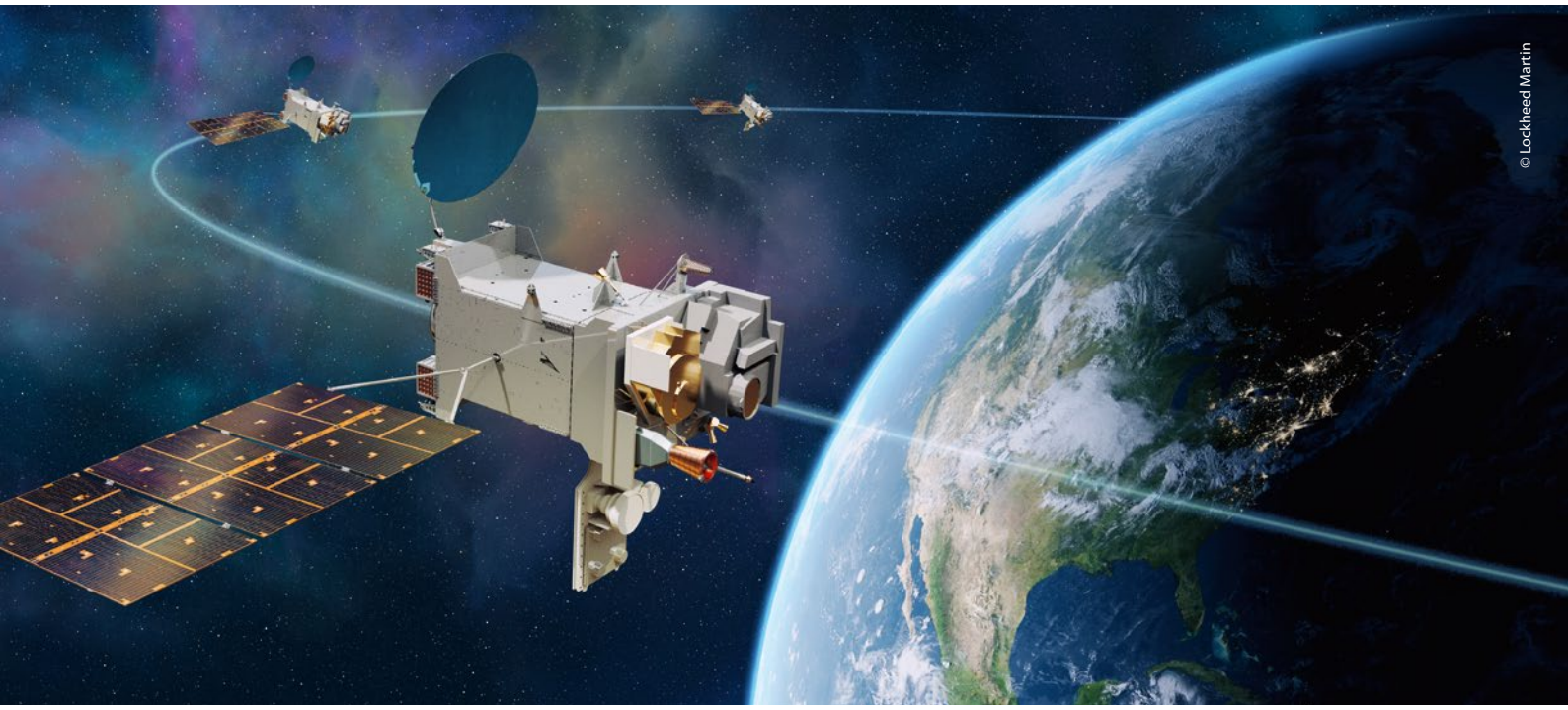
- The US, which is in the early stages of coordinating with multiple commercial companies to deliver Link-16 tactical datalink communications through space-to-ground connections from Low Earth Orbit (LEO) to a series of terrestrial receivers. Link-16 from space has the potential to increase the reach and redundancy of tactical communications and would be a key enabler of multi-domain operations.[6]

Commercial/Commercial: This partnership model is primarily focused on enhancing access to civilian markets. One prominent example is the collaboration between Intelsat and OneWeb. By integrating payloads onto their commercial satellites, Intelsat and OneWeb can offer high-speed internet access to regions that lack robust infrastructure, brining broadband internet services to underserved and remote civilian areas.[7]

Government/Government: US governmental agencies such as NASA and the National Oceanic and Atmospheric Administration (NOAA) are using hosted payloads to support a variety of environmentally-focused scientific missions. These missions include the Tropospheric Emissions: Monitoring of Pollution (TEMPO), Commercial Weather Satellite Program (CWSP), Geostationary Extended Observations (GeoXO) Program, and Clouds and the Earth's Radiant Energy System (CERES).[8]

Benefits and Considerations

Within the paradigm of NATO's collective defence, hosted payloads offer manifold advantages. Through collaborating on satellite launch and management projects, NATO member states can reduce the financial burdens of creating and maintaining customized space assets. Through resource pooling and cost-sharing, all NATO nations can actively engage in space missions and leverage space-based capabilities at reduced cost. Hosting payloads on satellites operated by more space-capable NATO members affords new members of the NATO space community the opportunity to access space without the up-front cost of developing, managing, and maintaining their own launch infrastructure or satellite systems.



The GeoXO constellation has NOAA payloads hosted on NASA satellites which contribute weather, ocean, and climate observations to NOAA forecasts and predictions.

From a Research and Development (R&D) perspective, the significance of hosted payloads cannot be understated. Hosted payloads offer substantial benefits for advancing technology, conducting experiments, and testing new concepts in space exploration and satellite operations. Researchers can prototype, deploy experimental instruments or systems on existing satellites, assess their performance in space, gather data, and iterate on designs more efficiently than traditional satellite development cycles. Engaging in R&D activities in space entails inherent risks, including potential hardware failures or operational challenges. By hosting payloads on proven satellites, researchers can mitigate some of these risks by leveraging the reliability and infrastructure of the host platform. This enables more reliable validation of recent technologies and concepts in a real-world space environment.

Hosted payload providers frequently offer flexible options to accommodate payloads in varying orbits. Non-spacefaring countries can collaborate with these providers to tailor their hosted payloads for specific

Orbital Rocket Launch Costs per Launch in USD	
Sounding Rockets	1 million
New Shepard	5 million
Electron	7.5 million
Falcon 9	67 million
Delta IV Heavy	350 million
SLS	4.1 billion
Soyuz-2	35–80 million
Long March	30–81 million
PSLV	21–31 million
GSLV	47 million
Ariane 5	178 million

***Table 1:** The immutable laws of physics impose a substantial cost for securing passage rights to space, with expenditures ranging from millions to billions of dollars per launch.[9]*

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orbital requirements, thereby gaining access to a variety of orbital configurations. This creates a notable opportunity to reach Geostationary Orbit (GEO) and Highly Elliptical Orbit (HEO) which are more challenging to reach than LEO.

Hosted payloads play a critical role in enabling capabilities across various space functional areas, supporting a wide range of civilian and military applications by including:

- Instruments such as GPS receivers or atomic clocks which are critical for providing accurate PNT information.
- Transponders, antennas, or other communication equipment that enhance satellite communication capabilities.
- Sensors and instruments for collecting weather and oceanographic data from space and monitoring space weather phenomena such as solar flares, geomagnetic storms, and radiation levels.
- Sensors and instruments that enhance space situational awareness by tracking and monitoring objects in space, including satellites, debris, and potential threats.
- Imaging sensors, Signal Intelligence (SIGINT) receivers, and other ISR equipment.

While there are many opportunities for technology exchange within NATO from a hosted payload perspective, limitations and barriers can impact sharing knowledge and expertise.

When the satellite bus operator and the payload operator differ, the payload operator is beholden to the actions of the bus. If the bus needs to manoeuvre or an issue occurs, coordination between the two parties is essential, but mission impacts may be unavoidable. When two or more commercial companies co-develop a satellite, there is a high potential for technology exchange barriers which could result in

interoperability issues. Additionally, hosted payloads must be compatible with the satellite bus and other systems on the spacecraft. Technical compatibility issues can limit the ability of NATO members to host a variety of payloads from multiple sources, which may require significant engineering resources. Addressing these limitations requires a coordinated approach, with member countries working together to overcome technical, resource, and policy-related challenges.

A Pathway to Resilience

The International Telecommunication Union (ITU) governs the allocation and use of radio frequency spectrum for satellite communications. In compliance with ITU regulations, hosted payloads offer a valuable and effective way to reserve specific frequency band slots for SATCOM missions. The ITU manages the limited amount of spectrum available in the GEO belt. If a nation has claimed a portion of the frequency spectrum but is unable to use it, they risk losing it. By using hosted payloads, NATO nations can coordinate their GEO missions to ensure that ITU frequency allocations are managed and not lost. Operators can maximize spectrum utilization, guarantee regulatory compliance, and deploy SATCOM missions in an economical and scalable way through hosted payloads. Diversifying NATO nations' space capabilities through hosted payloads enhances resilience, reduces vulnerability, and strengthens the overall security posture of space operations.

The Role of Hosted Payloads in Deterrence

Through several mechanisms, hosted payloads in the space domain support NATO's deterrence efforts. Hosted payloads improve terrestrial and space situational awareness cost-effectively. Ballistic missile launches

The International Telecommunication Union manages frequency allocations and geostationary orbit locations for the space commons.

and other hostile actions in orbit are examples of adversary activities that these payloads could be fitted with sensors and instruments to detect and identify. By demonstrating the Alliance's ability to promptly detect and respond to potential threats, NATO can enhance its deterrence posture.

Hosted payloads strengthen NATO's deterrent posture further by fostering better member-state coordination and communication. By using hosted communication payloads to improve the organization's communication channels, NATO member states can make decisions more quickly and securely during a crisis or possible threat. This improved communication infrastructure strengthens NATO's commitment to deterring aggression in space, bolstering the Alliance's collective defence capabilities.

The risks to space systems include any threats that can impact the system's control, reliability, bandwidth availability, security, flexibility, or affordability. Considering the variety of intentional threats (Directed Energy Weapons (DEW), electronic, cyber, or kinetic attacks) highlights the importance of deterrence in the space domain. At the 2021 Brussels Summit, NATO recognized that attacks to, from, or within space present a clear challenge to the security of the Alliance and could lead to the invocation of Article 5 of the North Atlantic Treaty. In this case, when a satellite with a hosted payload is targeted, it potentially impacts multiple NATO members. By integrating hosted payloads with strategic objectives and enhancing operational flexibility, NATO can better deter potential threats by ensuring continuous and reliable access to critical space assets.

Recommendations

When NATO declared space an operational domain in December 2019, it demonstrated the Alliance's understanding of the critical role that space-based capabilities play in modern warfare and security operations. This declaration not only acknowledges NATO's reliance on space assets for communication, navigation, intelligence gathering, and early warning systems, but it also reaffirms the Alliance's commitment to deterrence and defence against space threats.

NATO should encourage member nations to have a desired space roadmap that identifies how they best believe space should be used and developed for their defence.

Regardless of their current level of space capability, NATO nations pursuing space capabilities would benefit from investing in hosted payload projects because it would strengthen the spirit of the Alliance and improve collective security. By participating in hosted payload projects, NATO countries can pool their resources and expertise to develop and deploy space-based capabilities more efficiently and effectively. These collaborative efforts foster a sense of solidarity and cooperation among member states, strengthening the Alliance's bonds and encouraging unity in addressing shared security challenges.

[...] *'Diversifying NATO nations' space capabilities through hosted payloads enhances resilience, reduces vulnerability, and strengthens the overall security posture of space operations.'*

The commercial sector leads in various aspects of R&D concerning satellite bus and payload development. However, ambiguity exists within space law regarding the recognition of commercial satellites as legitimate targets, mainly when a commercial satellite hosts a military payload. To overcome this complexity, NATO nations should diversify the notion of hosted payloads to include both commercial and governmental entities. By embracing a diversified approach, NATO countries can benefit from the expertise and resources of the commercial sector while ensuring the integrity of military payloads and expediting the resolution of legal uncertainties they may entail.

Conclusion

Hosted payload projects allow NATO nations to leverage existing satellite infrastructure while sharing the costs of launching and operating payloads, making space more accessible and affordable for all members. This inclusive approach ensures that even nations with

limited space capabilities can contribute meaningfully to collective security efforts while reaping the benefits of space-based assets.

Recognizing the strategic importance of space operations on the battlefield potential adversaries have made a concerted effort to undermine or limit space assets' advantages for NATO nations. Implementing hosted payloads allows the Alliance to pursue two overarching objectives simultaneously. First, NATO can diversify resources across all functional areas of space operations and improve resilience. Second, by implementing a collective defence approach, the Alliance can deter potential hostile actions against its space assets, promoting the integrity and effectiveness of NATO's space-based operations. ●

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