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CONTENTS

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Technical Advisor

FEATURES

6 Delivering Satellite Lifelines
by Tim Winter

10 Advancing Mission Readiness
by Dale Segler

14 How Satellite Operators Can Prepare for More Crowded Spectrum
by Jeff Huggins

16 Space-Domain Awareness for Operational Decision Making
by Vassilis Karamanavis

22 Selling Space Through the SBIR/STTR Program
by Curt Blake & Tim Cox

26 Shifting Resilience From the Ground to the Cloud
by Dubi Lever & Dr. Juan Deaton

30 The Shape-Shifting Satellite
by Trevor Smith & Adam Wong

34 An Active Shield for Evolving Threats

36 Quantum Computing Threatens Premature Satellite Obsolescence
by Brant Pasco

40 Why the Future of SATCOM is Multi-Orbit
by Mike Grimshaw

42 SSC Expands On-Orbit Support Capabilities
by SSC Public Affairs

ADVERTISERS

25 ACORDE Technologies

5 AvL Technologies

1 ETL Systems

29 Hughes Network Systems

2 Mission Microwave

21 ND SatCom

33 SmallSat Europe 2027

3 SmallSat Symposium

13 Terma Technologies

47 SatNews

48 Omnetics Connector Corporation

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iDirectGov's interoperable solution links Army logisticians to headquarters, allowing them to requisition parts, attend video teleconferences and complete other tasks remotely.

DELIVERING SATELLITE LIFELINES

In modern satellite communications (SATCOM), the ability to maintain seamless, resilient connectivity in any environment is often the decisive factor between operational success and failure. Whether in the chaos of conflict or the urgency of disaster response, the power of reliable, interoperable satellite communications is what keeps missions moving and saves lives when every second counts.

> **" Effective response and coordination relied completely on communications. "**

By Tim Winter, iDirect Government President

Interoperability among mission-critical communications has advanced significantly, with satellites playing a central role in military satellite communications (MILSATCOM) and disaster response. This year marks 25 years since the 9/11 attacks on the Pentagon and the World Trade Center, and the failed United Airlines Flight 93 attack.

A few days following the attack, I found myself over Manhattan in a Navy P-3 aircraft. The airspace was deserted; the quiet was unprecedented and eerie. During the aftermath of 9/11, communications systems were down, overcrowded and locked in antiquated stovepipes. This was a problem. Effective response and coordination relied completely on communications.

Today, the lessons learned from 9/11 continue to ripple through the communication industry. The march toward interoperability, open architecture, resiliency and guaranteed service has never been stronger. With new capabilities to include global LEO constellations available, the need to orchestrate different systems, services and networks with an integrated approach has become paramount.

Today, the lessons learned from 9/11 continue to ripple through the communication industry. The march toward interoperability, open architecture, resiliency and guaranteed service has never been stronger. With new capabilities to include global LEO constellations available, the need to orchestrate different systems, services and networks with an integrated approach has become paramount.

Multi-modal communications providing redundant and resilient channels would have been very welcome on 9/11. What once was a wish or desire has now become a necessary requirement.

To understand how SATCOM became essential to modern communications and such requirements, it helps to look back. MILSATCOM must serve multiple users' mission sets that have differing needs. An initial capability set that once included frequency division multiple access (FDMA) and code division multiple access (CDMA) developed solutions now includes time division multiple access (TDMA) solutions. While all serve their own purposes, TDMA brought a unique channel-sharing capability that focuses on efficiently serving multiple users within a single network.

Years ago, iDirect Government (iDirectGov) developed and launched a TDMA capability for satellite communications designed for the military and federal government. When the nation was facing the war in Iraq, iDirectGov responded with the newly developed TDMA solution.

This is the story: As the U.S. military prepared to mobilize and go to war, iDirectGov received its first contract for $1.2M of satellite communication equipment. With this order, 200 operational remotes were deployed into theater. They performed well—beyond expectations. This was a decisive time for the company to have its equipment tested with the warfighter and would mark the beginning of the iDirect Federal team, which would later become iDirectGov in 2007.

From its inception, iDirectGov has supported the Department of War and other agencies in solving communications challenges in some of the most extreme circumstances and environments. iDirectGov consistently contributes to advancing current SATCOM solutions and providing innovative follow-on products and services to meet the ever-changing needs of the warfighter.

MWR Network: Connecting to Home

Prior to 2003, overseas troops lacked the necessary communications link to call home. The Morale Welfare and Recreation (MWR) Division of United States Army Europe focused on finding a solution. With the assistance of the SPAWAR Systems Center Atlantic-European Office, MWR built an interoperable network capable of supporting high volumes of voice, video and data traffic.

Warfighters at Camps Victory and Liberty located within Iraq were able to stay connected during that conflict. This network helped foster positive morale and troop welfare by connecting soldiers with their loved ones.

iDirectGov's Deterministic TDMA technology was used to help the soldiers stay connected to home via Internet cafés. The TDMA solution minimizes cost by effectively maximizing existing capacity across seven different satellites, and the Internet cafés are in designated tents and buildings at major U.S. military bases worldwide today.

Supporting Logisticians

The U.S. Army Combat Service Support (CSS) group's role is to man, arm, fuel, fix and move the force. CSS forces deployed in Iraq often had to deliver requisitions for parts and supplies by courier. These deliveries frequently meant driving through hostile terrain and exposing logisticians to potential enemy ambushes and harm.

iDirectGov provided a reliable communications system to help reduce and eliminate the need to deliver requisitions and sensitive data in person. The iDirectGov solution included a satellite modem, IP router, TCP optimization over satellite and QoS/prioritization all in one easy-to-deploy solution.

The iDirectGov interoperable solution not only provides a reliable, easy-to-deploy communications system that links Army logisticians to headquarters, it supports any IP-centric application. This allows logisticians to requisition parts, attend meetings via video teleconference and complete a number of other tasks remotely.

Chicago's Unified Command System



iDirectGov in 2002 helped to develop a satellite-based emergency response network for Chicago in a Unified Command Vehicle that uses satellite-based IP broadband for redirected 9-1-1 calls to remotely coordinate rescue efforts and dispatch police, fire and EMS units.

In the wake of modern disasters, redundant communications infrastructure is critical to cities. When terrestrial networks go down, a community can be crippled and unable to respond to its citizens or provide for their safety.

Chicago spearheaded a major effort in 2002 to keep communications alive in the event of a disaster. The city turned to technology solutions provider MorganFranklin and iDirectGov to develop a satellite-based emergency response network.

The city's Unified Command System, which includes a dedicated satellite hub and a mobile vehicle serving as the communications gateway for satellite services, equips emergency response vehicles with interoperable communications capabilities.



iDirectGov provided end-to-end IP services over satellite for the Red Cross in the wake of Hurricane Katrina in 2005, enabling the Red Cross to configure, monitor and control all remote access site

Responders have voice, video and data capabilities to handle 9-1-1 calls, receive and transmit live video feeds, and keep Chicago connected and in control.

By redirecting 9-1-1 calls via satellite-based IP broadband to the Unified Command Vehicle (UCV), Chicago can remotely coordinate rescue efforts and dispatch police, fire and EMS units. During a disaster, the UCV can provide satellite-based backup for the city's entire 9-1-1 call volume from any location, acting as a mobile communications gateway for a temporary base of operations.

SATCOM in the Wake of Hurricane Katrina

In the aftermath of Hurricane Katrina in 2005, the American Red Cross' ability to coordinate relief and serve thousands of displaced people, and even entire communities, was critical to its emergency response efforts.

The Red Cross came to iDirectGov for a communications solution. Within 36 hours, iDirectGov provided the Red Cross with a fully operational satellite-based broadband access solution, which was instrumental in facilitating communications and service delivery to 30 Red Cross shelters across Louisiana.

Providing end-to-end IP services over satellite, the iDirectGov system operated independently of the existing terrestrial infrastructure and could be deployed quickly to any geographical location under any conditions.

From its Virginia teleport hub, the Red Cross was able to configure, monitor and control all remote access sites, and even customize services to meet individual site requirements.

Following the initial response effort, iDirectGov shipped additional satellite routers to expand the Red Cross' reach into other affected areas in Mississippi, Alabama and Florida.

Tracking the Gulf Oil Spill

When the Coast Guard needed to track the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, iDirectGov's SATCOM technologies, which play an integral role in military efforts, were instrumental in the analysis and oil spill clean-up efforts.

The Coast Guard performed Gulf Coast flyovers to record and analyze the Deepwater Horizon oil spill. High-tech planes equipped with auto-tracking antennas and infrared cameras captured high-definition, full-motion video of the 3,300-square-mile spill.



Gulf of Mexico oil spill images are transmitted in 2010 to the Coast Guard and cleanup workers over a secure satellite communications backbone developed by iDirectGov.

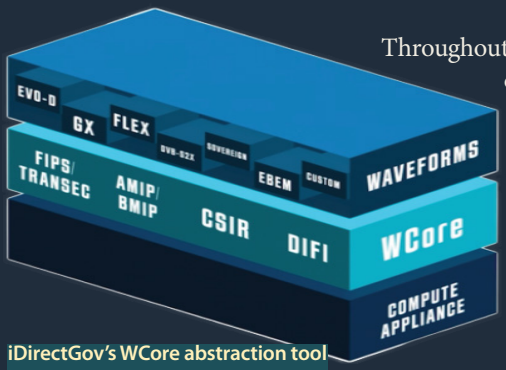
The images, which helped to track the oil spread in the Gulf of Mexico, were transmitted to the Coast Guard and cleanup workers over a secure satellite communications backbone developed by iDirectGov.

Airborne SATCOM used during flyovers was the only way the Coast Guard could see the full extent of the oil spill. The airborne SATCOM transmissions marked the first real-world implementation of airborne satellite and video connectivity for assessing and managing a major oil spill. Accurate, up-to-date information was vital to keep emergency response workers current on cleanup efforts.

Distance Learning and Disaster Response

Other areas where iDirectGov has solved real-world challenges include operating the Army Distance Learning Network in 2014. This network allows the Army to provide anywhere access to relevant, tailored training and education to soldiers, leaders and Army civilians.

In 2015, FEMA selected iDirectGov's network as the backbone of its disaster response system—providing all 50 states with vital emergency communications in the event of a natural or man-made disaster or terrorist incident.



iDirectGov's WCore abstraction tool creates a unified, flexible platform capable of supporting multiple waveforms and constellations.

Throughout the years, the company has developed solutions for interoperable communications. These specialized solutions support force protection, logistics, situational awareness, disaster recovery and emergency response.

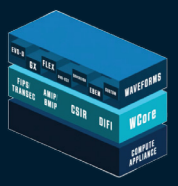
Building on a Legacy with Modern Innovation: WCore Hardware Abstraction Layer

The latest iDirectGov innovation is a hardware abstraction tool that transforms any compute appliance into a software defined modem (SDM). Called the WCore, the abstraction tool creates a unified, flexible platform capable of supporting multiple waveforms and constellations. By virtualizing the hardware interface,

WCore securely integrates iDirectGov hosted and third party applications, eliminating the need for waveforms to interface directly with specific hardware. This abstraction accelerates development, simplifies integration and supports a vendor agnostic approach to waveform deployment.

The WCore powered 4-Series can support as many as 16 waveforms, including Evolution Defense, Viasat Velocity GX, SES Velocity Flex, DVB-S2X, the enhanced bandwidth efficient modem (EBEM) and specific Sovereign networks.

IN FOCUS



WCore Hardware Abstraction Layer for Enhanced MILSATCOM

In May of this year, iDirect Government (iDirectGov) released the WCore virtualized waveform core and hardware abstraction layer that transforms an appliance into a software-defined modem (SDM) capable of operating seamlessly across multiple waveforms.



450 Rackmount Software-Defined Modem

The 450RM operates on iDirectGov's Evolution Defense, Viasat GX, SES Flex, DVB-S2X networks, as well as the military-standard 188/165B Enhanced Bandwidth Efficient Modem (EBEM) and supports operations across GEO, HEO, MEO) and LEO constellations, while maintaining the highest security standards.



SHIELD IDIQ Contract

The company was awarded a contract for the Missile Defense Agency Scalable Homeland Innovative Enterprise Layered Defense (SHIELD) indefinite-delivery/indefinite-quantity (IDIQ) contract earlier this year with a ceiling of $151B. This contract encompasses a broad range of work areas that allows for the rapid delivery of innovative capabilities to the warfighter with increased speed and agility.

The range of support provides MILSATCOM users with exceptional operational flexibility across mission sets. WCore provides shared services and critical capabilities accessible to all supported waveforms, including FIPS/transmission security (TRANSEC), Open AMIP/BMIP protocols and Communication Signal Interference Removal (CSIR™) signal excision technology. These shared services ensure consistency, efficiency and security across waveform implementations.

In Perspective

SATCOM and MILSATCOM have come a long way since my flight over Manhattan. The capabilities have made tremendous progress toward being more reliable and resilient for all mission requirements. However, interoperability does not mean connectivity challenges disappear. It reflects years of responding to in-theater needs and natural and man-made disasters—applying lessons learned and advancing technologies to strengthen communications connectivity.

A resilient and interoperable SATCOM ecosystem with seamless connectivity is now a key enabler for our military and government customers and their global objectives.



Author Tim Winter, iDirect Government president, oversees the corporate strategy and leads the iDirectGov team to bring solutions to the military satcom (MILSATCOM) arena. Winter brings more than 20 years of experience in the satellite communications arena. Prior to joining iDirect Government, Winter served as vice president of global accounts and global government & defense at parent company ST Engineering iDirect. Winter managed all strategic global account engagements and capture pursuits for International Defense opportunities. Winter served in the U.S. Navy and flew P-3 Orion aircraft as a Naval flight officer on active duty for eight years. He continued his service in the United States Navy Reserves, flying P-3 aircraft and the BAMS-D UAV through 2022. He retired from the U.S. Navy with the rank of commander.

ADVANCING MISSION READINESS

Edge AI for Space Domain Awarenes

By Dale Segler, Business Development Director, Aitech US



Space Domain Awareness (SDA) has become one of the most critical missions in military space operations. The number of satellites, commercial spacecraft, debris objects, and potential adversary systems continues to grow, creating an increasingly congested and contested orbital environment.

Maintaining awareness in this environment requires far more than cataloging objects in space. Military operators must detect, identify, track, and characterize spacecraft and orbital activity; monitor maneuvers and proximity operations; identify anomalous behavior; assess conjunction risks; and detect potential interference or hostile activity.

The challenge is not simply collecting more data. It is transforming large volumes of sensor, telemetry, and tracking information into actionable intelligence quickly enough to support operational decisions.

Traditional space architectures often rely on transmitting raw or partially processed data to the ground for analysis. As the scale and complexity of SDA missions increase, that model creates growing challenges in latency, bandwidth, resilience, and responsiveness.

AI-enabled edge computing offers a different approach: processing mission data in orbit, close to where it is generated, and delivering operationally relevant information rather than overwhelming ground systems with raw data.

The Growing Operational Demands of SDA

Space-based systems support nearly every aspect of modern military operations, including intelligence, surveillance and reconnaissance; missile warning and tracking; global communications; positioning, navigation and timing; and command and control across the joint force. Protecting and sustaining these capabilities requires persistent awareness of the space environment.

An unexpected maneuver, close approach, or change in orbital behavior may indicate routine spacecraft operations, inspection activity, interference, or a developing threat. Determining the significance of an event requires correlating information from multiple sensors, comparing activity against established behavior patterns, and evaluating how the situation develops over time. At the same time, operators need this information quickly. A detailed analysis delivered too late may have little operational value.

The continued growth of proliferated constellations, commercial space activity, and military space systems is increasing both the volume of SDA data and the number of events that must be evaluated. Future architectures must therefore do more than collect information. They must help identify what matters, prioritize it, and move relevant intelligence to the people and systems responsible for taking action.

The Limits of Ground-Centric Processing

Traditional military space architecture generally follows a linear process: satellites collect data, transmit it to a ground station, process and analyze it on the ground, and then distribute the resulting operational assessments to operators.

This approach remains effective for many missions, but it becomes increasingly difficult to scale when satellites generate large volumes of high-resolution sensor data or when decisions must be made on tactically relevant timelines.

Several constraints emerge:

- ***Downlink opportunities and ground-processing cycles introduce latency***
- ***Transmitting large quantities of raw data consumes limited communications bandwidth***
- ***Time-sensitive analysis remains dependent on available ground infrastructure***
- ***Contested or degraded communications may interrupt the flow of mission data***
- ***Expanding constellations can generate more information than centralized processing systems can efficiently manage***

These limitations can delay the identification of unusual orbital behavior, emerging threats, or rapidly changing operational conditions. They may also force operators to choose between downlinking large amounts of data and receiving the most important information quickly.

Bringing Intelligence Into Orbit

AI-enabled edge computing shifts part of the analysis process from the ground to the spacecraft. Instead of treating the satellite primarily as a collection platform, onboard processing allows the system to evaluate data as it is generated. The spacecraft can identify mission-relevant events, prioritize information for transmission, and reduce the volume of raw data that must be sent to Earth.

For an SDA mission, onboard processing may support capabilities such as:

- ***Detecting deviations from established spacecraft behavior***
- ***Identifying unusual maneuvers or proximity operations***
- ***Correlating information from multiple onboard sensors***
- ***Prioritizing objects or events for additional observation***
- ***Filtering routine or low-value data***
- ***Generating alerts or concise mission products for ground operators***

The objective is not necessarily to remove the human operator or ground-based analysis from the decision process. Rather, it is to ensure that those operators receive the most relevant information sooner and can focus their attention on events that require judgment or action.

This is especially important when communications are limited, disrupted, or contested. A spacecraft capable of continuing to analyze and prioritize information onboard can preserve mission utility even when continuous connectivity is unavailable.

Compressing the Decision Timeline

The operational value of edge AI is its ability to reduce the time between observation and understanding. In a traditional architecture, a satellite may detect an event quickly, but the orientation and decision phases can be delayed while data is downlinked, processed, analyzed, and distributed. With onboard AI-enabled processing, the system can begin assessing the event immediately.

A spacecraft may determine that a maneuver differs from expected behavior, assign a higher priority to the object, collect additional data, and send an alert or reduced data product to the ground. The operator receives a more focused understanding of the event rather than starting with a large volume of unprocessed information. This compresses the Observe, Orient, Decide, Act cycle (OODA Loop) by accelerating the transition from raw observation to operationally relevant insight.

The result can include faster threat detection and classification, reduced decision latency, improved responsiveness during time-sensitive operations, and greater resilience in contested communications environments.

As military space architectures become more distributed, satellites will also need to operate with greater autonomy. Proliferated constellations cannot depend on continuous human direction for every observation, prioritization, or data-management decision. Edge AI provides a mechanism for distributing intelligence across the architecture rather than concentrating every analytical function on the ground.

Enabling Technologies and Design Constraints

Performing advanced analytics in space presents significant technical challenges. SDA workloads may involve image processing, sensor fusion, anomaly detection, pattern recognition, object tracking, and autonomous tasking. These functions require substantial computing performance while operating within the strict size, weight, power, and thermal limitations of a spacecraft. Space systems must also withstand radiation exposure, launch vibration, extreme temperatures, long mission lifecycles, and limited opportunities for repair or replacement.

Advances in space-rated and radiation-tolerant embedded computing are making more capable onboard processing possible. High-performance CPUs, general-purpose graphics processing units, AI accelerators, and other specialized processors can now support workloads that previously required ground-based computing resources.

The computing architecture must also be scalable and upgradeable. Many existing space platforms were designed before AI processing became a primary mission requirement. Completely redesigning those platforms may be costly, time-consuming, or operationally impractical. Modular open system architectures, standardized interfaces, scalable processing platforms, and upgradeable embedded computing can provide a path for introducing greater onboard intelligence without replacing the entire spacecraft or mission system.

These approaches also support future technology insertion as the algorithms, processors, sensors, and mission requirements evolve.

Implications for Golden Dome and Future Defense Architectures

Future defense architectures, including the Golden Dome for America missile defense system, will depend on persistent



awareness across both terrestrial and space domains. These architectures must detect and track threats, support missile warning, correlate data from distributed sensors, and disseminate operational actions rapidly across the battlespace. Their effectiveness will depend not only on the quality of individual sensors, but also on how quickly the broader system can interpret and act on the information those sensors generate.

Edge AI can help reduce the time from detection to decision by processing data closer to the source. It can also reduce communications demands by transmitting prioritized information, alerts, or relevant data products instead of continuously downlinking every piece of raw sensor data.

Within a distributed missile defense or SDA architecture, individual satellites may, therefore, become active participants in the sensing and decision network rather than passive collection nodes.
This distributed operational architecture will be increasingly important as the number of sensors, spacecraft, and potential threats grows.

From Data Collection to Operational Intelligence

Military space is evolving from a primarily data-collection environment into an intelligence-driven operational domain. The decisive advantage will not come simply from placing more sensors in orbit. It will come from the ability to process, understand, prioritize, and distribute information quickly enough to support operational action.

AI-enabled edge computing helps make that transition possible. By performing selected analysis onboard, space systems can reduce unnecessary data movement, improve responsiveness, operate more effectively during communications disruptions, and deliver higher-value information to the warfighter.

For Space Domain Awareness, the central question is no longer whether more data can be collected. It is whether the architecture can determine what matters—and deliver that insight before the operational moment has passed.



aitechsystems.com

Dale Segler is the Director of Aitech U.S. Business Development, overseeing the Mil-Aero market at Aitech, a global leader in AI-powered rugged embedded computing and connectivity systems for defense and space applications.

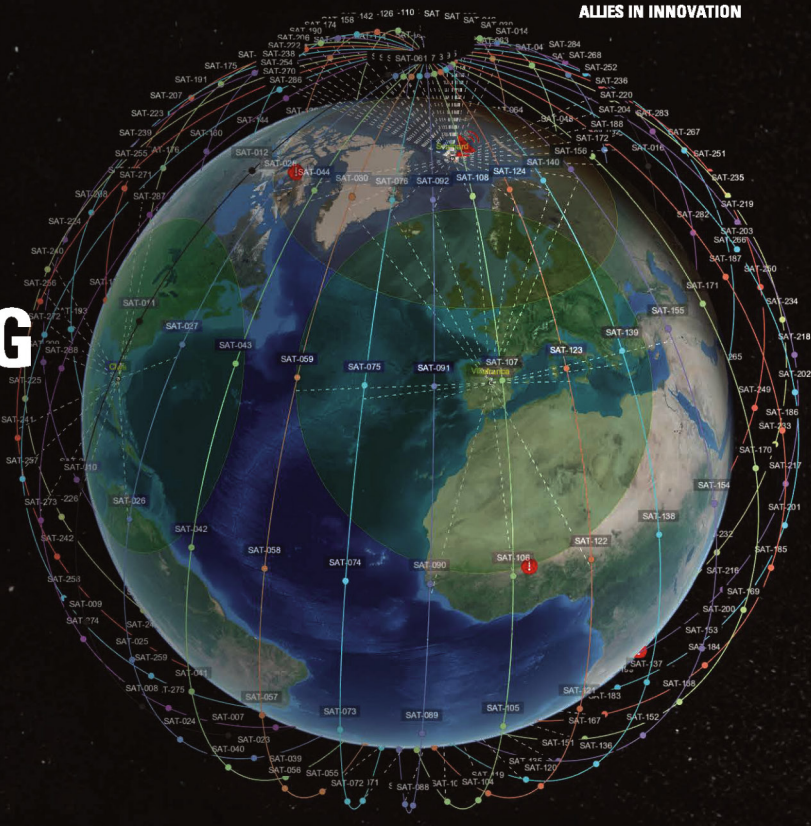
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HOW SATELLITE OPERATORS CAN PREPARE FOR MORE CROWDED SPECTRUM

By Jeff Huggins

Demand for satellite spectrum is rising. Constellations are growing, services are expanding and more and more data is moving through orbiting satellites.

At the same time, new technology is offering operators more ways to use spectrum efficiently. In recognition of this, the FCC recently replaced some longstanding limits on interference between Geostationary (GEO) and Low Earth Orbit (LEO) systems with a more flexible, coordination-led approach. The goal is to unlock more capacity while allowing operators to agree arrangements between themselves.

> "For military and government users, the cost of a degraded link goes beyond dollars, cents and brand reputation."

Previously, the limits on how much disruption one satellite network could cause another acted like guardrails, allowing companies to invest billions in satellites, spectrum licences and ground infrastructure with reasonable confidence that the operating environment would remain broadly predictable. A spectrum licence, which gives a company the right to transmit data, also, until recently, gave that company a degree of protection from other users.

The relaxation of the mandatory Equivalent Power Flux Density (EPFD) limits by the FCC—limits that were designed to protect GEO satellites from non-geostationary satellites, including LEO constellations, has changed things substantially. Put simply,



instead of saying, 'Here is the greatest amount of interference you're allowed to cause', the FCC is now saying, 'We trust you to work together with other users to find a tolerable level of interference; that way, you have more flexibility.'

The FCC's approach reflects the view that satellite operators can make more efficient use of spectrum by negotiating directly with one another, rather than relying solely on fixed regulatory limits. It is, if you like, a market-led view of spectrum management. This could unlock more capacity because rigid limits can leave valuable spectrum underused, especially as satellite technology becomes more advanced

The trade-off is that operators must take greater account of how other networks use the same frequencies. That is the central change: spectrum is not just about legal access, but how clean the signal is, how much interference is present, and how reliably the service can be delivered. For military and government users, the cost of a degraded link goes beyond dollars and brand reputation.

Spectrum access, in other words, is becoming a question of quality as much as ownership. Some operators may have more reliable access than others, even though all hold the same or similar rights. That could create a new hierarchy in the market – one in which the operators with better engineering teams, coordination processes, interference-mitigation technology, and industry relationships are able to make more valuable use of their licences.

Others may find that rights which look attractive on paper are harder to monetize in practice. The relaxation of rules could enable a more lively and dynamic market. However, it will certainly be a more complicated one. Investors, operators, equipment suppliers—they must think about spectrum differently: as a resource whose performance can vary depending on the behaviour of other players.

The broader point is that the satellite industry is entering an age in which orbit is more congested and spectrum use requires closer coordination. There are already 16,000 active satellites in orbit, and satellite numbers, constellation sizes and demand for data will continue to grow.

The FCC's recent decision reflects its confidence that industry can handle some of this complexity without prescriptive top-down regulation, and they may well be proved right. It also comes with more responsibility and more risk. It, therefore, gives operators both greater freedom and greater responsibility for maintaining reliable services—something they may relish.

One way operators can prepare is by reducing their dependence on radio-frequency (RF) spectrum alone. This makes them especially useful to military and government networks, which need to remain effective despite congestion, and in the teeth of disruption and deliberate jamming and interception.

Optical communications use lasers rather than radio waves to transmit data and are not affected by radio-frequency interference. They will not replace radio links altogether; but they can provide an important additional route for moving large volumes of data between satellites and, in suitable conditions, between space and the ground.

This proposal comes as the FCC considers a separate rulemaking that would allow satellites to use unlicensed Wi-Fi and Bluetooth spectrum. Taken together, the proceedings suggest the Commission is rethinking long-standing assumptions about how spectrum should be allocated to space systems.

The operators that really succeed in the months and years ahead will marry spectrum holdings to good coordination, the effective mitigation of interference, and a more diverse communications system. RF links will still be key, but optical communications will provide a useful hedge as demand grows and spectrum gets more crowded—especially for military and government networks operating in contested conditions.

In a more flexible market, resilience will depend on securing access to spectrum and on building networks that can continue to perform when circumstances change.

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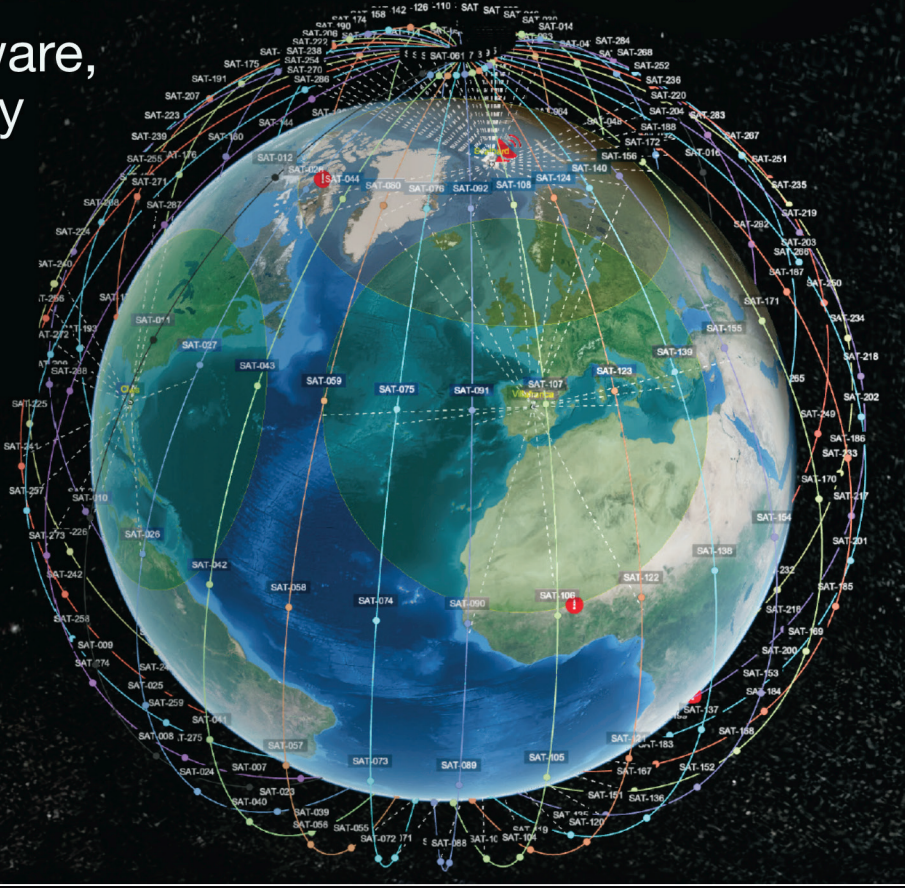
Author Jeff Huggins is the President of Cailabs US, which develops laser-based communications systems. Jeff has had a career as a naval intelligence officer and held senior roles at several major defense companies, including Israel Aerospace Industries North America and Raytheon. At Cailabs, he drives growth in the U.S. to meet rising demands for laser comms from the defense sector.

BEYOND SPACE TRACKING

Attribution runs on software, not sensors—a capability every nation can afford

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www.terma.com



By Vassilis Karamanavis, Terma

Europe is building the sensor infrastructure — radars and telescopes — to see what is in orbit. That is a necessary first step, but it is far from Space Domain Awareness. The harder capability, the one that matters in a crisis, is attribution: identifying who is behind a threatening act in orbit and what they intend to do next. The decisive capability in space is attribution, and it must arrive fast enough to act on. In other words, space security is not merely about procuring expensive observation equipment, but rather about fusing observations into an informed operational picture where the actors are identified and response efforts are proportionate.

Until recently, near-Earth space was a quiet, conflict-free place. The situation has dramatically changed in recent years, and the sheer numbers make it impossible to ignore. More than 46,000 objects are tracked in orbit today, and barely one third of them are working satellites.

> **"The harder and more consequential problem is understanding behavior, intent and attribution..."**

The remainder is debris, spent rocket bodies and defunct hardware. 2025 brought with it the highest launches rate ever recorded with most objects brought to orbit crowding into the already congested 400–600 km shell.

Below the observability threshold for any sensor, an estimated 140 million untracked fragments orbit at velocities that make even a paint fleck lethal upon impact. The trend is indisputable and unlikely to decelerate.

For a decision-maker or a field commander relying on space-enabled ISR, PNT and communications, space operations carry two distinct kinds of risk.

The threat taxonomy is quite clean and easy to understand—real-life operations are not.

In practice, the two are inseparable, as an operator's first task is to distinguish between a deliberate attack and a natural anomaly. This is the real-time discrimination problem the February 2022 cyber-attack on the KA-SAT network exposed, when disabled terminals across Europe were initially indistinguishable from a technical fault, before the incident was traced to a coordinated intrusion that also disrupted remote monitoring of German wind farms[1].

Military satellite launches have risen by roughly two-thirds since 2019, and every major space power now treats orbit as a warfighting domain[2]. The more actors maneuvering in a not only crowded but contested environment, the more room there is for an event to be genuinely ambiguous, and the more valuable that ambiguity becomes to whoever engineered it.

At the end of the day, this is why the capability that decides outcomes is attribution, not mere observation. Plus, attribution delivered at a speed that still leaves the decision-maker with options. The ability to say, while a decision is still available, whether this was an accident or an act.

Detection is the half everyone is buying

For decades, national space efforts focused on Space Situational Awareness (SSA) — knowing what is in space and where it is going. That remains necessary, but for a decision-maker under time pressure it is no longer sufficient. The harder and more consequential problem is understanding behavior, intent and attribution: is a maneuver routine or hostile, who is responsible, and what proportionate response does the commander have available?

This is the shift from SSA to full Space Domain Awareness (SDA), i.e., surveillance and tracking to detect, identification and attribution to characterize, classify and attribute, and mitigation and response to react. And slowly but surely the EU, NATO members and allied nations alike are converging to it. This is where the real advantage lies and the call to action is more pressing than ever.

The European Union has made this convergence clear in its Space Strategy for Security and Defence (EUSSSD)[3], founded on four pillars:

- ◊ ***Strengthening the resilience and protection of space systems***
- ◊ ***Responding to space threats through a Threat Response Architecture built on the detect, characterize, attribute and react sequence that is rehearsed annually in exercises such as STRA-X***
- ◊ ***Putting space to work for security and defense***
- ◊ ***Partnering internationally, with the UN, the United States and NATO, on responsible behavior in orbit***

In this framework, a sovereign national SDA capability is not a parallel structure to any of this—it is the member-state instrument through which the architecture is implemented and upon which it is based.

The same convergence shows in national strategies. Austria's Military Space Strategy[4] mandates a shift from being a user of space services to being an operator, with a national Common Operational Picture (COP) as its top priority. Germany's 2025 Space Security Strategy names space situational awareness a joint civil-military task of the first order and calls explicitly for sovereign reconnaissance to reduce dependence on non-European actors[5]. US Space Force doctrine makes SDA foundational to all space operations, built around resilience, rapid reconstitution and credible attribution[6].

In the UK, a national study commissioned by the UK Space Agency put a concrete figure on the case for investment: a modelled £568 million commitment to SDA capability through 2030 was estimated to return £2.1 billion once the mitigated cost of losing space services and the revenue of SDA-enabled activity were accounted for[7].

In short, nations of all sizes are doing the same thing: the line items that move first are almost always sensing assets like a space surveillance radar, an optical network, or a contribution to a shared catalog, because they are tangible and procurable. However, the important characterization and attribution half is harder to specify and demonstrate—and is, therefore, easier to defer.

But it is the wrong half to defer.

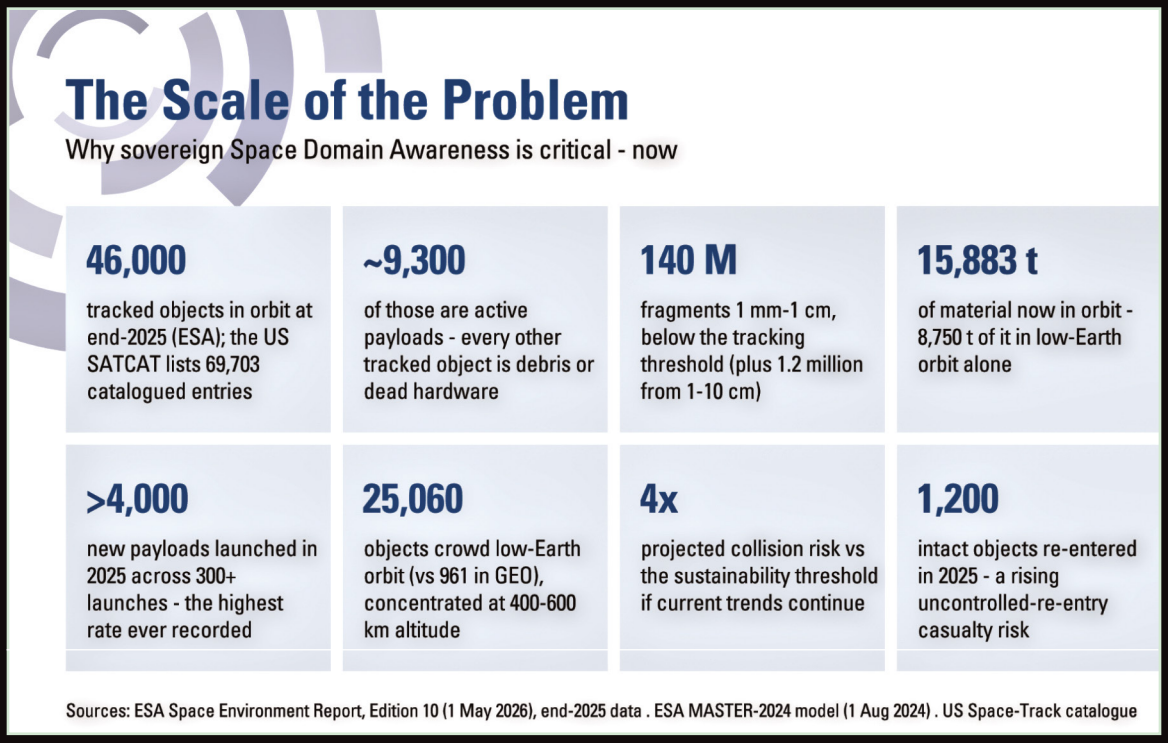
Sovereignty as a spectrum not a singular posture

One of the more persistent misconceptions in this debate is that "sovereign SDA" means every nation must build an identical, self-contained capability, founded on space surveillance infrastructure.

A neutral state, such as Austria, can own and operate a fully sovereign, observational, non-weaponized capability entirely within its constitutional framework being the sentinel, rather than the sword.

A core NATO or EU member, for instance—Greece, has in recent years become a significant contributor to EU SST, with primarily optical sensors, and a space debris radar under construction. This involvement advances Greece's capabilities in space surveillance and tracking and enhances security and safety for its space assets. It also opens opportunities for economic, technological, and educational growth along with influencing the EU space policy.

Germany, goes further still: Berlin's space strategy frames sovereign reconnaissance and a national space situational awareness capability with a sensor network of explicitly global reach, reducing non-European dependence while feeding NATO and EU frameworks—and it already signals ambitions beyond passive observation, underscoring interest in inspection and on-orbit capabilities as part of a shift towards active, defensive measures. Even at that scale, the design priority stays interoperability and burden-sharing, so the capability closes gaps for the alliance rather than duplicating what already exists.



A larger alliance-leading power, e.g., the United States, can operate SDA as the backbone of joint space operations, emphasizing battle management, mission assurance and partner synchronization.

The technical architecture does not change; only how a nation chooses to connect it to its allies does. That is precisely what makes this a capability every European and allied nation can realize on its own terms, adapt to its own requirements, and expand as its posture evolves.

The decisive edge is code, not steel

It is tempting to think of SDA primarily in terms of hardware — radars, telescopes, and space-based sensors. Sensors matter, and no single type is to be overlooked.

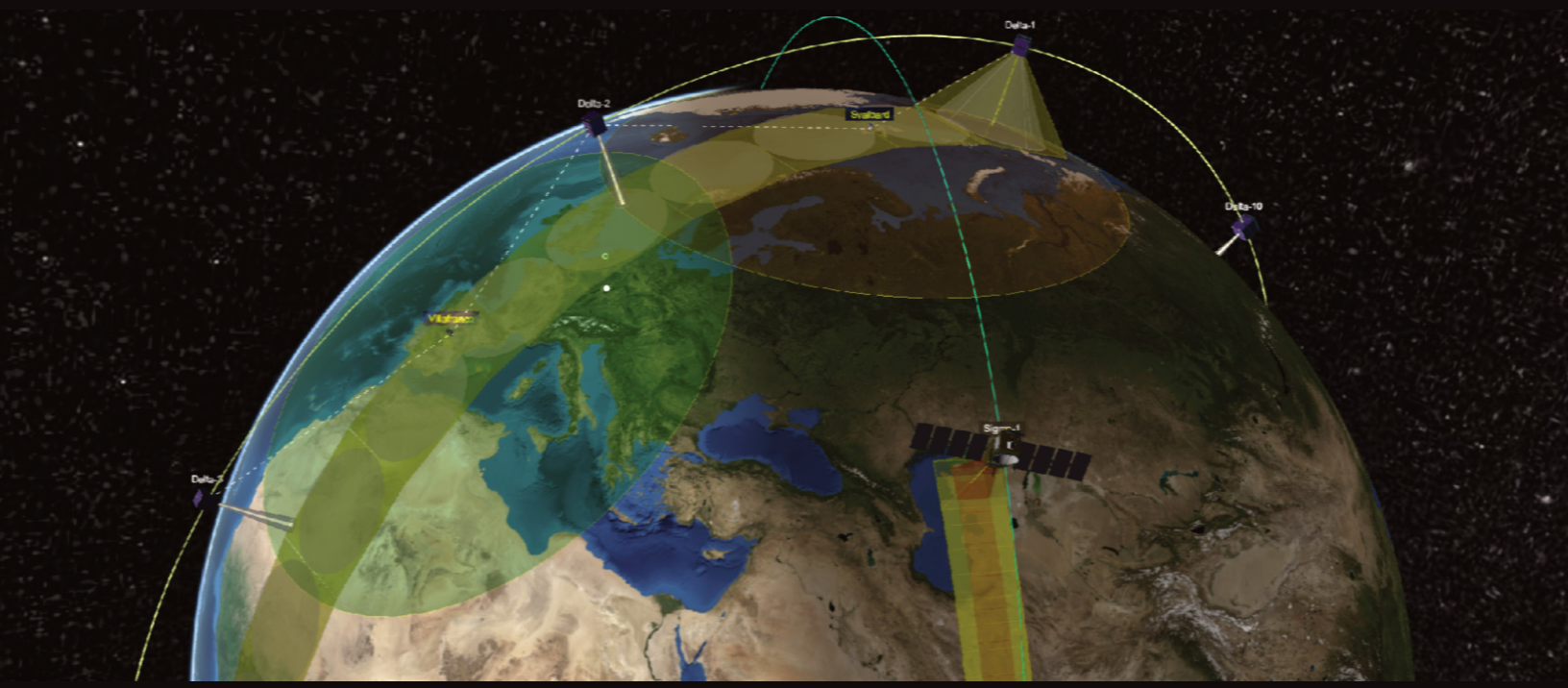
Ground-based radar, optical telescopes and satellite laser ranging provide all-weather, day-and-night tracking but are fixed to a location; space-based electro-optical, infrared and radio-frequency payloads add diversity and close observability gaps. A carefully designed mix of both layers is essential, because each covers the other's blind spots.

But sensors can be bought, shared or leased. What cannot be outsourced without giving up sovereignty is the fusion and AI processing software that turns raw tracks into understanding—correlating observations, discerning patterns, evaluating whether a maneuver is routine or threatening, and compressing an analyst's decision timeline from hours to minutes, with the human-in-the-loop remaining firmly in command.

This is where a smaller nation finds its asymmetric advantage: not in the size of any single antenna or network thereof, but in the speed and quality of its understanding.

Because this fusion software is the sovereign core, cyber defence cannot be an afterthought for later—it must be engineered in from day one, treating the Center itself, and the space systems it protects, as critical infrastructure and a prime target for cyber-attacks.

That means defence in depth across every segment: secure mission control software and authenticated commanding in the space segment; end-to-end, post-quantum-ready encryption with anti-jam and anti-spoof protection in the link segment; a zero-trust ground architecture with round-the-clock security-operations-centre monitoring; hardened, disciplined patching of user terminals; and supply-chain assurance through vendor and provenance checks [e.g., [8]].



Nor does the Center defend alone—it plugs into national cyber-defence structures and, at European level, into the EU Space ISAC and the NIS2 obligations now extending to the ground segments of space services, so that threat intelligence flows in and attribution flows out.

Rehearsing the response before it is required

Awareness and hardened defences are necessary, but a response is only credible if it has been rehearsed under pressure. This is why a mature Center includes a simulation and digital-twin capability: a high-fidelity model of the orbital picture and of the Center's own decision chain, used to wargame threat scenarios, test and compare response options, train operators, and validate indications-and-warning thresholds and escalation-control measures before a real event forces the issue.

That rehearsal capacity is what turns a gradually-escalating response-options spectrum—from passive measures such as collision-avoidance maneuvering, signature management and cyber hardening, through to active defensive measures at the far end—from a doctrine on paper into a decision-maker's tested playbook, and it is the same discipline behind exercises such as the EU's STRA-X.

From capability to operational deployment

The value of a sovereign SDA & Operations Center is best judged against what it enables a commander and a nation do in real-life. In practice that spans very wide:

- ◊ ***Overflight and rendezvous and proximity operation awareness over national territory.***
- ◊ ***Conjunction assessment, collision avoidance and re-entry prediction for national and partner assets.***
- ◊ ***Identification, classification and attribution of non-cooperative or hostile resident space objects, and of interference, to specific actors.***
- ◊ ***Continuous monitoring of GNSS and SATCOM signal integrity, to counter navigation warfare.***
- ◊ ***Space weather forecasting to protect the GNSS, SATCOM, and HF communications actors rely on.***
- ◊ ***Tasking and exploitation of Earth observation imagery for multi-domain operations and domestic disaster response.***

Each of these use cases carries a direct operational benefit for the commander and a contribution that feeds EU, NATO and civil-agency partners in turn. That last point matters as much as any single capability: none of this works in isolation. A national Center is built interoperable by design, on a plug-and-play, standards-based architecture and open, common formats that let every partner connect and contribute—the national Common Operational Picture interconnecting with the EU's security and defence framework and EUSPA, the EU Space ISAC, EU SST and IRIS², NATO's space situational awareness system, Centre of Excellence and Hybrid Alliance Layered Operations in Space (HALO) initiative, and ESA's SSA services.

No single central agency can or should do it all, and for a national contribution to count, it must speak the same language as the architecture it feeds.

This is the perspective Terma brings to conversations with defence ministries and space agencies across Europe: SDA is a decision-advantage capability, not a procurement line item, and the nations that treat it that way now, building sovereign cores that contribute cleanly to the wider allied architecture, will set the terms of space security in the decade ahead. The rest will own excellent sensors but still need to ask someone else what just happened.

If you have any questions, please contact us:
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Author Dr. Vassilis Karamanavis is a Senior Project Manager at Terma Group, with 10 years of experience in space domain awareness. Previously employed at the German Space Agency and Fraunhofer FHR, he is a specialist in satellite tracking, ISAR imaging and the characterization of resident space objects. He holds a Ph.D. in Natural Sciences from the University of Cologne and Physics Degree from the Aristotle University of Thessaloniki.

Terma Group is a global company with more than 2,400 employees, developing mission-critical solutions in defense, aerospace, and security. We work closely with customers and partners worldwide to deliver advanced technology that helps protect people.

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Terma has been delivering advanced space technologies since 1972. With flight equipment, spacecraft operations, ground segment solutions, and mission related services, Terma supports the full mission lifecycle from early development to launch and in-orbit operations. Backed by a heritage of 100+ space projects, Terma helps space organizations reduce risk, increase reliability, and deliver with confidence.



BIFROST" Through the BIFROST mission, Terma helped bring AI-enabled data processing into orbit. The onboard solution turns sensor data into relevant intelligence, reducing the amount of data transmitted to the ground and providing faster access to valuable insights. The capability strengthens maritime situational awareness by detecting and documenting vessel activity, even when a vessel is not transmitting its position.



BepiColombo: Terma has supported the mission with spacecraft power equipment, systems for spacecraft testing, mission-control capabilities, flight-dynamics expertise, and operational support. This lifecycle contribution helps safeguard the spacecraft and supports reliable operations throughout its long and technically demanding journey to Mercury.



WAT PIAST: The PIAST project supports Poland's development of a sovereign satellite imagery and reconnaissance capability. Terma supplied the Military University of Technology with a complete mission-control solution based on CCS5, PLAN, ORBIT, and TRACK. The integrated system enables efficient satellite monitoring, mission planning, flight dynamics, and trajectory visualization, while providing a scalable platform for future defense and commercial missions and for training Poland's next generation of space engineers.



Euclid: Terma ensured the sustained and reliable operation of the satellite through the firm's contributions of flight equipment and systems for testing and operations.



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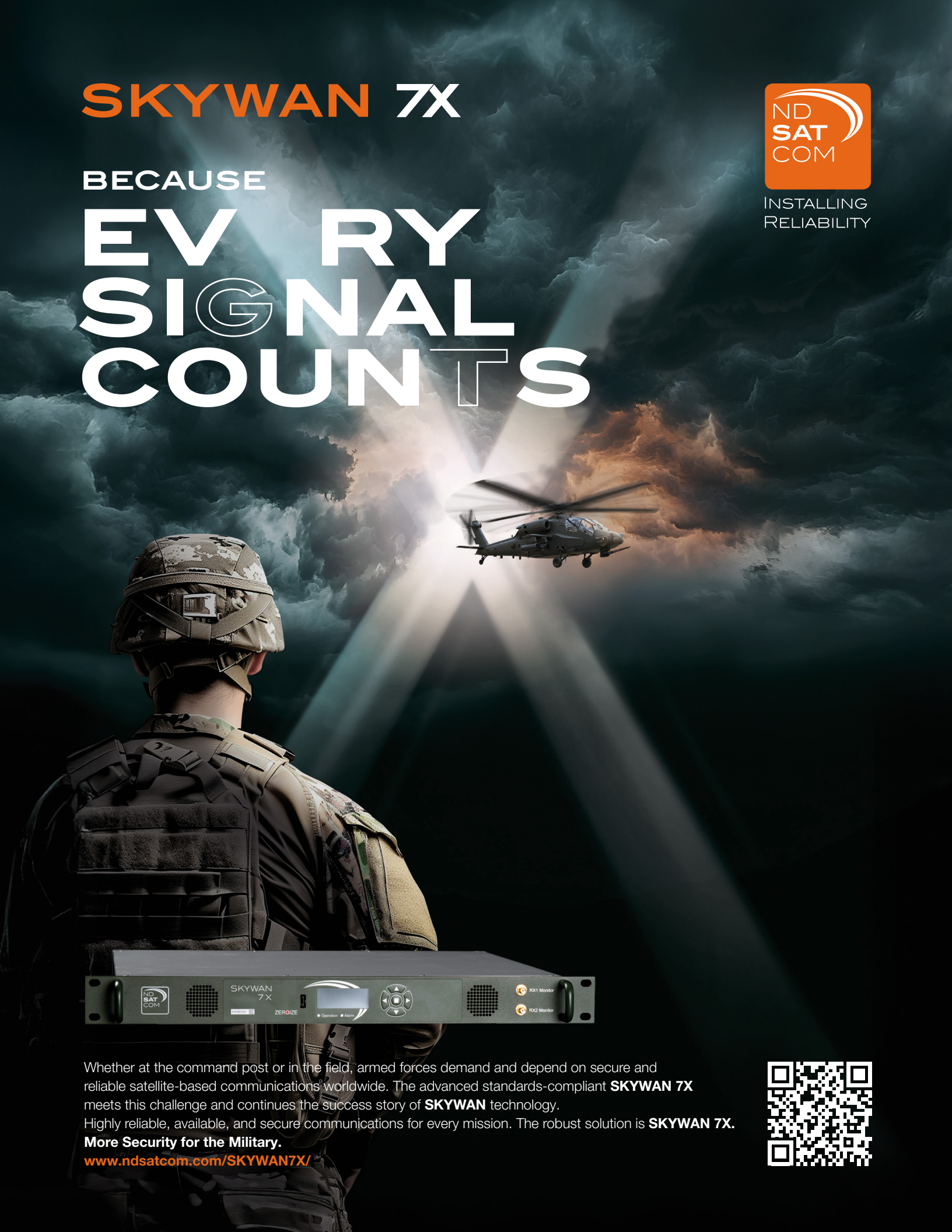
Hera: Terma supplied remote terminal units for platform and propulsion control, electrical and radio-frequency test equipment, and tools supporting flight-software development. These solutions helped verify the spacecraft before launch and support precise, reliable control of its critical systems throughout the mission.

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SELLING SPACE THROUGH THE SBIR/STTR PROGRAM

Know the eligibility rules

By Curt Blake and Tim Cox

Selling to the federal government can be a reliable pipeline for many companies. But there can be a high bar to entry, especially for small businesses. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs might be an attractive option for those smaller companies, as their names suggest, there is no competition from large, established corporations.

For companies in the space industry, there is no shortage of SBIR/STTR opportunities.

The Missile Defense Agency is looking for radiation-hardened microelectronics for use in satellites and other payloads.

The Air Force's SpaceWERX has multiple open topics for space solutions. One seeks digital scheduling/information-management tools to support launch operations at Space Force launch ranges, and another is interested in small companies with ideas on non-missile-warning, commercially-derived space sensing capabilities.

The Defense Advanced Research Projects Agency needs flash memory systems for use in payloads and spacecraft that can survive deep-space thermal extremes and radiation.

These are just a few examples of contract opportunities reserved for small companies with innovative ideas on solving the government's need to operate in space.

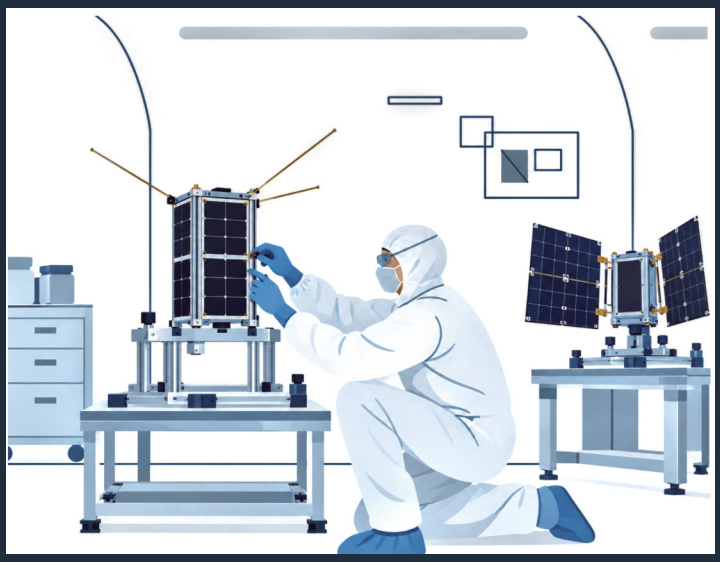
However, as with all government programs, there are rules to participate in the SBIR/STTR programs. Not all small businesses will be eligible. Before a small company decides to commit time and resources to pursue SBIR/STTR opportunities, the firm should understand whether it is, in fact, able to be awarded an SBIR/STTR contract. The discussion below serves as an introduction to these rules.

Background

The SBIR program is authorized by statute and requires certain federal government agencies to provide part of their research and development funding to technology-focused entrepreneurs, start-ups, and small businesses so that they can develop their innovative ideas. The funding is non-dilutive, and so small companies benefit by getting funds without ceding ownership or control.

The SBIR program was recently reauthorized in April 2026, through September 30, 2031, when President Trump signed the Small Business Innovation and Economic Security Act into law. By doing so, the president authorized up to $6 billion annually to be made available through SBIR contracts.

Small companies get access to this funding through a three-phase approach. In Phase 1, the SBIR contract involves technical merit, feasibility, and potential of the company's solution, and typically requires a proof of concept or a white paper. The budget may be up to approximately $322,090, and contracts are for six months to two years.



Thus, a small company with an idea of how to manage space debris, SpDe, LLC, could put together a 10-page analysis identifying the problem, articulating a solution, and demonstrating what it has done to bring that solution to bear. A Phase 2 SBIR award would require the small company to conduct further research and development on its idea and perhaps build a prototype solution. SpDe, LLC, might be awarded a contract valued up to $2,153,927, with a term of one to three years, to make the initial version of the device it thinks can manage space debris.

Phase 3 SBIR awards mean the government and small companies have a viable product that can be produced and commercialized. Funding is unlimited. Contracts can be longer. The company has developed valuable intellectual property rights because of the prior phases. And not insignificantly, at Phase 3, it no longer must be a small business—it can grow organically, or through merger and acquisition, and still keep its SBIR contract.

Eligibility

However, before SpDe, LLC, gets to Phase 3 and produces its space debris managing product, it must be eligible to win a Phase 1 SBIR award.

To be eligible, the company must have fewer than 500 employees and be more than 50 percent directly owned and controlled by a U.S. person. Although seemingly straightforward, these eligibility rules in practice can create issues for companies during funding rounds, have significant foreign ownership and/or management, or are part of a corporate family.

500 Employees. Most companies that think they have fewer than 500 employees likely do—the SBIR rules, however, look to whether a company has affiliates, and if it does, the SBIR rules include the employee counts of all affiliates to determine the number of employees.

Companies are affiliates of one another if one controls, or has the power to control, the other, or a third party or parties control or has the power to control both. Thus, SpDe, LLC, might have four employees: two founders, an engineer, and a business development person. But it is in negotiations to be acquired by a large aerospace company that has 1,500 employees. Even if SpDe, LLC, continues to exist as a subsidiary after an acquisition, the once small business will no longer be found to have fewer than 500 employees under the SBIR rules, and will not be eligible.

Companies interested in SBIR opportunities must examine their corporate organization to see if they have any affiliates and whether that means they will have more than 500 employees, companies looking to be acquired while still seeking to retain SBIR eligibility will want to ensure the buying entity will not cause an aggregate employee count to exceed 500.

More than 50 percent directly owned by a U.S. person. Under the SBIR rules, the small business must be more than 50 percent directly owned by one or more individuals who are citizens or permanent resident aliens of the U.S. The rules allow for the small business to be owned by another small business, but that small business itself must be majority owned by an individual.

There cannot be a second company that owns the company that owns the small business. Thus, if the 4-man SpDe, LLC, is bought by a 400-person aerospace company, it will retain its SBIR eligibility so long as the 400-person aerospace company's immediate majority owner was an individual who was a U.S. citizen or lawful permanent resident. But if that 400-person aerospace company were owned by a 50-person small business, SpDe, LLC, it would not be SBIR-eligible.

This, more than 50 percent rule, is also relevant when small companies take on investment. Assume one founder of SpDe, LLC, is a U.S. citizen and owns 51 percent of the company. The other founder is Australian and owns 49 percent. During a Series A raise, a foreign sovereign wealth fund obtains a four percent interest in the company. SpDe, LLC, is no longer eligible for SBIR awards. No U.S. person owns more than 50 percent anymore; therefore, companies prioritizing winning SBIR contracts will want to carefully vet investors and potentially decline funds if the nationality of the investors will result in the company no longer being more than 50 percent owned by a U.S. person.

Control. Importantly, the SBIR rules require U.S. person ownership and control. Companies that focus on the former and overlook the latter risk their SBIR eligibility. When forming SpDe, LLC, the founders took care to ensure the U.S. citizen owned a 51 percent stake while the Australian co-founder remained the minority owner. However, SpDe, LLC's operating agreement required both founders to approve any company expenditure over $50,000, the borrowing of funds, and entering contracts. As a result, the Australian founder has the ability to block certain transactions.

This type of negative control by a foreign person likely would mean the company would not qualify for SBIR contracts. Consequently, company governance documents, voting rights agreements, and even contractual and licensing agreements must not allow a foreign person to direct, control, or influence a company's operations if the company wants to be considered for SBIR awards.

Why It Matters

Space companies interested in SBIR opportunities need to understand their ownership, control, and affiliations. SBIR eligibility is not about making a good faith effort or making assumptions. Before every SBIR award and whenever the government asks, the company must certify that it is indeed eligible for SBIR-funded contracts. A false certification can lead not only to contract termination but also to potential False Claims Act liability and suspension and debarment from future government contracts.

Conclusion

As noted above, SBIR opportunities can be an excellent way for start-ups and small tech companies, including those in the space industry, to grow while also allowing them to deliver cutting-edge technologies to the U.S. government.

There is a growing need for space-based technologies and capabilities, with some yet to be discovered. The SBIR program is where many such technologies and capabilities will come from.

Small businesses wanting to participate in the SBIR program simply need to understand if they are eligible or not and not think being a small business is the only requirement.

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Author Curt Blake co-founded and was CEO of Spaceflight Inc., the largest provider of integrated launch services for small satellites. He established Spaceflight's global network of launch providers, which included SpaceX, Rocket Lab, Orbital, JAXA, Arianespace, and NSIL (the commercial arm of the Indian Space Agency). Curt was one of the first attorneys on-site at Microsoft, general counsel at Aldus, and COO at Starwave, giving him a solid combination of practical business experience and an intimate understanding of the legal risks involved in running companies. Curt has negotiated numerous launch contracts with companies all over the world, including India, Japan, Russia, New Zealand, Australia, France, Germany, Italy, the UK, Kazakhstan, Israel, Brazil, Luxembourg, Korea, and Canada, among others.



Author Timothy Cox is an accomplished attorney with more than 19 years of experience in federal procurement law and regulatory compliance matters and administrative investigations. Proven leader, driving process improvement and institutional transformation to enhance legal operations in support of organizational mission.




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SHIFTING RESILIENCE FROM THE GROUND TO THE CLOUD

"For too long, virtualized SATCOM has remained limited to a few, small-scale deployments. For end users to benefit, the sector must come together in an open ecosystem around proven operational realities."

By Dubi Lever and Juan Deaton

At the outset of Operation Epic Fury, Iran targeted SATCOM terminals and ground infrastructure across U.S. military bases in Bahrain, Kuwait, Saudi Arabia and the UAE.

In the days that followed, Hezbollah fired long-range precision missiles at the SES Ha'Ela commercial teleport in Israel. These events, combined with intensifying electronic warfare operations, have put the ground segment on the frontlines.

Recent conflicts are exposing the vulnerability of fixed ground infrastructure. Across the defense community, there is a growing need for distributed, software-defined SATCOM. Advanced electromagnetic spectrum operations require agility, which means more adaptive and diverse waveforms.

Mission-critical communications must leverage multiple networks, orbits and bandwidths. Within the U.S. Department of War, automated coordination of ground resources and a resilient infrastructure are becoming core requirements to ensure continuous operations, even when individual gateways are unavailable. In this new environment, legacy ground equipment is reaching its limits.

While companies are deploying virtualization to address the need, enterprise-level resilience cannot fall on a single vendor. It requires an open ecosystem. Building an open, interoperable SATCOM ecosystem, such as what exists in cellular, means broad participation by competing vendors.

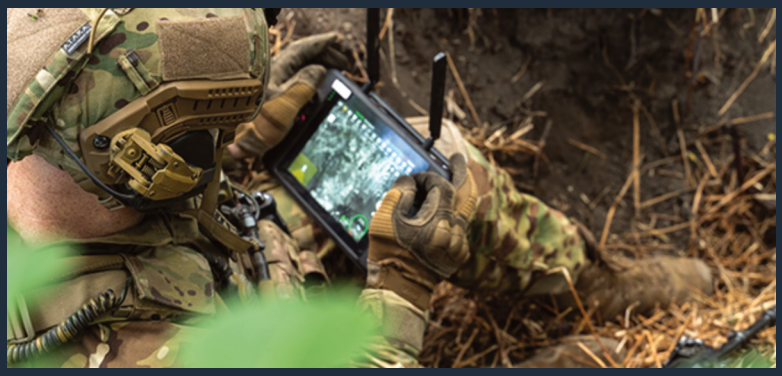
Gilat has taken the first step in porting its waveform to the cloud and worked through the challenges of flow control and link optimization from the cloud to the gateway.

In partnership with the ***Waveform Architecture for Virtualized Ecosystems (WAVE) Consortium*** and *Digital Intermediate Frequency Interoperability (DIFI) Consortium*, there is a validated, standardized framework that can be used across the industry.

For too long, virtualized SATCOM has remained limited to a few, small-scale deployments. For end users to benefit, the sector must come together in an open ecosystem around proven operational realities.

The Shift to Virtualization

In an increasingly contested environment, U.S. and allied defense organizations are prioritizing distributed, cloud-based resources over vulnerable, purpose-built ground assets. The approach must address resilience as well as fulfill the need for multi-band, multi-vendor, multi-waveform, multi-orbit connectivity.



The Air Force Research Laboratory (AFRL), Department of War Chief Information Officer (CIO), Army Product Manager for Wideband Enterprise Satellite Systems (PdM WESS) and others are underwriting the digital transformation of the ground segment, while supporting standardization through WAVE and DIFI, both recognized under Industry Standards and Technology Organization (ISTO).

Commercial innovation and government support have brought standardized, cloud-based SATCOM to a turning point. Members of the WAVE Consortium, AWS, Gilat Defense and SES Space and Defense, have validated a method for industry participants to transmit any virtualized waveform over an FPGA-based cloud platform using standardized protocol and reference architecture.

Virtual SATCOM deployments are on the cusp of commercialization and are ready for defense customers at the speed of need.

Beyond the Hype

This demonstration routed a 10 Mbps video stream through a Gilat Aquarius Pro modem running a DVB-S2X waveform, connected through a satellite emulator to a Gilat digitizer at the SES gateway in Maryland.

The RF signal was converted to a standardized Digital IF (DIFI) stream and transported into the AWS cloud over a dedicated 1 Gbps Direct Connect link. In the AWS cloud, a Gilat virtual modem used FPGA-accelerated cloud instances to receive and demodulate the stream back into video and generate return traffic through the SES gateway to the physical modem.

This demonstration was a milestone for standardized waveform virtualization. It was the first instance of an end-to-end virtualized SATCOM waveform in the cloud and recently first cloud-modem to transmit over the air. It used AI-enabled modem functions, specifically generative AI signal analysis to optimize link performance in real time.

This demonstration also validated the WAVE Gateway 1.0 specification—a benchmark for vendors and operators to migrate to digital waveform processing without redesigning modem architectures. The demonstration proved the feasibility of cloud portability, with development starting with an F2 instance in Germany and ending with the virtual modem software ported to an instance in Virginia.

Finally, aligning with the DoW's preference for reduced size, weight, and power, the cloud-based modem consumed just 8.5% of the F2 instance's CPU—a stark contrast to power- and compute-hungry CPU-only configurations. With FPGAs delivering roughly 10x the computational efficiency of pure CPU instances, early analysis suggests the potential to support six 100 mega-symbol Duplex DVB-S2X waveforms on a single FGPA instance.

A New Era for AI and Automation

The demonstration only scratched the surface of what AI can bring to SATCOM. Digitization and virtualization are forming the backbone for this new class of AI applications—moving modem functions into a software-defined environment makes signal data directly accessible to AI, an approach impractical with purpose-built hardware.

By running real-time AI analysis of digital signal streams, operators can implement event-driven triggers—programming automatic failovers to alternate to different paths, waveforms, or even constellations.

Together, virtualization and AI point toward SATCOM network autonomy, intelligent orchestration, and sovereign software-defined infrastructure, establishing a baseline for resilient military SATCOM and commercial 5G and future 6G networks.



The Path to Adoption

Current demonstrations are only the beginning. The same cloud infrastructure that runs DVB-S2X waveform can as easily run military-grade Direct Sequence Spread Spectrum (DSSS), 5G or proprietary waveforms. In the same way users pick an application on their smartphones, operators will soon be able to choose a waveform from a digital repository and run it as software.

The more vendors adopt standardized virtualization, the more the marketplace will mature and create the conditions for next-generation satellite services.

Migrating waveforms to the cloud will unlock resilience at a time when gateway infrastructure is increasingly at risk of physical targeting and degradation. Cloud-hosted waveforms give users a path to restore or reroute gateway functions when waiting for replacement hardware, field installation, or depot-level recovery are not options.

At the same time, AI and automation will deliver unique applications and real-time advantages in detecting degraded paths, recommending alternate routing and enabling faster mission recovery when fixed infrastructure is disrupted.

There is a real risk in allowing the threats to outpace the speed of adopting and deploying a standardized virtual SATCOM solution. The next step is to take a proven capability with broad industry and government support and operationalize it across hybrid SATCOM deployments.

As more partners join WAVE, industry must scale beyond limited trials to engage the defense community in functional demonstrations that will make today's breakthroughs tomorrow's operational reality.

Author Dubi Lever is Chief Technology Officer at Gilat Satellite Networks, where he has been driving innovations and shaping engineering concepts for next-generation satellite technologies for nearly three decades. He is also the Board Chair of the WAVE Consortium, where he leads initiatives to strengthen cross-industry collaboration and accelerate the development of open, virtualized SATCOM networks.

Author Dr. Juan Deaton is the WAVE Consortium's Executive Director, providing strategic technical guidance to the board while championing industry partnerships to drive SATCOM standards forward. He also serves as Chief Alignment Officer at Alignment Consulting and Engineering, helping clients with business and technology development strategies.

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THE SHAPE-SHIFTING SATELLITE

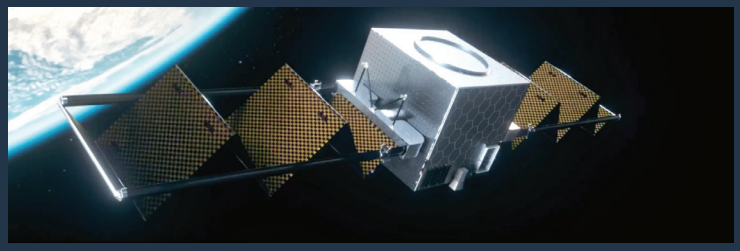
A satellite's shape is selected before launch, and fixed after deployment. Better deployment mechanisms turn shape into something spacecraft manipulate many times in flight.

"The more challenging problem is no longer simply detecting an object. It is deciding which characteristics of that object remain trustworthy when its shape can change on command."

By Adam Wong and Trevor Smith

A satellite starts life contorted into an uncomfortable shape. Solar panels are stacked against the bus, antennas are tucked into launch restraints, and booms sit wound around drums or flattened into canisters. Neatly folded, everything has to survive launch and fit within a fairing that has little sympathy for how large the spacecraft wants to become later.

Once the satellite reaches orbit, it starts unpacking. Latches fire, motors turn, hinges rotate, cables move through guides, and structures that occupied a thin volume against the spacecraft extend outward. Once everything reaches its operational position, the spacecraft settles down and usually stays roughly that shape for the rest of its life.



Part of the reason is reliability. Each of these latches, hinges, and motors are space mechanisms that can fail in several ways, and there are very few ways for a technician to walk over and fix it. If the appendage is necessary for power, communications, or sensing, one bad deployment can threaten the mission.

The natural response has been to minimize how often the spacecraft depends on those mechanisms. Deploy what needs to be deployed, verify that it made it out, and, for gods sakes, leave it alone. That engineering conservatism has quietly shaped spacecraft architecture.

As deployment mechanisms become reliable enough for repeated use, that assumption loosens. A deployable structure stops being only a way to package hardware for launch and starts becoming something the spacecraft can use during the mission.

Geometry becomes operational

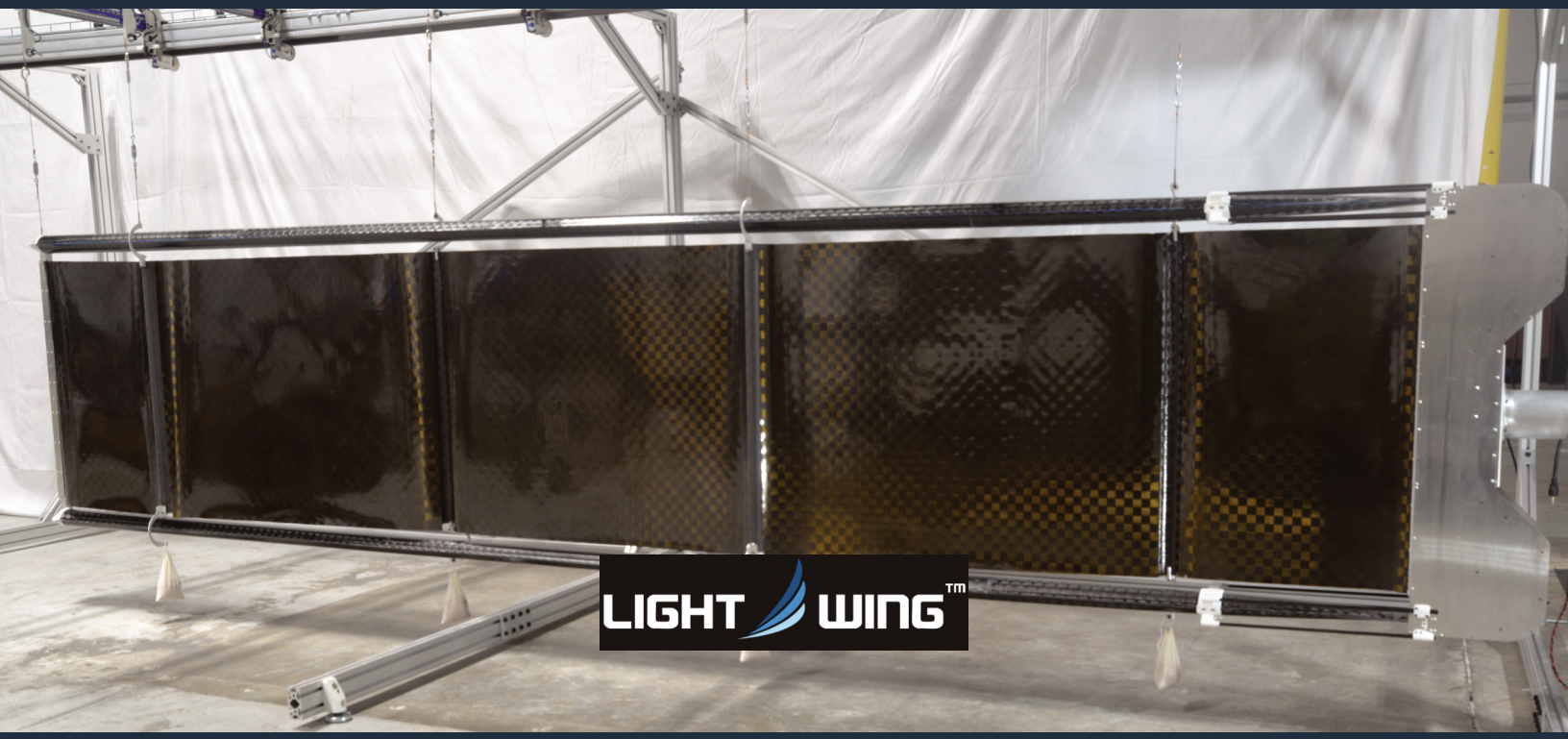
The solar array makes the trade easy to see. Electrically, the spacecraft wants as much collection area as it can reasonably carry. Large solar arrays have secondary effects though; mechanically, that same area becomes part of the vehicle, affecting inertia, structural response, pointing, maneuver, and the physical envelope the spacecraft occupies.

A configuration that is excellent for generating power, though, may be inconvenient during a close approach or a demanding maneuver. If the array can be pulled in and later deployed again with confidence, the spacecraft no longer has to live permanently with one compromise.

Once a spacecraft can morph between several useful geometries, shape becomes another control variable. This matters more as spacecraft become autonomous: a human operator can command a deployment or retraction occasionally, but a flight computer can continuously decide how configuration should interact with maneuver, pointing, sensing, power demand, and proximity to other objects. Fly-by-wire spacecraft can begin using geometry in the same way they already use other control inputs.

The observer sees the shape as well

Variable geometry also changes the assumptions around spacecraft observability. Spacecraft are usually detected, watched, and characterized from far away, using incomplete measurements



An inspection vehicle, for example, can travel with its power system deployed and become compact as it approaches another spacecraft. Reliable mechanisms mean that geometry itself becomes a variable to be tuned during operations. The same spacecraft can have a high-power configuration and a compact configuration without choosing between them before launch.

That is a familiar idea everywhere except space. Aircraft routinely change configuration because takeoff, cruise, maneuver, and landing place different demands on the machine. Spacecraft have historically concentrated most large structural motion into the beginning of the mission. More reliable deployables allow some of that motion to migrate into normal operations.

accumulated into a fuller picture over time.

Optical imagery, light curves, radar, infrared, RF emissions, and orbital behavior are combined to determine what a space object is, what it is doing, and whether it is the same object seen before. That process assumes physical continuity. The object observed tomorrow is expected to resemble the object characterized yesterday. However, a spacecraft whose geometry is deliberately variable weakens that assumption, and in some cases, breaks the process.

That is a significant change for space-domain awareness. Systems built to establish custody, classification, and pattern of life now have to distinguish between changes in the spacecraft's mission and changes in the spacecraft itself.

The more challenging problem is no longer simply detecting an object. It is deciding which characteristics of that object remain trustworthy when its shape can change on command.

A direct flight experiment would provide a cleaner answer. A variable-geometry spacecraft could be observed by existing commercial and government sensing networks while moving through several controlled configurations, allowing comparison of which identification methods degrade, which remain robust, and which characteristics prove invariant. The resulting data would clarify both how much control geometry actually gives the spacecraft over its observability and which cues tracking systems can continue to trust.

A different kind of spacecraft

The important threshold is not the invention of another deployable mechanism. Spacecraft have unfolded structures for decades. Instead, the threshold comes when engineers trust those structures enough to depend on their movement during normal operations. Once that happens, spacecraft design starts from a different premise.

The vehicle does not need one geometry that performs acceptably across every phase of the mission. It can have several geometries, each suited to a different part of the job, with software deciding when to move between them. At that point, drawing a spacecraft in one configuration begins to tell only part of the story. Its shape becomes a state rather than a definition.



Author Trevor Smith is the Founder and CEO of Atomic-6, an advanced manufacturing firm solving space's essential foundations of power, protection, and thermal management. By leveraging next-generation composites, Trevor's team is developing Hot Wing™, a redeployable high-efficiency radiator specifically optimized for the extreme thermal demands of orbital computing. This sits alongside Atomic-6's core portfolio: Light Wing™, a redeployable and mass-manufacturable solar array, and Space Armor®, an RF-permeable shield designed to stop hypervelocity impacts while resisting directed energy. Trevor previously co-founded Sprout Lighting and worked in commercial real estate. With hardware already in orbit, he remains focused on building the future of orbital infrastructure when he isn't following Formula 1 or riding dirt bikes.



Adam Wong is the VP of Business Development at Atomic-6, responsible for commercialization working across engineering, customers, government, and capital. He helps shape new programs from early mission concepts through technical scoping, pricing, proposals, strategic partnerships, acquisition strategy, and contract execution. He also works closely with Atomic-6's engineering team to close the gap between emerging mission needs and products. Before joining Atomic-6 full time, Adam co-founded a laser-comm startup, and accelerated aerospace startups and delivered due diligence to investors through his time at Starburst Aerospace. He worked previously in tech policy think tanks and on various DARPA projects.

IN FOCUS

Atomic-6 recently received a $2 million Space Systems Command (SSC) TACFI (Tactical Funding Increaes) contract to mature and flight-qualify the technology. What makes the firm's Ligh Wing lightweight, retractable and redeployable satellite solar array of interest to the military, especially SSC?.

Most conventional satellite arrays deploy only once and they then remain in their extended mode—with the Ligh Wing, the array folds back against the satellite and can be reployed later when needed. Applications for this tech include docking, proximity ops and rendevous capabilities.

In example, prior to even approaching another satellite, a military spacecraft with Light Wing the risk of damaging an extended array is reduced. Rapid maneuvers, inspection services and docking would not be so much of a concern with an array that can be retracted.

A number of capabilities this array offers include the ability to identify potentially enemy objects and identification of those objects, friendly satellite repositioning, on-orbit refuleing and repair, the inspection of satellites as well as disabled spacecraft recovery. According to the firm, the near-term application of Ligh Wing is for the identification of RPOD (rendezvous, proximity ops and docking).



Partially deployed, Light Wing™ solar array

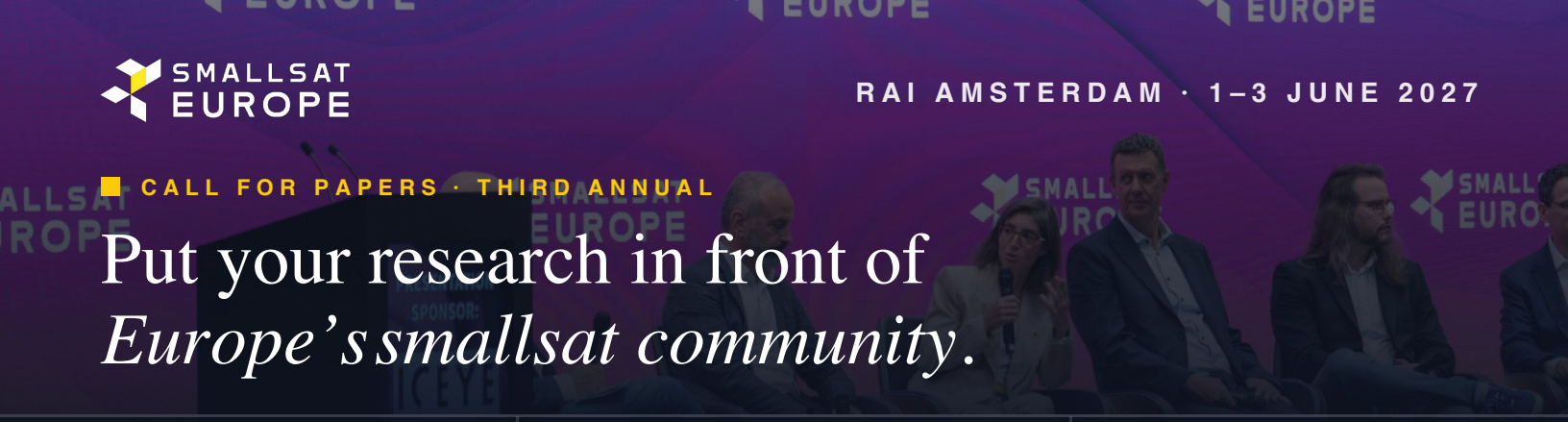
Spacecraft mobility is hindered by large, deployed, solar arrays and they are also suceptable to heavy structural loads and vibration. A military satellite with Light Wing would enable a satellite to entertain more aggressive maneuvers, debris field or threatening spacecraft avoidance, with the-then available ability to redeploy the array when negative conditions have been deterred. Another area is with a retractable array, the reflective area is reduced and that creates "stealth operations" as a possibility for such equipped satellies—not making the satellite invisible, but certainly gaining a temporary signature reduction., These matters are all quite relevant for a tactically responsive and more maneuverable spacecraft.

Dynamic space operations

The Space Force is moving beyond satellites that remain in predictable orbits throughout their service lives. Future spacecraft may need to reposition, inspect other objects, cooperate with servicing vehicles or respond to threats.

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15-MIN TALK · 30-MIN KIOSK Q&A

FORMAT 02

Poster presentation

A 30-minute session at your assigned digital kiosk, where your paper and supporting materials are displayed for attendees to explore in conversation with you.

30-MIN KIOSK SESSION

Papers presenting original mission details and in-orbit findings receive priority consideration, and may be selected for presentation on the primary business stage.

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SCAN TO SUBMIT



AN ACTIVE SHIELD FOR EVOLVING THREATS

Northrop Grumman's Layered Missile Defense

As the geopolitical landscape rapidly evolves, the need for a resilient, adaptable missile defense network is urgent. Northrop Grumman's layered approach combines capabilities available today with technologies that are designed to evolve as threats change, providing a ready-now, affordable solution that strengthens deterrence for the United States and its allies.

Through digital engineering, advanced manufacturing and close collaboration with government and industry partners, Northrop Grumman is accelerating the development and production of missile defense capabilities. The result is a comprehensive, multilayered shield designed to be faster to field, more affordable to produce and adaptable across domains—helping protect the United States and its global partners against today's threats while preparing for those of tomorrow.

Modern Architecture Built on Layers

Northrop Grumman's layered architecture allows a hostile missile to be detected in space, tracked by sea-based sensors, and engaged by the most appropriate layer—whether that be a kinetic interceptor launched from a frigate or a ground-based battery.

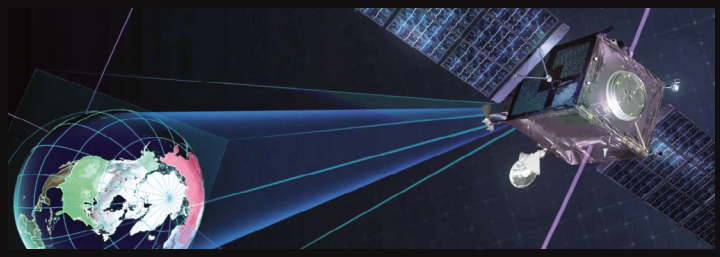
Together, the layers form a resilient net: a threat detected from space is tracked across multiple domains, classified with the help of AI and assigned the best interceptor before it ever reaches the defended area. The result is a unified kill chain—from first detection to final defeat—built to keep pace with the fastest threats.

That layered approach is reshaping how the joint force plans and fights.

> *"Northrop Grumman is bringing together next-generation sensors, advanced interceptors integrated with AI-enabled decision-making to help warfighters detect and understand threats sooner, make faster, more informed decisions and adapt as those threats evolve," said Rob Fleming, corporate vice president and president, Northrop Grumman Space Systems. "By connecting these capabilities through a software-driven approach, we can give warfighters a clearer picture of the battlespace and more options to respond."*

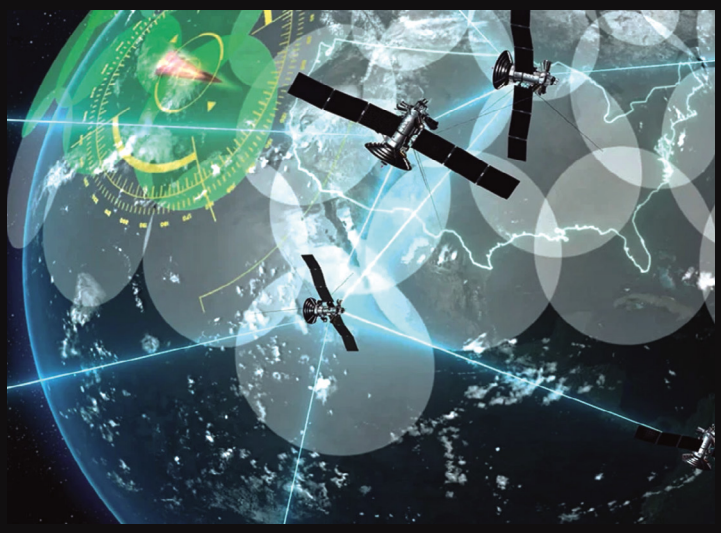
Missile Tracking and Warning

Next Gen OPIR Polar



Operating in highly elliptical orbits, these next-generation satellites will provide comprehensive early warning coverage of the entire Northern Hemisphere with modernized sensors designed to detect faint heat signatures from evolving ballistic and hypersonic threats.

Ballistic Missile Defense System Overhead Persistent Infrared Architecture (BOA)



Receives raw infrared sensor information from multiple satellite constellations, sending actionable data to warfighters via command-and-control systems to support rapid decision-making and active engagements.

Outpacing the Threat

Glide Phase Interceptor



Purpose-built to engage hypersonic threats during the high-energy and high-maneuverability portions of a missile's path.

Solid Rocket Motors & Propulsion Solutions: With more than 1.3 million produced to date, Northrop Grumman delivers solid rocket motors (SRMs) at scale and speed, while steadily ramping annual production rates from about 13,000 in 2024 to 25,000 by 2029.

Command & Control

Integrated Battle Command System: Connects sensors and effectors never designed to work together into one command and fire control system.

Affordability Through Smart, Scalable Design

It's not enough for capabilities to be advanced; they must be affordable and scalable. The company engineers affordability into every subsystem.

Northrop Grumman uses additive manufacturing, modular avionics and digital design to slash both acquisition and lifecycle costs while facilitating production at scale

Additive Manufacturing: Various critical interceptor components are 3D printed onsite using titanium alloys. This reduces lead time from months to weeks and eliminates costly tooling.

Modular Avionics: A flexible avionics architecture called Modular Avionics Control Hardware can be quickly configured to meet the demands of different launch vehicle control systems.

Digital Twin-Centric Development: Virtual testing and simulation throughout the design process cut risk, shorten schedules and keep the design adaptable.

Partnering With Allies to Extend the Shield

No nation can face hypersonic and advanced missile threats alone. Northrop Grumman is working with key allies to extend a shared shield and strengthen deterrence across Europe and the Indo-Pacific.

Northrop Grumman is addressing the growing threat of hypersonic missiles. Working alongside the Japan Ministry of Defense, the company is prioritizing cost-effective solutions to rapidly meet global demand for these technologies.

Northrop Grumman has formalized multinational cooperation agreements with the United Kingdom, Japan, Australia and several NATO members to achieve three critical outcomes:

Shared Procurement: Joint acquisition reduces per unit cost for all participants, resulting in more cost-effective solutions.

Interoperable Data Standards: Adoption of open architecture protocols ensures seamless sensor and shooter integration across allied forces.

Co-Located Basing: Forward deployed ground stations in Europe and the Indo-Pacific provide allied nations with real time situational awareness, extending the defensive perimeter beyond U.S. borders.

From first detection to final defeat, Northrop Grumman's layered missile defense is already helping protect the United States and allies every day. By combining ready-now capabilities with digital, rapidly upgradable architectures, the company is laying the groundwork to ensure the United States can remain ahead of whatever might come next.

northropgrumman.com

QUANTUM COMPUTING THREATENS PREMATURE SATELLITE OBSOLESCENCE

The quantum computing threat to encryption is "Q Day." When it arrives, a powerful quantum computer can and likely will shatter the public-key cryptography protecting our most sensitive dat and systems.



For satellite operators, however, a distant "someday" is the incorrect framing.

The U.S. government is preparing for Q Day by 2030/2031, well before the intended retirement of much of the world's satellite infrastructure.

To be resilient, industry must focus on building trusted, quantum-resistant products... today.

The problem is acute as satellites are commissioned, built, and flown on timelines commonly measured in decades.

A communications or Intelligence, Surveillance, and Reconnaissance ("ISR") platform entering production this year may still be operational well into the 2040s.

The cryptography protecting its command links, telemetry, and payload data must survive not just today's threat environment but whatever it looks like years after Q Day—on hardware that, once launched, largely cannot be replaced.

One well-understood risk is adversarial nations collecting encrypted data now, knowing quantum decryption is coming. This "collect now, decrypt later" threat lands hard on satellites due to the mismatch between their long service life and the accelerating quantum timeline: an adversary intercepting traffic today doesn't need to break it today, only store it until a quantum computer can, while the data may still be sensitive when it's finally read.

That threat, however, is far from the most severe one satellite operators face. More complicated and difficult to guard against are side-channel attacks, data integrity, and command-authentication risk—challenges that satellite programs must overcome to avoid premature obsolescence and economic losses.

The Deadline Is Crazy Tight

A significant challenge is broad failure among many senior policymakers outside the CIO stovepipe to understand this schedule risk. Media coverage of the government's post-quantum push centers on Executive Order 14412 (June 22, 2026), which gives federal agencies until 2030-2031 to migrate to PQC.

However, those dates don't govern satellites. EO 14412 carves out National Security Systems ("NSS"), which covers essentially all military satellites. Instead, the NSA's own Commercial National Security Algorithm Suite 2.0 controls — and it requires new NSS acquisitions to be CNSA 2.0-compliant by default starting January 1, 2027. That's the deadline that concerns anyone designing a satellite right now.

Software Approaches to PQC Are Valuable, But Do Not Mitigate All Q Day Threats

Faced with that timeline, the fastest response for many programs has been a software patch: swap vulnerable algorithms in flight and ground software for NIST-standardized PQC algorithms, and call the box checked.

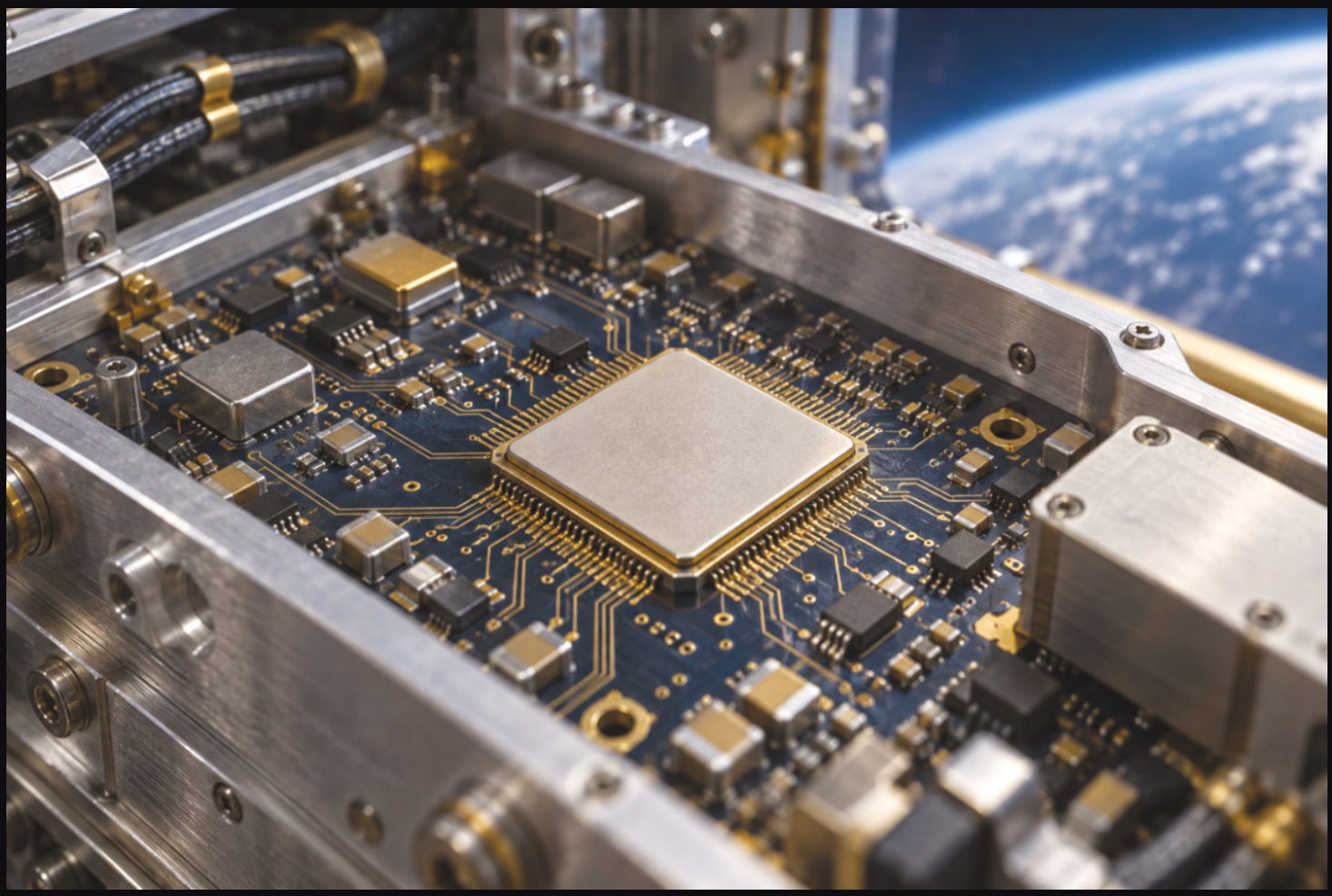
For harvest-now-decrypt-later interception, that's largely sufficient. ML-KEM and ML-DSA are designed to resist both classical and quantum cryptanalysis, and a correct software implementation likely defeats that threat on the math alone.

But collect-now-decrypt-later is only one of the risks a compromised system presents. Two other categories persist even when the algorithm itself is unbroken.

The first is side-channel leakage. Cryptography running as software on a general-purpose processor produces observable physical byproducts as it executes. This vulnerability has been known and well characterized for decades. Variations in timing, power draw, and electromagnetic emissions can depend on the secret key being processed.

Much like a safecracker listening for telltale sounds with a stethoscope, an attacker who measures those signals precisely enough may reconstruct the key without ever attacking the algorithm mathematically. A ground station or satellite that has upgraded its algorithms but still runs them in software on commodity processors remains exposed to this attack class regardless of how sound the PQC math is.

The second is integrity and command-authentication risk, which may not require breaking any cryptography at all. An adversary who penetrates a ground station or satellite through conventional intrusion can corrupt data in transit or inject unauthorized commands, disrupting or even destroying critical systems.



Defending against the former requires continuous authenticated encryption and integrity verification at line rate; defending against the latter requires the spacecraft to cryptographically verify every command's authenticity, and the broader system to detect a ground-segment compromise fast enough to revoke that station's authority before damage is done.



Hardware as the Missing Layer

Software running on a general-purpose CPU can technically perform authenticated encryption and continuous integrity verification, but it cannot normally do so in a way that provides adequate protection against side-channel attacks. Doing so at the throughput, power budget, and side-channel resistance a spacecraft or high-tempo ground station needs is a problem general-purpose software architectures are not well suited to solve on their own.

That gap makes room for a new category of silicon: small, reprogrammable, side-channel-hardened cryptographic accelerators built to serve as a hardware root of trust, anchoring not just the algorithms a device runs but its ability to prove, continuously, what it's actually running.

BTQ Technologies' QCIM (Quantum Compute-In-Memory) architecture illustrates where this category is headed. QCIM's underlying design is synthesizable "soft IP"—logic that must be run through chip-design tools before it becomes physical silicon.

BTQ delivers it two ways: licensing the RTL code to chip and device manufacturers for their own ASIC or FPGA designs, and pursuing standalone QCIM chips through a foundry partner.

Either way, QCIM combines classical algorithms (e.g., AES, SHA-3, ECDSA) and PQC algorithms in a single reprogrammable block, engineered for side-channel resistance and for the throughput needed to verify signatures and firmware integrity continuously rather than once at boot. That reprogrammability means that even if today's trusted algorithm is later compromised, a more secure one can be uploaded at the hardware layer without redesigning the chip. BTQ is targeting certification against FIPS 140-3, Common Criteria EAL5+, NIST's Cryptographic Module Validation Program, and CNSA 2.0 compliance.

The Competitive Case for Moving Early

To avoid early obsolescence, hardware manufacturers need a compact, side-channel-hardened, reprogrammable root of trust capable of continuous rather than one-time verification. Satellite and ground-segment architectures will need to land to satisfy CNSA 2.0's new-acquisition standard and hold up under NSA/CNSS reporting.

Programs and primes that build this in at the design stage, rather than retrofitting hardware already in production or in orbit, will be positioned to answer a question evaluators are increasingly likely to ask: not just whether a system supports PQC algorithms, but whether it protects them against side-channel attacks.

A program that can point to a hardware-rooted, continuously-attesting architecture has a materially different answer than one that can only point to a software patch. As that distinction becomes a proposal-evaluation criterion, it becomes a competitive differentiator that's cheap to build in now and potentially impossible to retrofit later.

The Amortization Problem

This is where the regulatory timeline collides with satellite economics in a way that should concern program financial planners as much as engineers.

Geostationary communications and ISR platforms are commonly designed for service lives of ten to 15 years, with some defense payloads planned for longer; proliferated LEO constellations plan on shorter horizons, commonly three to ten years.

A satellite entering production or launching today under a software-only PQC architecture could still be mid-life, or earlier, when CNSA 2.0's phase-out deadline for non-compliant equipment arrives at the end of 2030, and well within its service life when CNSA 2.0 use becomes mandatory at the end of 2031.

Software-only solutions are useful and have their place in PQC migration, but they are not the complete answer. If the operative standard shifts from "runs PQC algorithms" to "runs PQC algorithms inside a hardware-rooted, side-channel-resistant, continuously verifying architecture," the direction CNSA 2.0 and the broader push toward device-level, machine-speed defense are already signaling, a satellite designed today without that hardware foundation risks falling out of step with its customer's expectations years before the end of its service life.

That leaves three costly options:

1. ***an expensive and likely incomplete retrofit***
2. ***formal acceptance of elevated risk for the rest of the mission; or***
3. ***early retirement of an asset designed to be amortized over ten or 15 years but functionally obsolete in six or seven.***

Each compresses the economic life in a program's financial assumed model. This is a cost that shows up on a balance sheet, not just in a security assessment.

A Call to Action

The deadline that matters for satellite programs was never really "2030." For the parts of the satellite ecosystem that qualify as National Security Systems, the operative standard arrives much sooner; the obsolescence cycle is much shorter, and robust defense demands more than an algorithm swap.

Operators and primes that treat hardware-rooted, side-channel-resistant cryptography as core architecture now—not a future upgrade—will be the ones whose satellites are still trusted, still compliant, and still earning their full amortized value well after 2030 and 2031 arrive. The key to success after Q Day is building trusted, quantum-resistant systems now.

btq.com

BTQ

Brandt Pasco is a Washington, DC-based attorney and strategic advisor to BTQ Technologies Corp. He brings more than two decades of experience across government, law, venture capital, technology commercialization, and national security, including prior roles with the US Congress, Department of Defense, National Security Council, and In-Q-Tel.



WHY THE FUTURE OF SATCOM IS MULTI-ORBIT

By Mike Grimshaw, Senior Director of US Government Sales, Lite Coms



Satellite communication systems are moving away from single-orbit architectures: operators who need more reliable, flexible communications are now looking to more ambitious architectures to deliver the flexibility, reliability and high data throughput needed for operations today.

Today, no single orbit delivers everything that the warfighter might need from a satellite communications solution. Low Earth orbit (LEO) delivers ultra-low latency and is resilient against electronic warfare threats through the sheer number of satellites, while medium Earth orbit (MEO) makes up for its higher latency with predictable throughput and high-capacity beams. Geostationary orbit, or GEO, works with dedicated military constellations, providing fixed, highly reliable wide-area coverage, while highly elliptical orbit (HEO) is essential for polar operations.

Each has its own strengths and its own advantages in different situations—which is why forward-thinking military forces are looking for satellite communication systems that can deliver all of these advantages in one package.

Multi-orbit SATCOM (which brings together GEO, MEO and LEO constellations) delivers significant advantages compared to single-orbit systems such as improved flexibility, resilience, and throughput - and can ensure forces are not left without connectivity, even in the most challenging environments.

Rather than depending on one single network (with the potential for that connection to fail at a critical moment), multi-orbit SATCOM architectures offer a way to ensure operators can stay connected to command and control, even in extreme and austere environments. The technology also has important applications when it comes to delivering fast connectivity for vehicles, and for use alongside technologies such as autonomous vehicles.

Delivering In Austere Environments

For end users in the defense sector (but also in sectors such as emergency response or other commercial applications requiring connectivity in challenging areas), multi-orbit SATCOM architectures mean freedom from depending on a single network to deliver, instead integrating multiple orbits into a single, resilient communications architecture.

This is of particular importance in contested environments where electronic warfare is used to disrupt or jam connections, and in austere environments where infrastructure such as cell towers and power supply may be damaged, blocked, or otherwise absent.

In real-world operations, delivering uninterrupted command and control for personnel is vital, and multi-orbit SATCOM architectures deliver this via improved redundancy by leveraging multiple satellite networks. Commanders need to ensure tight integration across terminals and network infrastructure to ensure reliable performance and minimize operational complexity.

By focusing on the speed of deployment and the usability for operators, multi-orbit SATCOM architectures can help to drive mission success in the most remote, austere and contested environments. Multi-orbit SATCOM architectures are already playing a vital role in supporting critical connectivity in global defense.

Why Multi-Orbit Matters

Multi-orbit architectures are already used in thousands of terminals and are already delivering for forces in real-world conflict zones. Popular terminals operate across both geostationary and low Earth orbits, providing the twin advantages of both while also boosting resiliency. By offering more alternative paths, operators can make capacity planning easier.

In vehicles, for example, a move away from single-network VSAT towards multi-orbit vehicle-mounted capability offers increased options in terms of satellite resources, even when operating at the tactical edge.

With LEO constellations offering low latency and high throughput (ideal for real-time applications), and GEO providing stable coverage over large geographic areas, multi-orbit systems offer a way for vehicles to combine these strengths. Operators can make use of the reach and availability of GEO, while relying on LEO for low-latency applications while moving. This has important applications in contested electromagnetic environments, meaning that units can shift from GEO uplinks to proliferated LEO constellations when needed.

Delivering In the Field

What's critical is to have seamless transitions between different constellations, with terminals arriving ready to operate across multiple constellations. By combining multiple orbits into single systems, forces can ensure that the increasingly large data demands of today's forces can be delivered at any time. In contested environments (such as we are currently seeing in conflicts like Ukraine), access to data has become increasingly vital, with vehicles now getting hundreds of megabits per second. Multi-orbit architectures mean that new applications such as controlling autonomous vehicles and getting data out of them are possible even in heavily contested environments.



To do so, systems must manage handoffs between satellites, keeping links stable and operating even in the most challenging or communication-denied conditions. This involves trade-offs such as balancing portability and performance, reducing size, weight and power requirements (SWaP) where possible, and keeping systems simple enough to deliver for the warfighter.

Systems need to be deployed rapidly and also to be reliable even in the most austere environments. Such systems need to be designed so that vehicles, for example, can route data via LEO or GEO or even 5G—whatever has the highest throughput, resilience and availability—and that needs to be automated so people in vehicles do not have to think about it.

Today's ground vehicles are becoming increasingly connected, with everything from command and control to ISR and autonomous systems—and to deliver that, multi-orbit will be increasingly vital.

A Multi-Orbit Future

For combatant commands and planners evaluating different SATCOM systems, multi-orbit has grown vastly in importance in recent years. Thanks to factors such as electronic warfare and the greater data requirements of today's warfighters, multi-orbit will form a key part of delivering for forces in the field, particularly in challenging and austere environments.

With new technologies such as autonomous vehicles posing their own connectivity challenges, the importance of the redundancy, flexibility and reliability offered by multi-orbit is going to continue growing for forces operating in contested environments worldwide.



Michael Grimshaw is Senior Director of USSOCOM Sales & Business Development at Lite Coms, where he focuses on advancing tactical communications and technology opportunities for Special Operations Forces. He brings decades of experience in national and theater-level communications, having previously held roles including Director of Programs – USSOCOM at Klas Government, a role in SOCOM growth at Anduril Industries and Technical Lead for the USSOCOM PEO-TIS Satellite Deployable Node (SDN) program at SPAWAR/NAVWAR.

From Refueling to Relocation: SSC Expands On-Orbit Support Capabilities

Q&A with Col. Scott Carstetter, Director of Servicing Mobility & Logistics

By Space Systems Command Public Affairs



The U.S. Space Force created Space Systems Command's (SSC) Servicing, Mobility and Logistics (SML) program office to explore on-orbit capabilities. Today, that office oversees enterprise service level strategy and optimized space vehicle constellation architectures for what has become a high profile mission area for sustained space maneuver.



Col. Scott Carstetter
Director of Servicing, Mobility & Logistics, SSC

Col. Scott Carstetter serves as the director of SML at Cape Canaveral Space Force Station, Florida. Assigned to SSC's System Delta 80, under the Space Access Portfolio Acquisition Executive, Carstetter leads a diverse team in advancing emergent capabilities that enable on-orbit sustained space maneuver, close mission gaps through satellite life extension, and provide on-demand terrestrial delivery of cargo to U.S. Combatant Commands with U.S. launch vehicles.

SSC Public Affairs recently discussed this topic with Col. Carstetter to discuss the many opportunities within this growing mission area.

Colonel, what is the latest information regarding On-Orbit Refueling?

Col. Carstetter

We are leaning forward to leverage commercial development and targeted government investments to change the way we operate and fight in space. Operationalizing on-orbit refueling is another step in meeting USSPACECOM's demands for Sustained Space Maneuver.

Our team plans to conduct the USSF's first-ever GEO refueling demonstration in 2027 while simultaneously kicking off an operational refueler prototype that we expect to begin on-orbit refueling operations in 2032. This will significantly increase reachable RG-XX targets at a reduced cost compared to procuring additional spacecraft.



Artistic rendition of an on-orbit Rendezvous, Proximity Operations and Docking (RPOD) activity.

What is Sustained Space Maneuver?

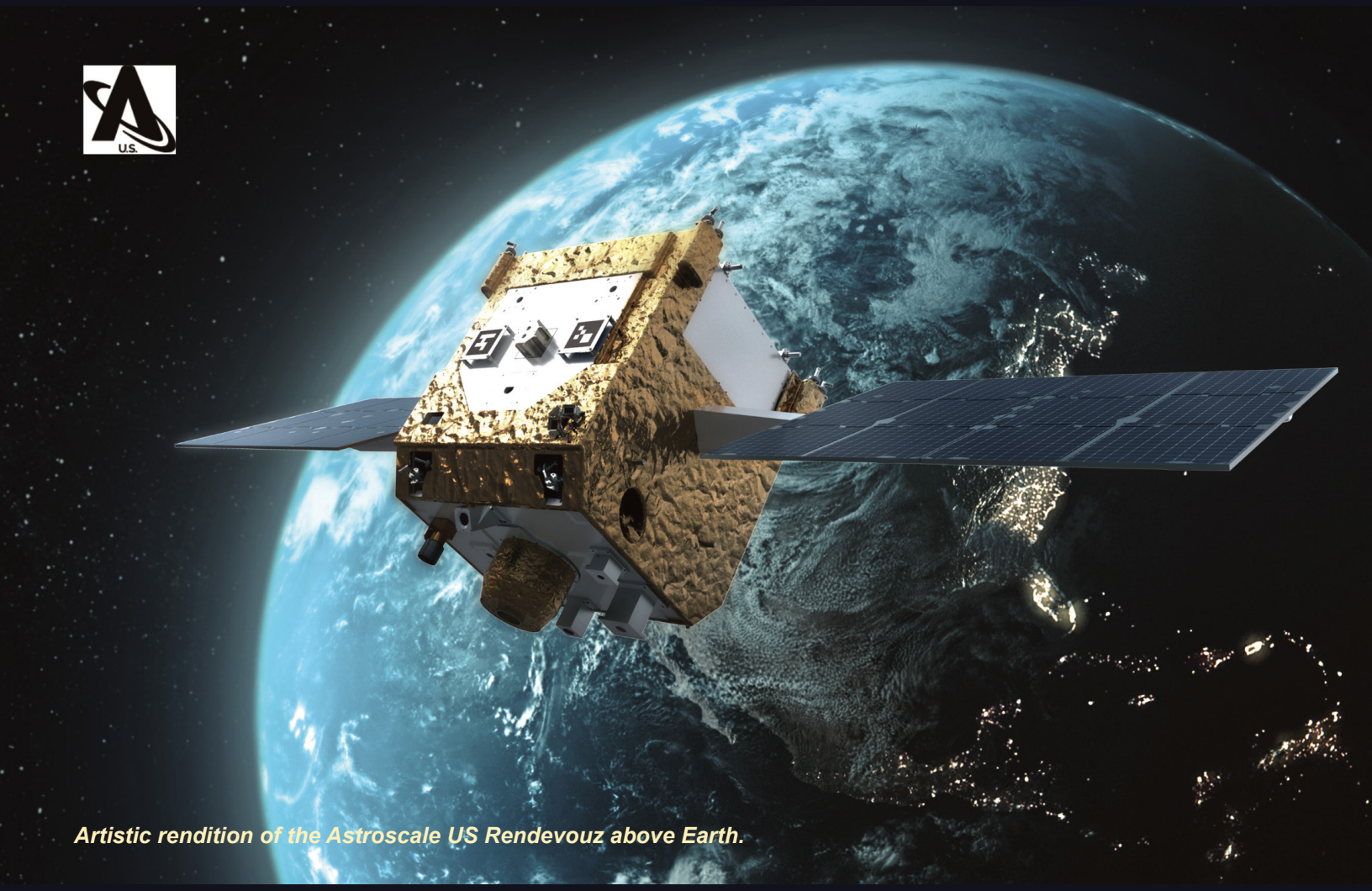
Col. Carstetter
Increasing competition and emerging threats in space have led to an increased urgency for finding non-traditional solutions that protect space assets. USSF needs sustained space maneuver (SSM) to conduct counter-space operations to achieve space control or space superiority. Continued analysis of the current and future state of the space environment will help determine what role SML will have within the Department of War (DoW) to achieve the required SSM in the future.

What is On-Orbit Augmented Maneuver and why is it important?

Col. Carstetter
Augmented maneuver provides station-keeping, life extension, or relocation services to spacecraft that were not originally designed to be serviced on orbit. In partnership with Combat Forces Command, we have identified several satellites valued at billions of dollars that would immediately benefit from augmented maneuver services, enabling increaed capability to the warfighter at a fraction of the cost though life-extension services.

We are leveraging advancements in commercial Rendezvous, Proximity Operations and Docking (RPOD) capabilities to provide Augmented Maneuver (Space Tug) services to unprepared on-orbit satellites. (*See image on previous page.*)

Our demonstration with Starfish Space's Otter space vehicle (*pictured at the bottom of the preceeding page*) in 2027 will include relocating Electro-Optical Weather System (EWS) G1 to a disposal orbit, paving the way for an operational Space Tug to begin providing relocation and life-extension services to operational satellites in 2028. Orbital transfer, capability extension, and technically responsive space capability will be part of this 2-year demonstration.



Artistic rendition of the Astroscale US Rendevouz above Earth.



Artistic rendition of the Starfish Space's Otter space vehicle on-orbit.

Col. Carstetter
Yes, Astroscale US will build and launch the Astroscale Prototype Servicer – Refueler, now called Provisiotner (*pictured on the following page*). The refueling demo is a partnership between AFRL, DIU, SYD 80 and SYD 89 and aims to demonstrate a scalable commercial architecture using a depot-shuttle-client model.

The demonstration uses DIU-purchased fuel stored on a commercial Orbit Fab depot and the commercially owned and operated Astroscale Provisioner to refuel government owned AFRL Tetra-5 satellites.

What is the timeline for operationalization of the capabilities that the SML team is exploring?

Col. Carstetter
We are evaluating these emerging technologies and capabilities for their military utility. The upcoming SML demonstrations will inform how the capabilities can be operationally employed. By leveraging the Accelerate the Procurement and Fielding of Innovative Technologies (APFIT) initiative, the SML team is rapidly pursuing an operational augmented maneuver vehicle to follow the demonstration.

We're also pleased that the RG-XX program has a satellite refueling requirement for the proposed future space vehicles and is actively engaged in cross-program discussions to identify potential options for an operational refueler to service these vehicles.

How is the Space Force meeting demand signals for SML capabilities that are coming from USSPACECOM and have witnessed Congressional interest?

Col. Carstetter
In some cases, SML services and client satellites will need to be developed and presented on similar schedules which will dictate timelines. Other capabilities, such as augmented maneuver satellites that can service unprepared, allow us to move forward quickly as we are doing with the $48.5M Office of Secretary of War (OSW) AFIT award.

This will support procurement of the space tug vehicle which will provide on-orbit augmented maneuver to operational space vehicles in need of support for station keep, life extension, or relocation services. Additionally, we have a robust engagement strategy with industry and academia to align industry investments and promote commercial innovation.

What we are seeing a lot of now is the huge amount of Venture capital (VC) or private equity being used to support startups and early-stage Servicing, Mobility and Logistics companies driving great progress without direct government investment. VCs also help the companies with their strategies, mentoring, technical assistance and provide additional investor and business development contacts.

What is the role of commercial? We read that USSF senior leaders are relying on commercial capabilities from industry to service this market.

Col. Carstetter

The Space Force prefers to leverage commercial services generally available to a commercial market, with minimal but necessary DoW-unique requirements. The SML team is taking a measured approach to understand the commercial landscape and the best places to apply limited government investment, consistent with DoW priorities.

While would-be providers have shared an optimistic view of capability maturity, industry and market experts have postulated the business case for commercial clients is yet to be fully realized. Thus, industry may need the Space Force to be the anchor tenant for several years if SML capabilities are required. As with other industries—aviation and space launch, for example—government needs are addressed and commercial business cases develop over time.

Is the USSF commercial-first strategy a driver for your current On-Orbit Space Logistics Challenge?

Col. Carstetter

Absolutely, we are challenging commercial industry to bring their most innovative ideas to inform the next generation of novel SML capabilities. The $24 million On-Orbit Space Logistics Challenge is being led by Space Systems Command in partnership with SpaceWERX.

It focuses on six major areas necessary to building out a resilient in-space logistics network: propellant management; orbital transfer vehicles; network mechanics; orbital warehousing; repair, reuse and refuel; and logistics health monitoring.

As space becomes an increasingly contested warfighting domain, the U.S. military has its eye on technologies that would allow satellites to maneuver in GEO—both to avoid becoming sitting targets and to shift locations to better support military activity on the ground. Key to these ambitions is the nascent industry focused on a host of on-orbit servicing activities, including satellite refueling. Do you think that the USSF will decide this year to call for refueling capabilities on some of the next generation satellites?

Col. Carstetter

The President has directed that we'll secure national interests in, from and to space. In support of that charge, our primary goal right now is to identify requirements, concepts of operations, and the true feasibility of these capabilities.

We need to understand if these capabilities make sense in the grand scheme of things. Alternatively, if they are supported by good business cases, it may be better to develop these capabilities or replacement satellites might be less expensive or more effective given rapid growth in technology.

The Space Force cannot defend or reposition satellites if those spacecraft cannot maneuver. Dynamic space operations, a phrase increasingly used by the service, depends on mobility and sustainment that rockets alone cannot provide.

Together, Space Force representatives, industry experts, academia and acquisition professionals are helping to define the capabilities needed to build a resilient in-space logistics enterprise and enable sustained operations in orbit.

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