SPACE FORCE ASSOCIATION
SPACEPOWER
MAGAZINE

The Warfighter Ethos

The Beating Heart Driving SSC's Internal Transformation

SFA Founder Message: Welcome to Spacepower Conference 2025

Software Modernization Strategies in Legacy Space Systems

Fueling the Future of Spacepower

SPACE FORCE ASSOCIATION
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MESSAGE FROM SFA'S CEO

Dear Space Force Association Members and Conference Attendees,

As we come together for the third annual Spacepower Conference, I am reminded of the resilience and dedication that defines our community.

This year, Spacepower Conference feels especially significant as a portion of our planning for this conference took place during a period of uncertainty. Before all else, SFA made sure to prioritize supporting our Guardians, offering them a valuable resource guide to navigate the shifting landscape and to stay focused on mission readiness.

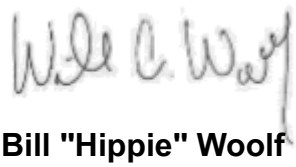
Despite these challenges, SFA knew, without a doubt, the show must go on. Our team remained steadfast, working to ensure this event would continue as a platform for thought leadership, collaboration, and progress. It is, after all, SFA's responsibility to advocate for our Guardians and the USSF, and Spacepower Conference is prime opportunity to do so.

The Spacepower Conference is more than a mere conference in Orlando. It is a celebration of the people and ideas that are transforming spacepower every day. It's a place where Guardians, industry innovators, military leaders, and thought leaders come together to share knowledge, push boundaries, and ignite new possibilities.

Whether in the form of groundbreaking research, cutting-edge technology, or operational excellence, the voices you will hear over these next few days are a testament to the strength of our collective mission. I invite attendees to take full advantage of the opportunity to connect with colleagues, engage with thought leaders, and walk away with a renewed sense of purpose.

Looking ahead, Spacepower Conference also sets the stage for the opportunities that await us in 2026. The conversations we spark, the partnerships we form, and the innovations we showcase here will influence the strategic, operational, and technological milestones that lie ahead. As part of that momentum, we will be expanding our volunteer initiatives in 2026—and I encourage every SFA member who is able to step forward, get involved, and help strengthen the foundation of our growing community.

Thank you for being part of Spacepower Conference and SFA. Together, we are shaping a trajectory that helps to position the Space Force and the community that supports it for unprecedented growth and impact for years to come.



Bill "Hippie" Woolf
President & CEO

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On the Cover: *Art courtesy of United States Space Force.*

SFA is committed to achieving superior national space power by shaping a Space Force that provides credible deterrence in competition, dominant capability in combat, and professional services for all partners.

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LETTER FROM THE EDITOR

BY EMILY HONHART
Spacepower Magazine Editor

Dear Readers,

In this edition of Spacepower Magazine, you'll find a dynamic blend of topics – ranging from all-acquisition insights to what to look for at the 2025 Spacepower Conference and much more -- all packed into one comprehensive issue. It's a reflection of our community's momentum, curiosity, and commitment to advancing the conversation around national spacepower.

As we look ahead, 2026 marks an exciting evolution for the Space Force Association's flagship publication. We will be pivoting from the traditional, quarterly magazine format to a more agile, blog-style platform: **Spacepower News.**

This new format will serve as a vibrant hub for innovative ideas, industry developments, and government resources. Articles and advertisements will be accepted on a rolling basis, and members will gain the ability to reserve specific publication weeks, giving you greater influence over when and how your story reaches SFA's audience.

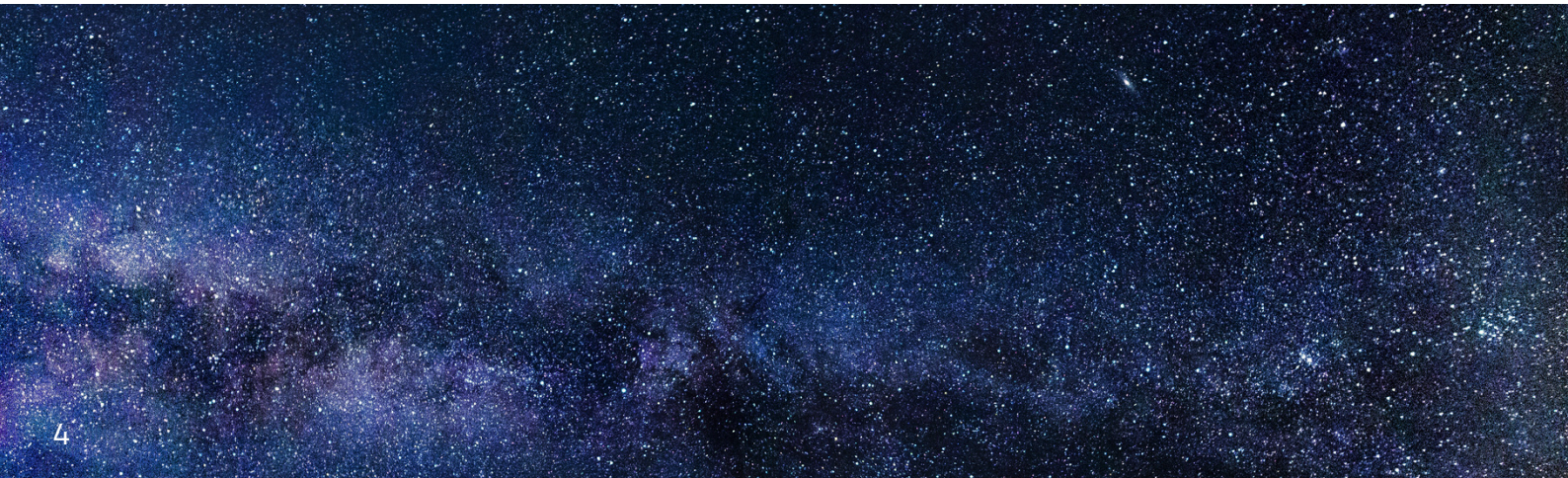
This shift brings significant benefits for our contributors and readers alike:

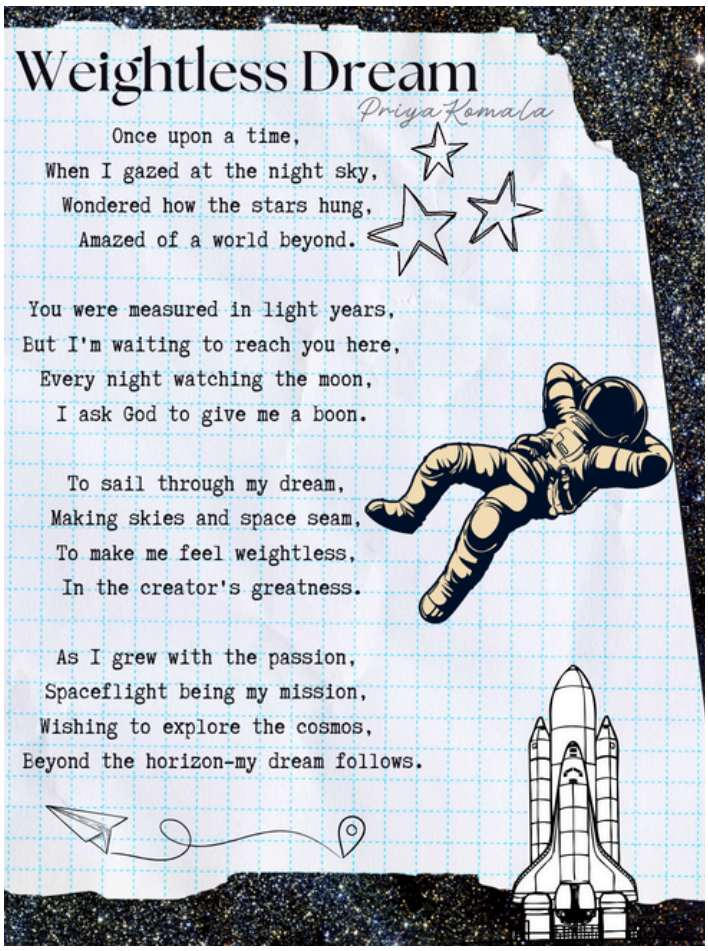
- **Timely submissions -** Share news and perspectives when they matter most. Or submit evergreen articles.
- **Alignment with your outreach calendar -** Publish in sync with product launches, announcements, or events.
- **More digestible content -** Bite-sized articles deliver greater clarity and impact.
- **SEO-friendly structure -** Member-provided link-backs help drive traffic and visibility.
- **Stronger social media promotion** - Focused amplification for your content.
- **Expanded advertising opportunities** - Go beyond the traditional membership deliverables with modernized display ads.

While we're enthusiastic about the transition, we're equally committed to closing this chapter with the quality and professionalism you expect. The final edition of Spacepower Magazine in its current form will be published digitally on January 15. **To be included, please submit ads and/or articles by December 15.**

Thank you for being part of this publication's evolution—and for continuing to shape the future of spacepower with your ideas, expertise, and vision.

Emily Honhart
Editor, Spacepower Magazine





Narayana Priya Komala is an SFA International Student Member. She is a high school student, a space enthusiast and aspiring astronaut.

Dr. Sierra Calhoun-Pollard poses with students at the Innovation Academy at the University of Florida. Under the guidance of faculty mentors and feedback from Space Florida professionals, Dr. Pollard led a group of sixty students in teams of five as they moved through the design thinking cycle: discover, perceive, ideate, prototype, and launch. The culmination of the course was a Showcase Event, where each team delivered a private ten-minute presentation with Q&A before a panel of judges from both UF and Space Florida. ***Read the article on page 22.***

The Warfighter Ethos

A Driving Force in Next Gen Space Acquisition

BY USSF LT. GEN. PHIL GARRANT
Commander, Space Systems Command

The transition from space as a benign technological frontier to space as a warfighting domain has been rapid, profound, and irreversible. Chief of Space Operations Gen. Chance Saltzman captured this reality in a particularly salient element of his Six Space Force Truths:

"Space is a warfighting domain, not a collection of supporting activities."

At Space Systems Command (SSC), we design, acquire, and field capabilities that deter aggression, assure freedom of action, and, if necessary, fight and win in space. To achieve that mission, we must see ourselves clearly for what we are: warfighters. Every engineer, analyst, program manager, and contracting officer contributes to the operational advantage of those on the tactical edge. Every decision we make has consequences that ripple across the joint force.

This warfighter ethos is the beating heart driving SSC's internal transformation and is codified in our Command Plan along with a commitment to measure and report on progress against goals. Just over one year in, I'm immensely proud of our progress. The results are tangible and already having an impact on readiness.

Under our Command Plan's first Line of Effort – Modernize our Command Structure by Aligning and Prioritizing Resources – we have accelerated SSC's transformation from a legacy Air Force acquisitions center to a streamlined, acquisition-focused field command.

Key steps included:

- Separating embedded S-staffs and consolidating essential functions from legacy structures;
- Transitioning sustainment squadrons to Space Operations Command (SpOC);
- Establishing a new System Delta construct in alignment with operational Mission Deltas; and
- Developing a space-acquisition-focused manpower model to facilitate rapid reallocation of resources as SSC and the U.S. Space Force pursue initiatives that improve the readiness and lethality of our space capabilities.

Early wins include expedited GPS launches, delivery of M-Code, and the operational acceptance of several next-generation systems such as ATLAS and FORGE,—each a milestone in our drive to deliver resilient, interoperable capabilities faster.

The second Line of Effort within our Command Plan addresses the increasing complexity that is space acquisition, the urgency of the overall mission, and anticipated acquisition reforms directed by the Secretary of War and reflected in proposed House and Senate legislation. While the letter of the law is pending, the spirit of acquisition reform is alive and well within SSC as we cultivate a Guardian culture ***(continued)***

focused on warfighting and speed. Key achievements include the development of digital programs focused on Acquisition Professional Development, Knowledge, and Assessment, as well as ongoing Career Vectoring, and Speed Mentoring programs.

We also established the SSC Program Manager Intern Program to strategically acquire and develop early-career program managers through rotational assignments, certification fulfillment, formal training, and mentorship.

As efforts continue to streamline the Federal Acquisition Regulation, SSC's contracting professionals will be gaining more autonomy, and therefore must possess even deeper expertise, judgment, and confidence. From internships to post OTC, exposure to multiple programs across diverse phases of the acquisition life cycle ensures that Guardians of today and tomorrow gain the broad and deep understanding necessary for future leadership —of cost, schedule, and performance — in a contested domain.

Our third Line of Effort – Deepening Connection with Stakeholders – addresses the inherently joint, commercial, and international collaboration that is essential to maintaining U.S. space superiority. Here again we're seeing significant progress against goals. Here are just a few examples:

On October 1st, SSC's Commercial Space Office (CSCO) assumed management of pLEO SATCOM procurement from DISA and secured a capital working fund to accelerate commercial partnerships. In FY25, CSCO awarded over 90 new contracts on behalf of the Joint Force. Our Space Force Front Door portal has expanded beyond SSC to serve the entire Space Force and launched Orbital Watch to provide

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Ahead of the Reform Curve

Driving Acquisition Speed Through System and Mission Deltas

BY COL. ANDREW MENSCHNER
Deputy Commander, Space Systems Command, United States Space Force

Earlier this year, a White House statement said America's defense acquisition workforce is a national strategic asset critical to maintaining military superiority.

Those are powerful words that have particular significance for the warfighters of the U.S. Space Force. The operation – and the might – of our Navy, Air Force, Army and Marines depends on our superiority in space. We can't win the joint fight without winning the space fight.

Early Space Force leaders recognized that maintaining U.S. space superiority would require tearing down traditional acquisition silos and integrating stove-piped systems. With the activation of System Deltas (SYDs) in alignment with Mission Deltas (MDs), the Space Force is uniquely ready to answer the Secretary of War's burning question - Are we accelerating the delivery of integrated capabilities to solve our most pressing operational problems? – with a resounding YES.

The pivot to SYDs, while new, is already delivering wins. One of the first was reducing the launch timeline for GPS-III SV-07 from 24 months to seven months in December and further reducing it to just over three months for GPS-III SV-08 the following May. In addition, two legacy programs – FORGE and ATLAS - reached major operational milestones this year after transitioning to System Deltas and their corresponding Mission Deltas.

How – and why – do SYDs work faster?

In December 2023, Space Systems Command stood up two System Deltas pathfinders: one for positioning, navigation and timing (PNT) and one for electronic warfare. These System Deltas were aligned with what was then known as Integrated Mission Deltas (IMDs) in Space Operations Command (SpOC). The pilot pairings worked closely together, shared lessons learned, and formed a solid foundation for the creation of eight System Deltas activated by SSC between August and October of this year.

SYDs are all about erasing the divide between acquisitions and operations that exists in other services and that existed when SSC operated as a Space and Missile Systems Center. Each SYD consolidates capability development under a single mission-focused structure and is led by a colonel who coordinates directly with an operations and sustainment counterpart in Space Operations Command (SpOC), Space Training and Readiness Command (STARCOM) and/or Space Force component commands. For example, SSC's System Delta 88 is responsible for acquiring satellite communications capabilities. It is aligned with SpOC's Mission Delta 8, which is responsible for operating satellite communications constellations. Key acquisition decision making occurs at the System Delta level, allowing for greater agility to pivot and adjust as needed to meet delivery timelines.

> We can't win the joint fight **without winning the space fight**
> -Col. Andrew Menschner

That's a very brief overview of how System Deltas work. Why they work is what really excites me.

Before joining Space Systems Command as deputy commander, I spent almost two years as Commander of SpOC's Mission Delta 31 and personally witnessed the power of this construct to remove acquisition bottlenecks and get to finish faster. Take OCX. When I stepped into the Mission Delta Commander role, the relationship

(continued)

between acquisitions and operations was almost non-existent and the OCX program had been broken by years of delays. One of my first moves was to dedicate an entire crew of operators to development testing. That was a Mission Delta action. The development team's action was to integrate those operators into the development process and listen to their feedback about which capabilities to prioritize. This continuous communication loop meant that when the two sides came into development meetings and test readiness reviews, they were able to focus very quickly on the problems that were critical to fix and identify problems that could wait. Because in today's threat environment, our warfighters would rather have 50, 60 or 70 percent of a solution today versus waiting months or years for a 100 percent solution.

This is a decided cultural shift away from the days in which we would develop capability against a comprehensive set of requirements and not even show it to operations until it checked every single box on the list. That approach just doesn't work anymore.

To outpace the threat, our acquisition teams must be in conversations every single day with their operator counterparts. Having that tight organizational linkage between acquisitions and operations sends a clear, consistent, and unified demand signal to the development team and the test community. It allows us to get after the problems that are most important to fix and – based on feedback from operations - it allows us to make informed decisions on what can wait. This natural extension of our centralized PEO structure ensures our lean staff of acquisition personnel are uniquely focused on the warfighting mission rather than the next acquisition milestone. We are still working against requirements, but we are doing so in a smart, prioritized way that allows us to deliver warfighting capability incrementally faster.

Acquisition that takes smart risks informed by the operational environment is a huge win for the Space Force, for Space Systems Command, and for the joint force. And I can say with absolute certainty that this construct is going to help us move faster in space acquisition than we ever have before.

GUEST COLUMN

In Space Acquisition, Commercial Integration is Not an "Either/Or" Decision

BY COL. TIMOTHY TRIMAILO
Director, Space Systems Command Commercial Space Office (COMSO), USSF

For decades, government space systems were built as bespoke, standalone architectures. That made sense when only a handful of nations could operate in orbit. Today, the commercial market is global, fast, and unprecedently inventive. The challenge isn't whether commercial technology can meet our needs: it's how quickly we can adapt our acquisition culture to embrace it and get it into the hands of the warfighter.

Without commercial, dual-use technologies, we cannot maintain space superiority nor win in the event of a conflict in space. The threats we face today are evolving too quickly, the technology landscape is shifting too fast, and our adversaries are taking note. They see the opportunity of commercial technology and they are embracing it: building mega constellations, dabbling in dynamic space operations, investing in cybersecurity and hypersonic-type weapons that can be used to defeat us in the future.

For all these reasons, we can't afford to treat commercial space as an optional supplement to the fight. It's an operational imperative to integrate commercial into our architecture before we get to the fight.

The Commercial Space Office (COMSO) was established in 2022 then expanded a year later to put manpower and technology against that imperative. Early work involved unifying various commercial initiatives under a single entity, mapping the commercial landscape, getting a bead on emerging technologies, communicating mission needs to broader industry, and connecting small businesses with SBIR and STTR opportunities to nurture promising solutions. A pivotal lesson learned is that commercial integration falls along a continuum depending on mission risk tolerance, technology maturity, commercial market size, and the urgency to field the capability.

- In some cases, we can buy commercial off-the-shelf (COTS) products, data, or services that provide us with end-to-end solutions. The Commercial Satellite Communications Office (CSCO) is a great example of this approach, buying commercial SATCOM-as-a-service from a vast number of mature commercial companies where the systems are commercially owned and operated, and providing that capability to all of DoW, other government agencies, and some international partners.

- In other cases, we can buy commercial components and incorporate them into tailored capability builds. SDA's Proliferated Warfighter Space Architecture (PWSA) is a great example of this category of commercial integration. For SDA's Missile Tracking Layer, for example, there's not a big commercial market for things like infrared sensors, but there is for satellite buses, data processors, communications payloads, and other relevant off-the-shelf components. Integrating these into a custom government build allows for faster delivery to operations, saves money, and allows for greater focus of resources on developing the hard, military-specific components needed to deliver the mission.

- There are several other cases along the continuum. We are exploring unique, commercial-like concepts of operation that emphasize automation, machine learning, and artificial intelligence to reduce operator cognitive load and speed up decision-making. We are

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exploring increased R&D cost-share with the private investment community through mechanisms like SpaceWERX's Tactical Finance Increase (TACFI) and Strategic Finance Increase (STRATFI) program.

- All of these examples fall somewhere along the continuum of commercial integration.

Today, COMSO's focus is on delivering operational capability at speed. That means finalizing the first Commercial Augmentation Space Reserve (CASR) contracts, optimizing procurements through CSCO and the USSF's first-ever working capital fund called Enterprise Space Activity Group (ESAG), partnering with SpaceWERX, DIU, AFRL, DARPA, SDA, and others to mature dual-use technologies, engaging with venture capital and private equity enterprises to co-invest in critical capabilities, and driving toward fielded systems that provide real-world utility—not just components and tech maturation, but end-to-end capability. Our close partnerships with the commercial space industry and private finance are paying significant dividends ensuring both the government and private capital are investing in those technologies most dear to our success and continued dominance in space. This tight coupling is a revolutionary force multiplier in getting capabilities to the warfighter in record time.

I often describe CASR as the "master's degree" level of commercial integration. It's a massive, first-of-its-kind effort designed to ensure the nation can access commercial space capabilities in times of crisis or conflict. That means understanding what companies are out there, which ones are mature enough to contribute, and how their systems can be integrated with our government architecture. The lessons have been clear—every partner is different, with its own technical strengths, business models, and

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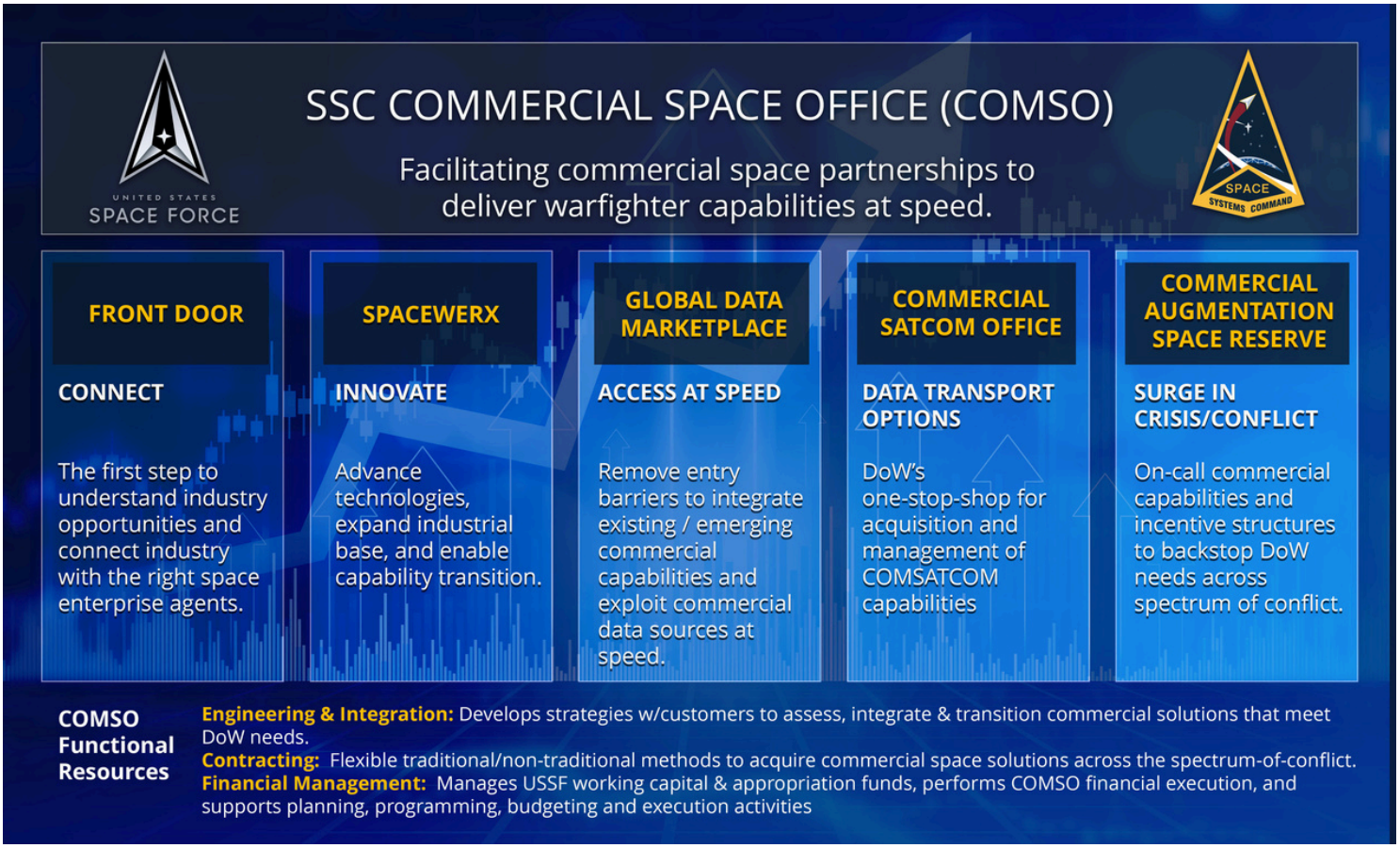

Building the New Space Ecosystem

BY DR. SIERRA CALHOUN-POLLARD
Woman in Space Board Member

The space industry is undergoing a remarkable transformation. Once defined by launches, payloads, and government agencies, it has become a thriving ecosystem of entrepreneurs, engineers, designers, and investors working together to build a sustainable future beyond Earth. Yet as technology accelerates, one constant remains: the need for education and collaboration that can keep pace with innovation.

Many people still describe space as a niche field, and space entrepreneurship as an even smaller corner of it. But that perception no longer fits the reality. Space is no longer limited to rockets or exploration missions. It touches industries as diverse as data analytics, manufacturing, materials science, artificial intelligence, design, and sustainability. The opportunities extend far beyond the launch pad.

Today's space economy thrives on cross-disciplinary collaboration. Engineers work alongside business strategists, data scientists, and creative thinkers. Startups and major corporations alike are reshaping how we explore, communicate, and sustain life beyond our planet. New partnerships between public and private sectors are driving innovation at a speed once thought impossible, opening opportunities that reach from the classroom to the cosmos.

A critical part of this transformation lies in bridging research with real-world applications. Organizations like NASA's Technology Transfer Program, Space Foundation, Space Florida and many others play a vital role in ensuring that technologies developed for space missions find new life here on Earth. From advanced materials to water purification systems and remote sensing tools, the innovations born from aerospace research are improving industries across healthcare, energy, and climate resilience.

Still, innovation alone is not enough. What the space industry needs most are translators, people who can connect technical breakthroughs to market needs, and who understand both the science and the story behind them. This is where the next generation of thinkers and entrepreneurs will define the future. By blending creativity, systems thinking, and sustainable design, they can transform isolated discoveries into solutions that advance life on and beyond our planet.

Florida's Space Coast offers a unique environment for this kind of progress. It is a living laboratory for innovation, where technology companies, startups, and universities converge. My current collaborations and partnerships with leading organizations such as Blue Origin, Space Foundation, Star Catcher, Collins Aerospace, Raytheon, and many more demonstrate how collaboration fuels progress. As I build the connection for students, researchers, and professionals to engage directly with these organizations, our goal is for them to gain not only technical understanding but also the confidence to shape the next era of exploration.

Artificial intelligence is another driving force in this new ecosystem. From autonomous navigation and predictive maintenance to satellite imaging and mission planning, AI is changing how we approach space exploration. The ability to process and act on vast amounts of data accelerates innovation, reducing risk, and expanding what is possible in both orbital and terrestrial applications. Understanding how to harness this technology responsibly will be central to the future of the industry.

As the ecosystem evolves, one truth becomes clear: space innovation is no longer the work of a

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Fueling the Future of Spacepower: In-Space Refueling as a Strategic Imperative

Why Refueling in Space Is Critical for U.S. Defense and Exploration

BY RICHARD NEDERLANDER, PHD
Founder & CEO, Spargo Space

Satellites today are constrained by the fuel they carry at launch, limiting their operational life and agility. In military space operations, this is a strategic vulnerability. U.S. Space Force leaders note that without on-orbit refueling, operators face a painful choice: conserve fuel and limit maneuvers, or expend fuel to evade threats but shorten the satellite's lifespan. As Gen. Stephen Whiting of U.S. Space Command put it, satellites should fly "until missions are complete, not until the fuel we launched with is depleted," yet currently "once they deplete their initial reserve, they are all but dead." In-space refueling would eliminate this dilemma, allowing satellites to "maneuver without regret," whether to dodge hostile acts or reposition for mission needs.

The same holds true for exploration. Sustained travel to the Moon, Mars, and beyond will hinge on orbital refueling depots and tankers to extend spacecraft range. NASA recognized that to make lunar missions sustainable by 2028, human landing systems must be reusable – and that means they must be refueled in space [1]. Deep-space transport vehicles like SpaceX's Starship are explicitly designed for orbital propellant transfer: multiple tanker flights in Earth orbit will top off a Moon or Mars-bound ship with liquid oxygen and methane. This architecture turns what would be one-way missions into round-trip voyages, carrying heavier payloads farther than ever before.

In the long run, tapping extraterrestrial resources could fuel missions; NASA's Artemis plans emphasize in-situ lunar propellant production, so future explorers can "produce fuel, water, and oxygen from localmaterials" and rely less on Earth supplies [2]. In short, orbital refueling is the linchpin for both resilient military spacepower and sustainable deep-space exploration.

Technological Advances and Key Industry Players

Not long ago, the idea of "gas stations in space" seemed far-fetched. Today, it is rapidly becoming reality due to advances in on-orbit servicing and autonomous rendezvous. As far back as 2007, DARPA's Orbital Express mission demonstrated autonomous docking and transfer of hydrazine between satellites – a historic first. Although that early program was shelved, it proved the concept was technically feasible [3]. Fast forward to the 2020s: a host of commercial and government initiatives are now pushing in-space refueling from experiment to operational capability.

Several key players are leading the charge. Northrop Grumman's SpaceLogistics division made headlines by extending the life of aging satellites using Mission Extension Vehicles (MEV) that dock and take over propulsion – the first-ever commercial servicing missions in GEO in 2020-21. Building on this, Northrop is developing a new Mission Robotic Vehicle and a fuel transfer payload dubbed "Elixir," slated to demonstrate refueling on the U.S. Space Force's Tetra-6 experiment in 2027.

Another pioneer, Astroscale U.S., is preparing a 300-kg refueler spacecraft that will perform the first-ever on-orbit refueling of a U.S. military satellite in geostationary orbit by 2026. This vehicle will carry a refillable hydrazine tank and conduct multiple refueling operations in GEO, showcasing how a servicer, client satellite, and propellant depot can work in tandem as an end-to-end fueling ecosystem.

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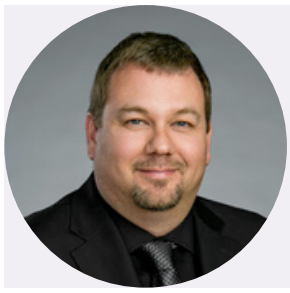
Software Modernization Strategies in Legacy Space Systems: The Data-Centric Imperative



BY KELLY STUHLSATZ
Solution Architect, Space Growth, OMNI Federal

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DISRUPT | INNOVATE | SUCCEED

The operational reality for many current space missions is that they still rely on legacy ground systems, heritage architectures built decades ago using rigid Waterfall development processes and dependent on specialized, aging procedural languages. These systems are slow, siloed, costly to sustain, and inherently brittle, limiting adaptability and resilience in today's dynamic space environment.

Many legacy systems were designed for simpler, closed-loop environments that never anticipated today's complex and evolving threat landscape. Their architectures are inherently non-resilient, security controls were bolted on as afterthoughts rather than engineered into the core design. This has created significant vulnerabilities, particularly in data handling, where fragmented legacy databases and hard-coded interfaces present easy targets for exploitation and data compromise. Such technical inertia threatens mission resilience and operational agility, especially in the era of Dynamic Space Operations (DSO). Compounding the challenge, many of these heritage systems underpin mission-critical space operations in congested and contested orbits, even as the Space Force redefines battle management and space domain awareness strategies to counter emerging threats.

Modernization is no longer optional, it is essential. The industry must evolve from years-long software upgrade cycles to a model of continuous, secure, and rapid capability delivery. OMNI recognizes this imperative and is applying its best-in-class digital transformation expertise to deliver integrated, modernized, and resilient space architectures that empower the mission edge.

1. The Software Factory Solution: Agile Integration

Addressing this legacy crisis requires leveraging the proven success of modern government Software Factory models. The strategy begins with adopting Agile Integration and DevSecOps principles to replace process rigidity with rapid, secure, and iterative development. This approach is not just about modernizing software, it's about building an adaptive infrastructure engineered for continuous evolution and mission resilience. OMNI's commercial heritage combined with its robust software factory expertise has seen this approach work across the Department of the Air Force, National Geospatial Agency and the Army supporting dozens of modernization efforts.

Agile Integration and DevSecOps: Modern iterative practices should be integrated into the mission-critical environment. Development cadence should be synchronized with enterprise baselines, such as the 8-week release cycle, to incorporate configuration and integration maintenance. This disciplined rhythm allows programs to manage long-lead mission requirements while delivering capability incrementally every two weeks.

Certificate to Field (CtF) Automation: CtF automation is essential for achieving rapid, secure software deployment. At the core is an automated CI/CD pipeline configured to execute all required security scans and code quality analyses while generating the evidentiary artifacts needed for the CtF package, such as Software Bills of Materials (SBOMs), scan results, and test reports. This end-to-end automation minimizes manual effort and accelerates accreditation timelines, enabling continuous, compliant software delivery at mission speed.

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2. Modernization Analysis Strategies: Data & AI
Modernizing space operations cannot be done with coding alone; it must start with a disciplined, strategic assessment of legacy systems and the data that drives them. The first strategic imperative is to embrace a data-centric approach that not only identifies risks and costs but also illuminates opportunities, guiding informed decisions that lay the foundation for resilient, agile, and mission-ready space architectures.

Integrated Data Layer and Data-Centricity: The industry needs to address the challenge of siloed data by adopting a Data-Centric architecture. This approach replaces fragmented archives with a unified, integrated data layer that centralizes telemetry, command history, and processing artifacts. By doing so, all mission partners and applications operate from a single, authoritative source of truth, reducing integration friction and enhancing interoperability across subsystems.

Microservices and Open Architecture: To enhance mission agility, systems should move beyond monolithic dependencies by migrating core functionalities and Mission Unique Software (MUS) into modular, containerized microservices. This open architecture empowers mission partners to integrate and innovate rapidly, supporting continuous adaptation to evolving operational requirements. Solutions, like those implemented on the Big Bang program, should leverage elastic, resilient, secure, and cost-effective infrastructure that fully aligns with the DoD Enterprise DevSecOps Reference Design, ensuring scalable, mission-ready capabilities for the modern space environment.

AI/ML and Decision Advantage: Programs should leverage Artificial Intelligence (AI) and Machine Learning (ML) as foundational enablers across the entire system lifecycle, transforming not only how space systems operate but how they evolve. Beyond supporting real-time operations, AI-driven tools can autonomously analyze legacy architectures, uncover hidden inefficiencies, and prioritize modernization efforts, accelerating the transition from aging codebases to resilient, future-ready systems. By applying ML to the high-volume, continuous stream of telemetry within an integrated data environment, space operations gain predictive maintenance, automated anomaly detection, and rapid mission planning capabilities that surpass human speed and accuracy. This convergence of AI and ML empowers the warfighter with unprecedented situational awareness and decision superiority, fundamentally reshaping space mission effectiveness and driving strategic modernization across the enterprise.

3. Secure by Design for Mission Assurance
All modernization initiatives are guided by the "Secure by Design" philosophy, embedding security as an intrinsic, non-negotiable attribute of every solution. By integrating security from the outset, programs not only accelerate innovation but also safeguard critical operations, ensuring resilience, trust, and operational superiority across the full spectrum of space missions and system lifecycles. Achieving this requires disciplined application of security principles throughout every stage of the development lifecycle:

Threat Modeling: Prior to finalizing any integration component, architects and developers systematically conduct threat modeling to identify potential attack surfaces. The architecture is proactively designed to mitigate risks, ensuring that classified data (Red) remains fully segregated from unclassified systems (Black).

Principle of Least Privilege (PoLP): Each software module, automated process, and operator account is granted only the minimum access required to perform its specific function, minimizing potential exposure and limiting the potential "blast radius" should any credential be compromised.

Defense in Depth: Programs implement layered security controls across every system component, ensuring that if one mechanism (e.g., a firewall) is bypassed, others, such as encryption, auditing, or access controls, continue to provide immediate protection, maintaining continuous mission resilience.

Trust Boundaries: Programs define and enforce clear boundaries between system components, leveraging secure mechanisms such as cross-domain solutions (CDS) and strict network segmentation. This approach preserves separation of concerns, maintains security classifications, and ensures that sensitive data remains protected across all domains.

4. Conclusion: Resilient Missions
The era of rigid, monolithic ground systems is over. Mission success now relies on a secure, agile infrastructure that can rapidly integrate new capabilities and respond to emerging threats.

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Design Thinking in Orbit: When Space Innovation Meets the Unexpected Classroom

BY DR. SIERRA CALHOUN-POLLARD
Space Entrepreneurship Professor & Design Thinking Expert

The summer of 2025 marked a new experiment in how we teach innovation at the University of Florida. Drawing from my background in aerospace and design thinking, I helped bridge the Innovation Academy, a program that trains students from all majors in creativity, leadership, and venture creation, with Space Florida, the state's aerospace finance and development authority. What began as a simple capstone project quickly evolved into a living case study in how university-industry partnerships can spark ideas, inspire new career pathways, and prove that space innovation is for everyone.

At UF, I usually teach courses that connect directly to the space industry, Innovating for Space in the College of Engineering and Space Entrepreneurship in the College of Business. But this summer project was different.

This was a non-space course, a creativity-driven, cross-disciplinary entrepreneurship Senior Capstone within the Innovation Academy (IA). It wasn't designed for rocket scientists or engineers; it was designed for innovators of all kinds. Yet with my background in the aerospace sector, I saw an opportunity: what if we brought the space industry to students who had never once pictured themselves working in it?

That's how a class that usually partners with local businesses ended up collaborating with our amazing friends at Space Florida on a real industry driven challenge.

Alayna Curry, APR, Director of Public Relations at Space Florida, crafted the central design challenge that would anchor the semester: How might we develop a physical roadmap or experience to showcase career pathways in the space industry? A bold ask for students whose majors ranged from psychology and business to anthropology and information systems. But what unfolded over the next twelve weeks was nothing short of extraordinary.

Over 12 weeks, 60 students, divided into teams of five, learned to navigate the design thinking process: empathize, define, ideate, prototype, and test. For most, this was their first encounter with the space sector. They learned how to conduct user interviews, gather customer insights, and turn abstract ideas into actionable product solutions.

Under the guidance of faculty mentors and feedback from Space Florida professionals, teams of five moved through the design thinking cycle: discover, perceive, ideate, prototype, and launch. They interviewed target audiences, surveyed professionals, gathered insights, and refined their ideas into physical prototypes that could travel to schools or be showcased at expos. These weren't engineering students designing spacecraft. They were creative thinkers, communicators, and problem-solvers learning to apply innovation principles to a field most never imagined they'd touch.

As Dr. Jeff Citty, Director of the Innovation Academy, shared afterward, "Introducing a space-focused project brought a bold new dimension to the IA experience. It pushed students to think beyond traditional boundaries and apply creativity, design, and entrepreneurship to an entirely new industry." ***(continued)***

Faculty member Dr. Diane Porter-Roberts added, “By participating in a design sprint involving space, students saw that design thinking could be applied to any field. Their individual skills and multidisciplinary expertise collided to produce innovative ideas and prototypes.”

Among the many inventive concepts that emerged, one team stood out for their creativity, professionalism, and heart: CosmoChomp. The team included Bailey Reeves (Psychology: Behavioral & Cognitive Neuroscience), Alice Decker-Jones (Anthropology & Education Sciences), Samuel Lewis (Business Management), and Colin Duncan (Information Systems). Their project, Discovery Days, reimagines how middle schoolers are introduced to the space industry through a science-fair-style event featuring six interactive “mission stations.” Each station represents a different space-related career path, ranging from medicine to media, athletics to aerospace engineering, designed to show students that there’s a place for every passion in this vast field.

“Our goal was to show students at an early age that the space industry isn’t limited to STEM,” Bailey explained. “We wanted to make it clear that every interest and talent has a place in space.”

Alice, who plans to pursue a career in education, added, “We realized that interest in STEM drops sharply by eighth grade. Discovery Days keeps that excitement alive by making aerospace exploration fun, accessible, and inclusive.”

Samuel reflected on the collaboration: “Working with Space Florida showed us just how many people and careers make space innovation possible. It made me want to pursue even more ideas that connect people with this industry.”

Colin, who hopes to attend law school, shared, “Going through Dr. Calhoun-Pollard’s design thinking process taught me how to creatively and critically solve problems in an area I knew nothing about. We turned uncertainty into something amazing, and affordable, for schools.”

The culmination of the course was a Showcase Event, where each team delivered a private ten-minute presentation with Q&A before a panel of judges from both UF and Space Florida. The judging panel included Dr. Matthew J. Traum, Master Lecturer of Mechanical and Aerospace Engineering; Dr. Melissa White, from the Engineering Innovation Institute; Joel Parker, Associate Director of Experiential Learning; and the dedicated team from Space Florida. “The richest and most consequential learning happens when students solve real-world problems,” Dr. Traum said after the event. “Aerospace is dynamic and complex. Learning to thrive despite uncertainty is critical to success in this field.”

When CosmoChomp was announced as the winning team, the excitement in the room was electric. Their enthusiasm, professionalism, and teamwork reflected everything the Innovation Academy strives to instill. “The future of Florida’s aerospace industry starts with the students we’re investing in today,” Alayna Curry said. “The CosmoChomp team’s Discovery Days concept was such a creative and tangible way to spark interest in space at an age when students are starting to think about their futures.”

While the capstone has ended, CosmoChomp is continuing their mission. They are now preparing to pitch Discovery Days to Alachua County Economic Development Advisory Committee, hoping to pilot their concept in local schools. “We adapted our project to align directly with the goals and curriculum standards of Alachua County,” Bailey explained. “Our focus is on making sure it supports local educational priorities while opening students’ eyes to the wide range of opportunities in the space industry.”

Alayna Curry reflected, “Curiosity and adaptability are huge in this field. Students who collaborate, keep learning, and find creative ways to solve problems will go far. That’s exactly what we saw in CosmoChomp.”

Unlike my other space-focused courses, this was a one-off collaboration, a passion project that blended the Innovation Academy’s entrepreneurial spirit with my own lifelong connection to the space industry. Watching students who had never considered space before discover their potential in it reminded me why this kind of experiential learning matters so deeply. It proved that innovation doesn’t always start in a lab or a launch facility, it starts in a classroom where curiosity, collaboration, and courage converge. ▪——▪

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unclassified threat information to approved commercial industry partners. Front Door has received more than 1,700 technology submissions from more than 1,400 companies interested in sharing their innovations and technologies. Those connections contributed to more than 750 contracts for new space capabilities that we awarded during the first half of this year.

We hosted the first-ever USSF investor roundtable between the VCSO, SAF/SQ Military deputy, O-6 level strategic leaders, and 15 top-tier venture capitalists. Subsequent meetings with venture capital, private equity, and commercial space companies have resulted in over $400M in direct investment for commercial technologies and capabilities of interest for USSF operational requirements.

We are seeing record levels of foreign military sales cases with our allies and partners across almost all mission areas - evidence that our combined strength and shared ethos are paying dividends on the global stage. We are projecting $12 billion in FMS case value in the next two to four years.

As we look ahead, our mission remains clear: to develop and field dominant space-based capabilities by advancing an expert warfighter workforce. The warfighter ethos is how we get there. It binds us together, reminds us of who we are and why we serve, and shapes how we respond to the challenges of a dynamic domain.

Semper supra!

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tolerance for risk. That diversity is an asset, not an obstacle. Our job is to harness it. When the first CASR contracts go live, they'll represent more than just contingency access: they'll prove that commercial capability can be seamlessly tied into the operational fight. In a conflict, that flexibility will improve our nation's lethality.

Another major success story is SSC's Proliferated Low Earth Orbit (PLEO) IDIQ contract. In just a few years, demand for proliferated LEO services has exploded, expanding the contract's ceiling from $900 million to $13 billion. That's not bureaucracy: that's the warfighter sending a clear demand signal that these capabilities are contributing to the fight. More than a contract vehicle, PLEO is a blueprint for the future hybrid architecture the Space Force is building. It provides resiliency, flexibility, and speed. Every new entrant raises the bar, and that relentless competition gives the warfighter better deals, better technology, access to each new spiral in the commercial development ecosystem, and faster delivery. It's exactly the kind of dynamic environment we need to maintain an edge in space.

Finally, no discussion of commercial integration would be complete without mention of our Space Force Front Door program. Front Door is a hub for reducing barriers to entry for our commercial partners. Through it we launched Orbital Watch, a "neighborhood watch" in space that shares unclassified threat information with more than 900 registered commercial partners. In time, Orbital Watch will become a two-way vehicle with industry reporting back what they see on orbit. That kind of transparency strengthens the entire ecosystem. It builds trust. And it helps everyone design more resilient systems from the start. There are more big things coming soon for the Front Door as we automate the system and focus on providing additional resources to both industry and government stakeholders.

COMSO's evolution mirrors the broader evolution of the Space Force: We can't win the next war with yesterday's acquisition model. We can't win it with isolated systems. We will win it by integrating commercial speed, flexibility, and innovation into the fight and by delivering operational capability that increases our lethality and keeps our Nation secure. When skeptics say no-fail missions like nuclear Command and Control or strategic missile warning are not set up for commercial integration, we remind them that commercial integration is no longer an "either/or" decision. There are ways to integrate commercial into every single mission area. That's the mission. That's what COMSO is here to do. And we're just getting started.

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few specialized institutions. It is a collective effort that thrives on shared knowledge, inclusive access, and creative problem-solving. The companies and universities that succeed will be those that see beyond competition and embrace collaboration as the foundation for growth.

The future of space depends on how well we prepare people to engage with it. That means designing educational and professional pathways that reflect the realities of the modern space economy. It means creating opportunities for students and professionals to learn not only the science but the systems that make innovation sustainable. And it means ensuring that every breakthrough, every partnership, and every launch is grounded in curiosity, collaboration, and a shared vision for what comes next.

Because when industry, academia, and creativity align, we don't just explore the future of space. We build it. ▪——▪

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On the commercial front, startups like Orbit Fab are literally building "Gas Stations in Space." Orbit Fab has developed a standard fueling port – the Rapidly Attachable Fluid Transfer Interface (RAFTI) – which the Space Force has now qualified for use on military satellites. At only $30,000 per unit, RAFTI is designed to be an affordable addition to satellites of all sizes. The company is launching fuel shuttles and depots in orbit; in one upcoming demo, an Orbit Fab mini-depot will rendezvous with an Astroscale servicer via the RAFTI port to deliver hydrazine fuel on demand. Even traditional launch providers are contributing: United Launch Alliance (ULA) and Lockheed Martin, with NASA's support, are flight-testing cryogenic propellant transfer (e.g. liquid oxygen and hydrogen) on new upper stages. SpaceX, under a NASA contract, is similarly developing the capability to transfer 10 metric tons of liquid oxygen in orbit between Starship vehicles – a key stepping stone for refueling missions to the Moon and Mars. These technological advances, coupled with autonomous rendezvous sensors and standardized interfaces, mean the core building blocks for in-space refueling are finally in place. The industry momentum is undeniable, with both startups and aerospace primes racing to field operational fuel servicing in the near term.

U.S. Space Force Initiatives & Strategy in Orbit

Recognizing these possibilities, the U.S. Space Force is beginning to embed refueling into its force design and future architectures. The service's first Space Warfighting Framework (2025) stresses the importance of satellite maneuver to confound adversaries, but acknowledges that enabling such dynamic movement requires new logistics like refueling. In fact, U.S. Space Command has been "very open" about its desire for satellites that can be refueled or repaired on orbit. Responding to combatant command needs, Space Force leaders have made on-orbit servicing, mobility, and logistics a core focus area since 2020. A dedicated program office for Space Mobility and Logistics now coordinates these efforts, working closely with companies on technology demonstrations.

Several pilot programs are underway. In 2024, Space Force awarded Astroscale U.S. a $25.5 million contract to build an operational prototype refueling vehicle, aiming to demonstrate on-orbit fuel transfer by 2026. That mission will involve two refueling ops in GEO, and use an Orbit Fab depot as the propellant source. Additionally, the Air Force Research Laboratory's Tetra-5

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experiment is set to test rendezvous, docking, and refueling maneuvers in GEO, supported by commercial partners' hardware. Looking ahead, the Space Force's next-generation space domain awareness constellation (codenamed "RG-XX") is breaking new ground by mandating on-orbit refueling capability as a requirement from day one. These intelligence-gathering satellites in GEO, successors to today's GSSAP "neighborhood watch" spacecraft, will be designed with refillable tanks. "It absolutely has to have a refueling requirement," says Maj. Gen. Stephen Purdy, who pushed this mandate to ensure these assets can maneuver freely and be sustained long-term. This marks a pivot in acquisition strategy: rather than replacing dead satellites, the Space Force plans to refuel and reuse its most capable orbiters. Purdy notes that while launching more "cheap" satellites is one way to mitigate losses, it takes years to budget, build, and deploy replacements – whereas topping off a satellite in orbit could restore capability far faster. In essence, a tanker in space can provide immediate life extension or extra delta-v, enhancing resilience during conflict or surge operations.

The Space Force is also eyeing the cislunar domain (the space between Earth and Moon) as the next frontier for logistics. With NASA's Artemis program and commercial lunar ventures on the horizon, leaders recognize the need for fueling infrastructure beyond Earth orbit to support continuous presence. The service's warfighting analysts are gaming out scenarios of future conflicts extending to lunar space and assessing how on-orbit depots or tankers might enable U.S. spacecraft to reposition or operate in that vast area. As one Space Force vision document argues, dynamic space operations will require "access to all the places you need to go" – which is only possible if we have the means to refuel or re-energize spacecraft across all orbital regimes, from low Earth orbit to GEO and beyond.

Notably, the U.S. is not alone in pursuing these capabilities. Adversaries are moving quickly: China has reportedly begun developing its own satellite refueling vehicles and demonstrating far-ranging orbital maneuvers. In a future conflict, the side that can keep its satellites fueled and maneuverable will hold a decisive advantage. U.S. Space Command has therefore called for urgent action to field on-orbit logistics "to the space domain" and end the era of static, fuel-limited spacecraft. The Space Force's challenge now is to translate this vision into operational reality before others catch up.

Policy Pathways to a Robust Refueling Ecosystem

Building an in-space refueling ecosystem will require not just technology, but smart policy and sustained commitment. Funding is a foundational issue. To date, the Space Force's investments in on-orbit servicing have been modest – for example, only about $16 million was requested over five years for refueling R&D. Experts argue this is far below what's needed to move quickly. Analysts from the Air & Space Forces Association urge that a "robust investment of $200 million each year for three years" would jump-start an initial operational refueling capability, calling it a "strategic imperative" on par with other game-changing military technologies. In practice, Congress has begun to step in with plus-up funding (such as an extra $30 million in FY23 for prototype servicing missions). Going forward, the Space Force should make refueling a visible line item in the budget, sending a clear demand signal. As industry leaders note, seeing a dedicated program and funding in black-and-white is "critically important for this technology to progress". It gives contractors confidence that if they develop refueling vehicles and depot hardware, the government will be there as an anchor customer.

Another policy priority is setting common technical standards. Refueling ports and protocols must be interoperable across many spacecraft and fuel types. The Space Force has taken initial steps by identifying a "preferred refueling interface standard" – it recently approved Northrop Grumman's passive fuel interface as one option, and is evaluating Orbit Fab's RAFTI and other designs as well.

The goal is to publish interface standards that satellite builders can adopt widely. This will prevent a fragmented market where each fuel servicer is only compatible with its own clients. Mandating refuel-ready design for certain classes of satellites is another lever. Future military satellites, especially in GEO, should be required to include a standard fueling port (for a negligible mass cost) as a condition of acquisition. This policy would immediately create a captive market for refueling services as those satellites age or need extra maneuver capability.

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It also encourages commercial sat operators to follow suit, especially if they see DoD satellites benefiting from life-extension while theirs face end-of-life. In essence, making refuelability "baked in" to designs now will pay dividends a decade hence.

The Department of Defense and NASA should also coordinate their refueling initiatives. There is significant overlap between military and civil needs for space refueling: both need reliable fluid transfer techniques, insulating storage for cryogenic propellants, and solutions to prevent orbital debris during servicing. Sharing test data (such as NASA's on-orbit cryogenic demos) and co-investing in dual-use technologies can accelerate progress. It's equally important to work with international partners. Allied space agencies (like ESA, which is contributing a refueling module for the lunar Gateway) and commercial partners abroad are developing their own servicing tech. Establishing norms and agreements for safe refueling operations, akin to air-to-air refueling procedures, will be key to avoiding mishaps in orbit. The U.S. can lead in crafting guidelines for satellite servicing that ensure transparency and prevent hostile misuse (for instance, agreements on how to inspect a client satellite's status before docking).

Lastly, strategists must consider security and resilience of the refueling infrastructure itself. Tankers and fuel depots could become high-value targets in wartime, much like supply convoys or fuel farms on Earth. This means the U.S. should plan to defend these assets (perhaps via escorts or hardening) and build redundancy (multiple depots, dispersed or in different orbits). It may sometimes be wiser to use a proliferated approach – for example, instead of one large fuel depot, deploy several smaller ones to mitigate single points of failure[4]. Lt. Gen. Shawn Bratton of the Space Force noted the trade-off: if you invest in a refueling infrastructure, you must also protect it, so the benefit must outweigh the cost and risk[4]. Careful analysis and war-gaming are underway to quantify the military advantage of refueled satellites in conflict scenarios. Early results indicate that the ability to rapidly replenish satellite fuel could be a decisive force multiplier, enabling tactics that are impossible with one-and-done spacecraft.
In conclusion, in-space refueling is emerging as a cornerstone of spacepower for the United States. It extends the operational longevity of expensive assets, unlocks unprecedented maneuverability, and makes ambitious journeys to the Moon and Mars feasible on a routine basis. Just as aerial refueling revolutionized air warfare and global reach in the 20th century, orbital refueling promises to transform military and civil space operations in the coming decades. The U.S. must embrace this shift with investment, industrial partnerships, and forward-leaning policy.

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