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Empowering the Future: SFA and the Leadership of Dr Lois Wardell

Interview with Lee Rosen, CEO of ThinkOrbital

Op-Ed: Integration of AI/ML into DoD Processes

Image credit - Boeing

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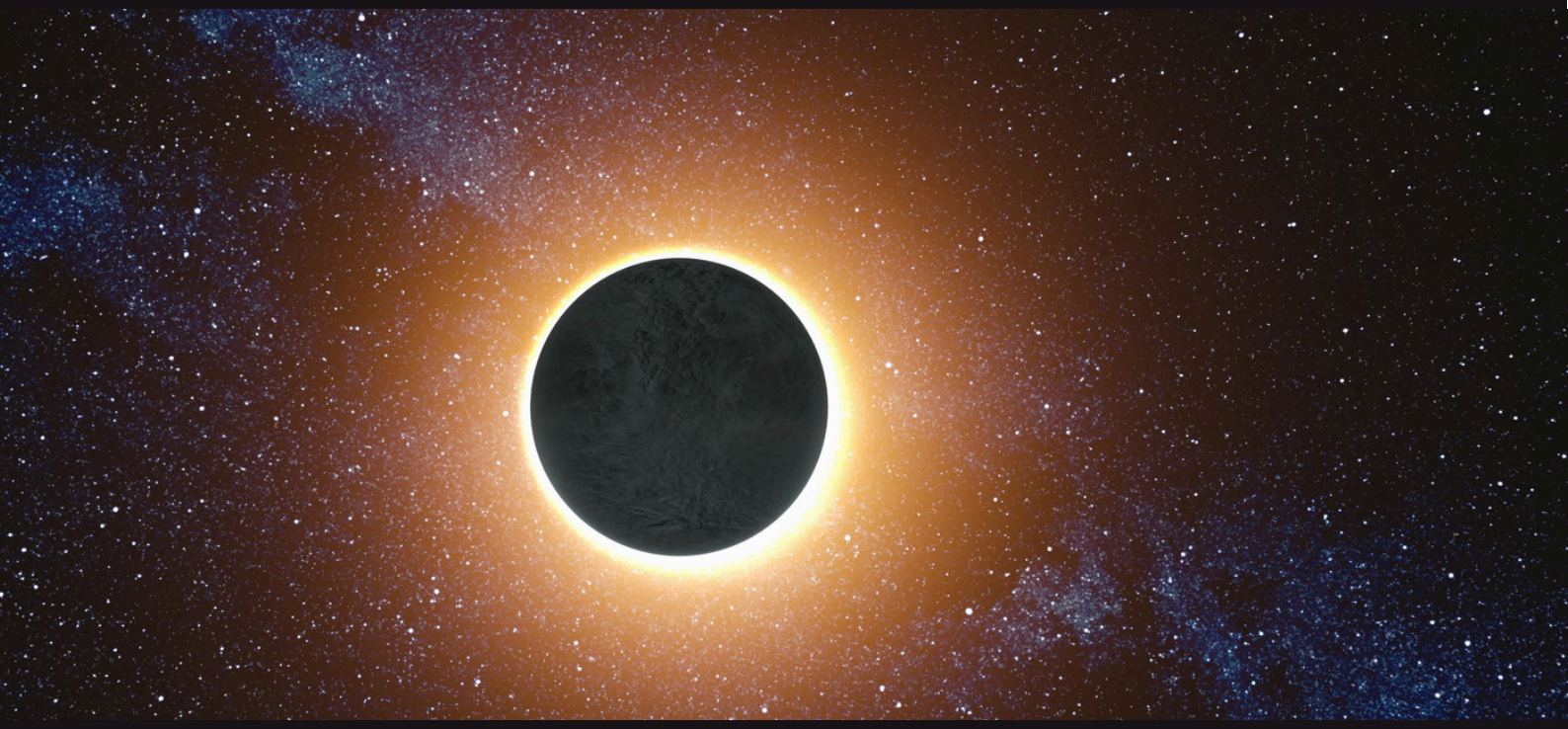

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SFA Women in Space Highlight:
Empowering the Future: Dr. Lois Wardell

BY SIERRA POLLARD, SFA WOMEN IN SPACE MARKETING CHAIR

In an era where space exploration is no longer a distant dream but an evolving reality, the role of women in this domain is more critical than ever. The Space Force Association (SFA) is paving the way for a future where women are not only included but are leading the charge. Leading this stellar mission is Lois Wardell, Ph.D., the brilliant Executive Chair of the SFA's Women in Space. With her leadership and vision, she's not only reaching for the stars but also ensuring that female Guardians have the tools and support to shine brightly in the galaxy and beyond.

The Launch of SFA Women in Space

The USSFA's Women in Space was formed with a powerful drive to support female Guardians and ensure they have the resources, network, and opportunities to thrive in their careers. Dr. Lois Wardell, with her vast experience and passion for exploration, was the natural choice to lead this initiative. "I've often been driven by the desire to do what others said a girl like me couldn't do," Wardell shared during our conversation, and her life is a testament to that unyielding spirit. From a solo trek to the base camp of Mount Everest to scuba diving in the depths of the ocean and even researching remote volcanoes, Wardell has left no corner of our planet unexplored. She's touched every continent, delved into the mysteries of the earth, and pushed the boundaries of what it means to be an explorer. But for Wardell, the next frontier is not beneath her feet but above her head.

This passion for exploration also extends to her achievements in technology innovation, having excelled in a range of scientific and engineering fields. "Transitioning into the space sector reminds me of how it feels to work in Antarctica, so much of what you do and see is new and unique." This boundless drive of curiosity is what led her to the Space Force Association, where she now channels her experiences into a new area of exploration.

Wardell's approach to leadership in the space industry is rooted in her experiences leading science expeditions in high-stakes environments, where personality dynamics can be a matter of life and death. Her leadership philosophy is simple yet so profound: "don't reinvent the wheel but build upon what's already there to create something even greater". Whether she's leading small teams in extreme environments or assisting the next generation of female Guardians, Wardell's mission is clear—to learn, create,

Dr Lois Wardell reflects on her role with SFA and the future of women in space.

and build a network that empowers women to reach for the stars and beyond.

Challenges and Opportunities for Women in Space

While there has been significant progress in the number of women entering the space industry, Wardell acknowledges that challenges remain. "There are so many more women in the industry today, but not in every room," she observed, pointing out the persistent gap at higher corporate levels. The challenge, she believes, is not just attracting women to the field but retaining them.

"Retention is key," she emphasized. Wardell is spearheading efforts to develop an advisory panel within the SFA, aimed at addressing the specific challenges women face in the space industry and prioritizing the actions needed to overcome them. She advocates for partnerships with industry leaders to create environments where women can thrive and remain engaged in their careers.

Wardell's advice to young women aspiring to enter the space industry is rooted in passion and resilience.

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"Lead with passion and follow it. Exploration opens so many doors, and failure is just a data point—don't be afraid of it," she said. Her inspiration comes from the passionate people she works with in the Space Force Units, and she is driven by the rapid pace of technological development in the field. "The space technology race is exciting and engaging, and we are needed here." Joining Women in Space helps build that community where we can support each other.

The Future of Women in Space

Under Wardell's leadership, Women in Space is poised to become a vital community in the space industry. The committee's initiatives are designed not only to support women guardians but to create a diverse and inclusive environment that welcomes all women interested in the space community. As the SFA continues to grow, so too does its commitment to fostering a community where women can lead with confidence, creativity, and passion.

For those looking to join, Wardell's message is clear: "Find us and join the conversation!" The Women in Space is not just a network, it's a movement dedicated to empowering the next generation of space leaders.

Image credit Lockheed Martin

A Note from the Author:

What a blast it was to virtually sit down with Lois and dive into her incredible vision for Women in Space! I'm thrilled to join the crew as Marketing Chair and can't wait to help launch some out-of-this-world conversations. If you know a remarkable woman in the space industry who deserves to be in the spotlight, or if you'd like to be featured yourself, don't hesitate to reach out, I'd love to hear from you!

Join the Women in Space group on LinkedIn, and let's get this conversation orbiting! I can't wait to (hopefully) meet you at Spacepower Conference 2024!

SFA Feature Interview:
Lee Rosen, CEO ThinkOrbital

BY RHONDA SHEYA,
SFA GENERAL MANAGER

Building the Future in Space: ThinkOrbital's Pioneering Work

A new era of construction is dawning in the vast expanse of the cosmos. ThinkOrbital, a trailblazing company led by Lee Rosen (Col. USAF, Ret.) and Vojtech Holub, Ph.D., is revolutionizing the future of space infrastructure and space domain awareness. With the recent successful launch of the world's first autonomous in-space welding system, ThinkOrbital is paving the way for massive structures and groundbreaking innovations beyond Earth's orbit.

A Visionary Approach

ThinkOrbital's mission is ambitious: to accelerate the accessibility and commercialization of cislunar space through cost-effective, pressurizable, scalable, and multi-purpose infrastructure. ThinkOrbital delivers a large, scalable, and cost-efficient space structure for the New Space economy. ThinkPlatforms are based on mature technologies, configured for a single-launch, autonomous assembly in orbit, re-imagining opportunities for satellite servicing, prepositioned systems, space debris processing, in-space manufacturing, on-orbit storage, refueling, space tourism, and research. ThinkOrbital is also developing the capabilities necessary for defending the space domain today, including the innovative ThinkX x-ray technology for imaging the interior of satellites both in proximity and at long standoff distances. With near-peer competitors hiding weapons and clandestine capabilities in their seemingly benign satellites, the ability to characterize and determine the intent of space objects becomes even more critical. Additionally, the ThinkToolkit's ability to weld, cut, and inspect transforms today's servicing "tow trucks" and "gas stations" into full "service stations" for diagnosing and fixing things on orbit.

This ambitious goal is driven by a belief that space construction and massive infrastructure in space can unlock a new era of human potential.

As co-founder and CEO of ThinkOrbital, Lee Rosen, explains, "Our goal is to build big things in outer space. We're talking about structures that can change how we use space, from manufacturing to military missions and beyond." When asked what to expect five years from now, Rosen answered, "I see a toolkit with a cutting, welding, inspection, and additive manufacturing capability on every satellite launched. Because it's very low in size, weight, and power and is cost-effective to use on one's own satellite. If a problem arises, take an x-ray image, see what's going on inside, and repair it."

Lee Rosen is a former SpaceX VP with around 200 successful missions. He led the build of three Falcon launch pads, Dragon Spacecraft Ops, and Astronaut training. In the military, he served as a Commander, Space Operator, Engineer, and Acquisition Officer with assignments at the Pentagon, National Reconnaissance Office, and Space Systems Command.

ThinkOrbital co-founder Vojtech Holub, Ph.D., has 14+ years of research & development, software & aerospace experience. His accomplishments include holding 30+ patents and writing 17 conference & journal papers. Vojtech's AIAA Journal of Spacecraft and Rockets article is the founding thesis for ThinkOrbital's scalable space infrastructure. They have assembled an impressive team and are making this vision a reality.

The Power of Autonomous Welding

The cornerstone of ThinkOrbital's vision is its autonomous welding system. This groundbreaking technology enables precise and efficient welding, cutting, x-ray, and additive manufacturing operations in harsh space environments. By overcoming the limitations of traditional welding methods, ThinkOrbital is unlocking the potential for constructing much larger and more complex structures.

"The autonomous welding system is a game-changer," Rosen says. "It allows us to build structures in space that were previously not possible, finally realizing the vision we all dreamed of."

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Overcoming the Challenges of Space Construction

Constructing large infrastructure in space presents unique challenges. Traditional methods, involving building components on Earth and assembling them in orbit, are time-consuming and limited in scale due to “the tyranny of the payload fairing”. Modules built on the ground are constrained by the size of the rocket’s payload accommodation. ThinkOrbital's approach is radically different, as it eliminates this constraint by constructing in situ. It aims to build directly in space using advanced robotic technology, thereby overcoming the limitations of traditional methods and revolutionizing space construction. This approach allows for a single launch of “flat-packed” hexagon and pentagon panels to create a volume over four times that of the International Space Station.

"We're essentially building a toolkit for space construction," Rosen explains. "The welding system is just one part of that Swiss Army Knife toolkit."

A New Era of Space Exploration

ThinkOrbital's technology has the potential to revolutionize space exploration. Large-scale space construction could enable:

- Advanced Manufacturing: Producing materials and products that are impossible to create on Earth.
- Renewable Energy: Building massive solar power stations to harvest energy from the sun.
- Space-Based Defense: Establishing forward operating bases to protect Earth's interests in space.
- Scientific Research: Conducting experiments and observations that are not feasible on Earth.
- Human Habitation: Large-scale human habitation of theoretically unlimited size for exploration, tourism, R&D, sports venues, etc.

Beyond the International Space Station

Rosen envisions a future where massive space platforms, far exceeding the size of the International Space Station, can be built more efficiently and cost-effectively in space than on Earth. These structures could serve as manufacturing hubs, research facilities, and even forward operating bases for military operations.

THINK ORBITAL

To learn more, visit www.thinkorbital.com.

The International Space Station is not built for manufacturing, especially manufacturing on a large scale. A potential use-case of these mammoth structures is pharmaceutical manufacturing. Researchers can take advantage of the unique benefits of microgravity to create new pharmaceuticals not possible terrestrially. The potential for new treatments and life-saving medication is unlimited. Due to current limitations on available space to conduct experiments on the ISS, we can only create a few doses on the, but in the future, the possibility of creating thousands of doses in space is exciting.

"We're not just talking about building satellites or small structures," Rosen says. "We're talking about building entire cities in space."

A Bold and Ambitious Endeavor

ThinkOrbital's mission is ambitious, but the potential rewards are immense. By pushing the boundaries of space technology, they are helping to shape the future of humanity's presence beyond our home planet. As they continue to develop and refine their technology, the world eagerly awaits the next groundbreaking achievements.

A Glimpse into the Future

Imagine a future where astronauts live and work on massive space stations, manufacturing essential goods, conducting groundbreaking research, and even exploring distant planets. "ThinkOrbital's ThinkToolkit is a key step towards making this vision a reality. That's super exciting and enables a great future for humanity in outer space. That really gets me jazzed." -Lee Rosen.

A MESSAGE FROM OUR CEO

WILLIAM WOOLF

Dear Space Force Association Members,

It is a privilege to be part of this exceptional community of individuals dedicated to advancing the mission and vision of our Space Force. As we navigate the evolving landscape of space exploration and defense, it is crucial that we remain united in our efforts to foster excellence, innovation, and collaboration within our organization.

As we enter into an era of great power competition, it is imperative for all of us to take an active role in ensuring the U.S. Space Force has the capabilities it needs to maintain freedom of action in the space domain.

The Space Force Association Magazine is a vital platform for us to share insights and stories that spotlight the achievements of our members and the progress in space technology. It reflects our collective passion for pushing the boundaries of what is possible and our steadfast commitment to advancing our mission. In each issue of the magazine, you will find a rich array of articles that highlight the incredible work being done by our members across various sectors. From groundbreaking research and development to inspiring tales of leadership and dedication, the magazine provides a window into the dynamic world of space exploration and defense.

I encourage you to engage actively with the magazine—submit articles, provide feedback, or simply explore its contents. Your contributions are essential in shaping the future of the Space Force Association and propelling our mission forward.

Additionally, I look forward to seeing many of you at the Spacepower Conference 2024. This event will be an excellent opportunity to collaborate, share knowledge, and strengthen our collective efforts as we face the challenges and opportunities of the space domain.

Together, we have the power to make a profound impact on the future of space exploration and defense. Let us continue to embrace innovation, tackle new challenges with resolve, and uphold the values of excellence and integrity that define our organization. Thank you for your unwavering dedication. I am excited to see what we will achieve together in the promising journey ahead.

Sincerely,

Bill

William Woolf
CEO & Executive President

GUARDIAN OP-ED:
Guardian Culture Thought Leadership

BY PAUL BOYENGA

"Tip? — Keep the Change"

It is no small feat taking on the responsibility and accountability of an entire domain. It is not unheard of —the Navy has been cruising the seas of the world for over 235 years, anywhere international law has allowed—not unprecedented by that standard even; right? Well, technically, sure. But holistically, not so much.

The absence of comprehensive governing policies over the use and navigation of the space domain at the time of our service's founding is just one factor bringing our story back to "unprecedented" territory from "parallel" territory. The fact that our service's success is critical to the survivability of our sister services' missions and our daily way of life—there is another factor. The dependence on our service is so enmeshed within our lives, culture, and military missions, the degree of criticality that falls on our responsibilities is almost impossible to fully comprehend. There is an unprecedented reliance on space, and that is a fact.

So how is the Space Force taking on such heavy tasks with little comparative reference material or playbooks? How are we accomplishing the unprecedented?

The answer is right in front of us; it's on our flags, in our insignia, our logos, websites, even our operations language. It's at the very birth of our service and has been with us incessantly (sometimes annoyingly so) in every aspect of our story and heritage. The answer is change.

The Greek letter "delta" is used in mathematics to indicate change or variability. Our service was born out of a need for change—a change in how we manage, operate, and defend our space assets as well as the commercial use of space. Our service was born from an amalgamation of service members across all the other branches who have had to influence, advocate for, embrace, and sometimes survive, an endless and growing plethora of change we now know as the Space Force. Our promotions have changed. Our missions have changed. Our organizational constructs have changed. Our culture is changing. Even our most critical missions center around the mathematics of orbital maneuvers and fuel expenditures we refer to as "delta V"—we cannot escape change. Change is everything and everywhere; it has both dictated and facilitated our growth and impact. We have successfully "turned and faced the strange—Ch Ch changes" as David Bowie would have us all doing.

The Space Force has been taking strides to master change. It has done so fundamentally through its values; change is mentioned numerously throughout The Guardian Spirit (six times in the nine pages of core text), but most notably in the first value, "Character."

"We must put into context what matters today, what matters in the future, what matters for the mission, the team, and each of us individually. Character allows us to navigate these dilemmas in real time and character demands consistently reevaluating them as the environment changes."

Our force has the blessing of being surrounded by opportunities to embody, embrace, and empower change. Teaching change as an ever-viable tool in the toolbelt of our future leaders is a task we current leaders should take with pride—and when possible, teach by example. We must teach dynamic adaptability as a competency, not an option. "Dynamic Adaptability" –or "the capacity of an organization to be responsive to a changing environment in order to thrive" –is damn-near the Space Force's credo. It's so relevant, I would go as far as to say it's the reason our mission statement is so…universal. Not often can two words capture the application and breadth of an entire organization and their pillars of success like that. And it is rooted entirely in change—making changes and navigating them.

As much as change is critical to our success, it is equally elusive in defining itself most effectively. Sometimes change isn't right; sometimes it comes with the price of fatigue; sometimes it takes more time than it seems it's worth; and sometimes it just flat out fails to catch the buy-in it needs to work.

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Change is a fickle variable in the formula of life, let alone a military branch with a dozen bowling balls to juggle one handed. It can be the difference or the detriment to any decision. Change, in and of itself, is hard to capture; and even harder to master.

As the Space Force continues to grow in an ever-changing environment, it is critical that we value our opportunities to solicit, advocate for, embrace, and empower change. The changes may not be big and ambitious like SPAFORGEN; even minor changes can have intensive results, like "delta V." But the defining similarity of all the changes we make will always be the courage and creativity to propose them, and the courage and open mind to accept them. With that mindset, even Garth Algar could learn not to fear change…maybe.

The more effort we put into mastering change, the more dynamic and adaptable we become. The more we exercise our dynamic adaptability, the more we will learn to wield change as a weapon. And with such an unprecedented weapon, I think we may continue to achieve the unprecedented.

SFA OP-ED:
Thought Leadership

BY SHAWN BARNES, POLARIS STRATEGIC SOLUTIONS, LLC

The Future of the United States Space Force: Three Core Functions and an Expanded Area of Responsibility

As the Space Force approaches its fifth birthday, it's worth taking a few moments to understand and posture for the likely future of the nation's youngest military service. The Space Force will execute three "Core Functions" or sets of missions: Global Mission Operations, Space Superiority, and Assured Space Access. Additionally, the Space Force should expand its historical area of responsibility to cis-lunar and interplanetary space. The Department of Defense, Congress, industry, and private capital should posture for and facilitate each. The current velocity of government funding, intergovernmental/allied/industry collaboration, industry research and development, and private capital investment are insufficient to address the growing demands.

The term velocity implies both direction and magnitude. The nation must adjust direction and increase speed and effort. In short, we must accelerate down multiple paths.

Core Function One – Global Mission Operations (support to the terrestrial warfighter). Until recently, DoD's "Title 10" space-based support to the terrestrial warfighter has been limited to communication, weather, strategic missile warning, and positioning, navigation, and timing. Historically, the intelligence community has been responsible for providing space-based "Title 50" intelligence, surveillance, and reconnaissance. Since the standup of the Space Force in December 2019, the DoD (Title 10) missions were transferred from the Air Force, Army, and Navy and consolidated under the new military service.

The Space Force has great potential to provide additional day-to-day support to the military services and critical support to the terrestrial fight. In the future, the Space Force will almost certainly, be responsible for tracking ground and maritime moving targets. They are developing and fielding space-based data transportation capabilities that will be vital to future networked warfare. The Space Force can and should provide additional surveillance, reconnaissance, and tracking capabilities necessary to succeed in major conflict. Space Force capabilities should also augment, but not replace, the capabilities of the terrestrial forces, including logistical support (point-to-point delivery of critical materiel), offensive and defensive cyber operations, electric power generation, and even kinetic effects.

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Core Function Two – Space Superiority (protect U.S./allied satellites and protect against attacks enabled by adversary satellites). For many decades, national security space professionals have understood the importance of protecting the nation's vital space capabilities from adversary interference. For just as long, the importance of denying a near-peer, space-faring adversary from the advantages space capabilities provide has been understood. In 1985, the U.S. Air Force successfully tested an air-launched satellite interceptor against a U.S. satellite and in 1997, the DoD successfully tested a ground-based laser against a U.S. satellite. Historically, political considerations, policy restrictions, and resource limitations prevented the development and fielding of robust defensive and offensive counterspace capabilities. For decades, the few fielded space superiority systems were insufficient to the growing operational need.

Today, space capabilities are unquestionably vital to U.S. and allied economic and national security. China understands this and has fielded robust operational space systems to support their terrestrial forces and capabilities to deny U.S. systems during conflict. The nation requires significant capability and capacity to protect U.S./allied space systems AND to deny adversary capabilities in a responsible manner. A visibly muscular Space Superiority capability is foundational to deterrence and will be essential in a near-peer conflict if deterrence fails.

Core Function Three – Assured Space Access (launch and other ground and space-based support to space operations). The Space Force is currently responsible for space launch, which they procure from commercial launch providers. Additionally, the Space Force provides space domain awareness with a system of ground and space-based optical systems, and ground-based radars. Finally, the Space Force uses a network of ground-based radio frequency transmission and reception capabilities to communicate with and control their satellites.

Moving forward, the Space Force will need to increase capacity and capability for all three of these activities (launch, space domain awareness, and Satellite C2). Additionally, "Assured Space Access" is likely to include on-orbit capabilities and operations to refuel, repair, replenish, de-orbit, and move operational satellites. These new Assured Space Access capabilities will increase the lifespan of operational systems; help maintain a safe and sustainable space environment and provide resilience from malign activities.

Expanding the Area of Responsibility – Operations in and support for systems in cis-lunar and interplanetary space. Historically, national security space capabilities operated in "near-Earth orbit," from approximately 100 miles to 22,500 miles above the Earth's surface.

NASA, of course, has operated science and exploratory missions well beyond these altitudes, including manned missions to the Moon, landings on Mars, and probes to the other planets and even beyond the solar system. Commercial companies and defense contractors are now pursuing business opportunities such as asteroid and lunar mining, manned and unmanned lunar outposts, deep space communication, transport, and logistics. Private capital and industry are investing in cis-lunar space operations, betting on a tremendous return in the next decade or two. If these returns are realized, commercial operations in cis-lunar space will contribute to the nation's economic security and require protection. Just as the Navy and Coast Guard help protect and support U.S. and allied commercial maritime operations, the Space Force should help protect and support commercial space operations. As the commercial world looks beyond near-Earth orbit, so must the Space Force. China is operating in cis-lunar space and their operations must be monitored to understand if they pose a threat to U.S. national and economic security. Additionally, there are national security missions that can be conducted from outside the historical near-Earth space environment. If the nation is to exploit deep space for economic gain and national security, Space Force must be there.

None of these futures are achieved without concerted and purposeful action. The onus, however, is not solely on the Space Force – the nation's newest service can influence but does not exclusively control their future. Space Force must develop, share, and advocate plans to field necessary capabilities. It must develop and

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sustain talent; change the culture of its acquirers and operators; posture to field the systems; and develop the necessary tactics, techniques, and procedures.

The Space Force must take full advantage of commercial capabilities and services and consider offloading some current capabilities, particularly weather and GPS, to civil agencies and commercial entities. Executive and legislative branches of government must align their goals and fully resource a strategy to field the capabilities necessary. Fielding the capabilities and operating beyond the historical area of responsibility will cost tens of billions of dollars. Failing to fund the capabilities will cost orders of magnitude more. The executive and legislative branches need to collaborate to relieve restrictive policy barriers, facilitate rapid acquisition, encourage risk management over risk avoidance, and advocate to the American public the need for robust space capabilities for our national and economic security.

Traditional defense industry must adjust course and recognize the growing role of commercial, commoditized capabilities and services. Nontraditional industry must continue to innovate and press the government to adopt and adapt commercial capabilities. And private capital must continue to seek and fund opportunities for high returns on investment.

If the United States is to realize its full potential as a space-faring nation, government, industry, and capital must act. The future of the Space Force is bright, but not assured. The Space Force must be resourced, organized, trained, and equipped consistent with the importance of space to our nation.

DISCLAIMER

The views expressed are those of the author's and do not reflect the official guidance or position of the United States Government, the Department of Defense the United States Air Force or the United States Space Force.

ACADEMIC OP-ED:
Thought Leadership

BY CYBEL N. EKPA

Small Satellites, Big Impact: Revolutionizing Space Exploration and Policy

In the vast and silent expanse of space, a quiet but powerful revolution is unfolding—led by none other than small satellites. These pint-sized pioneers, some no bigger than a loaf of bread, are transforming space exploration in ways that were once the stuff of science fiction. They're opening the cosmos to new players, sparking a flurry of innovation, and even shaking up the rules that govern the final frontier. As we stand on the brink of a new space age, it's time to dive into the fascinating world of small satellites and the big changes they're bringing.

The Small Satellites Takeover

Picture this: just a few years ago, sending a satellite into orbit was a feat reserved for government space agencies with deep pockets and years of planning. But today, the game has changed, thanks to the rise of small satellites often referred to as CubeSats or nanosatellites. These mini marvels are turning the traditional model of space exploration on its head. What makes small satellites so special? For one, they're incredibly affordable. Instead of costing millions of dollars, these tiny spacecraft can be built and launched for a fraction of that cost. This has opened up space to a whole new crowd: universities, startups, and even high school students are now getting in on the action.

The best part? Small satellites are incredibly versatile. They can do everything from monitoring our planet's climate to providing internet access in remote areas, and even aiding in disaster response efforts. They're also a dream come true for international collaboration—teams from different countries can work together on satellite missions, fostering a global community of space explorers. The old saying "good things come in small packages" has never been more true.

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Space Policy: The New Frontier

With great power comes great responsibility—or in this case, with great numbers of small satellites comes the need for new space policies. As more of these little satellites are launched, it's becoming clear that the rules of the space game need an update.

One of the biggest challenges is space traffic management. Imagine the busy skies above Earth filled with thousands of small satellites, all zooming around at incredible speeds. The risk of collisions—and the resulting space debris—is a serious concern. Space debris, or "space junk," is not just a buzzword; it's a real threat. A collision in space can create a cloud of debris that can damage or destroy other satellites, leading to a cascade of problems. To tackle this, there's a growing push for a comprehensive system to track all objects in orbit. This system would predict potential collisions and provide warnings to satellite operators—kind of like air traffic control, but for space. However, since space doesn't belong to any one country, this effort requires international cooperation. It's a complex challenge, but one that's crucial for keeping space safe and accessible.

Then there's the matter of regulations. The current framework for launching satellites was developed when space was the exclusive domain of a few large players. But with small satellites flooding the market, there's a need to streamline the regulatory process. This includes everything from licensing to spectrum allocation (which is basically the management of radio frequencies that satellites use to communicate). For small satellite operators, navigating these regulations can be tricky, but it's essential for ensuring fair and responsible use of space.

The Sustainability Challenge

As more satellites head into orbit, sustainability has become the buzzword in the space community. But what does it mean to make space exploration sustainable? Essentially, it's about making sure our activities in space don't harm the environment—whether it's on Earth or in the cosmos.

Small satellites have a leg up in this regard. Because they're so small and lightweight, they have a smaller environmental footprint during launch. Plus, many of these satellites are designed to burn up in the Earth's atmosphere at the end of their mission, rather than becoming long-term space junk. This feature makes them a more environmentally friendly option for space exploration.

But sustainability isn't just about what happens at the end of a satellite's life. It's also about how we design, launch, and operate these satellites in the first place. This means developing standards for responsible satellite disposal, designing satellites that can be easily deorbited, and following best practices to minimize the creation of debris.

To make this happen, international standards and agreements are crucial. It's going to take a global effort to ensure that space remains a sustainable and safe environment for future generations of explorers.

Looking to the Stars

As we peer into the future, it's clear that small satellites will play a starring role in the next chapter of space exploration. Their ability to be quickly and affordably deployed makes them ideal for a range of missions—whether it's advancing scientific research, supporting commercial ventures, or even exploring new worlds.

But with this exciting potential comes a responsibility to manage space wisely. This means updating policies to reflect the realities of today's space industry, ensuring that space remains accessible to all, and prioritizing sustainability both on Earth and in orbit.

The rise of small satellites is more than just a technological revolution—it's a wake-up call to rethink how we approach space. By embracing innovation and sustainability, we can ensure that the future of space exploration is one that's open, collaborative, and respectful of the delicate environment in which it takes place.

As humanity continues its journey into the stars, we can be sure of one thing: small satellites are here to stay, and their impact will be anything but small.

SFA EXECUTIVE COLUMN

How SFA Europe is Pioneering Global Industrial Strategy:

BY DR MANJIT POPE, PRESIDENT, SFA EUROPE

In the dynamic landscape of global space exploration and innovation, the Space Force Association (SFA) Europe stands as a beacon of leadership and progress. As the European President of SFA, I am committed to driving industrial strategy and fostering international collaboration to ensure sustainable growth and success. Our efforts are pivotal to the UK's future industrial strategy and underscore our role as a global voice for innovation and excellence.

Essence of UK Industrial Strategy for Space

The spirit of innovation and dedication that characterises the space sector is evident from my 30 years of leading industrial strategy globally. Those who work in technology and industrial innovation are not only passionate but relentlessly driven to push the boundaries of what is possible. This passion is infectious and integral to the mission-led approach of our new UK government.

UK and Its Place in the Global Industrial Strategy Opportunity

The UK's space sector is a powerhouse, growing four times faster than the overall UK economy. Its workforce is twice as productive, showcasing the potential for significant contributions to national and global prosperity. To capitalise on this, we must create opportunities for companies to start, scale, and succeed in the UK, thereby generating jobs and fostering community prosperity. The space sector serves as a model for other industries, demonstrating the potential for innovation and growth.

SFA Europe will lead these Key Actions and Recommendations for Innovation and its Future Strategy in the Space Sector:

- Promote Innovation: Support startups and established companies through initiatives like the National Space Innovation Programme (NSIP).
- Foster Collaboration: Encourage partnerships between businesses, researchers, and government agencies to drive technological advancements.

Innovation and Industrial Strategy Implementation and Delivery

Space technology is critical for improving public services and enhancing quality of life. From climate monitoring to providing internet access in rural areas, space-based solutions are indispensable. They ensure the safety and security of our armed forces and emergency services, underpinning the essential functions of modern society.

SFA Europe will lead these Key Actions and Recommendations to International Space Sector:

- Integrate Space Technology: Implement space-based solutions in public service delivery to enhance efficiency and effectiveness.
- Support Rural Connectivity: Use satellite technology to bridge the digital divide and provide universal internet access.

Innovation and Industrial Strategy for Security

In an increasingly unstable world, the role of space in national security cannot be overstated. Satellite communications, remote sensing, and precise GPS data are foundational to our security infrastructure. As space becomes more congested and contested, collaboration with NATO allies is crucial to protect our interests.

SFA Europe will lead these Key Actions and Recommendations:

- Strengthen Defence Capabilities: Invest in space-based security systems to safeguard national infrastructure.
- Enhance International Cooperation: Work closely with NATO and other allies to ensure collective security in space.

Innovation and Industrial Strategy for Discovery

The pursuit of knowledge and discovery in space is unparalleled. Innovations like the James Webb telescope and missions such as the Rosalind Franklin rover to Mars highlight the transformative power of space exploration. These endeavours not only inspire but also drive technological advancements that have far-reaching impacts.

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SFA Europe will lead these Key Actions and Recommendations:

- Support Scientific Research: Fund and promote cutting-edge space research to drive innovation.
- Celebrate Achievements: Highlight the contributions of British scientists and engineers in global space missions.

Strategic Partnerships for Innovation and Industrial Strategy

A strategic partnership between the government, industry, and academia is essential for success in space. This collaboration must be built on stability and certainty, focusing on long-term goals rather than short-term gains. Our commitment to a strategic defence review and a new industrial strategy reflects our intent to foster this partnership.

SFA Europe will lead these Key Actions and Recommendations:

- Launch Skills England: Develop a coherent skills system to train the next generation of space professionals.
- Enhance Funding Mechanisms: Provide flexible funding options for training and development to meet industry needs.

SFA Views on the Launch of the National Space Innovation Programme (NSIP)

Announcing £33 million in funding for innovative businesses under the NSIP marks a significant step forward. This funding will support groundbreaking projects across the UK, from climate data collection in Cambridge to satellite technology in Glasgow, embodying the potential of our science and tech economy.

SFA Europe will lead these Key Actions and Recommendations:

- Invest in Innovation: Continue to fund and support innovative projects that address critical challenges.
- Promote Regional Development: Encourage the growth of space-related industries across different regions of the UK.

To Summarise…

The future of Britain's space sector is bright, and Farnborough offers a glimpse into this promising future. By leveraging decades of experience and fostering a culture of innovation, we can drive economic growth, create jobs, and ensure national security. As President of SFA Europe, I am dedicated to championing this cause, advocating for our industry on the global stage, and working tirelessly to turn our vision into reality.

Together, we can transform the UK's industrial landscape, fuelled by the boundless possibilities of space. This is our mission, and the SFA Space Power Conference is where we start.

SFA
SPACE FORCE ASSOCIATION

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SHARONICA SMEDLEY
EVENTS MANAGER

CAT SAWYER
OUTREACH

SHAWNA BUCKLEY
BOOKKEEPER

SFA THOUGHT LEADER COLUMN: AI/ML

BY CLINTON AUSTIN,
SFA DIGITAL OUTREACH

The Department of Defense (DoD) is actively exploring the integration of Artificial Intelligence (AI) into its processes to enhance operational efficiency and effectiveness. However, the DoD must learn from past failures, such as the IBM Watson deployments, to avoid repeating the same mistakes. Despite its initial success on "Jeopardy!" and its versatility in various fields like healthcare, finance, and customer service, IBM Watson faced significant challenges when applied within the DoD. These challenges primarily revolved around data cleaning, data ownership, and the complexities of cloud infrastructure.

One of the critical lessons from the IBM Watson deployments is the paramount importance of clean data. Clean data, which is free from errors, inconsistencies, and irrelevant information, is the cornerstone for building accurate and reliable AI models. However, the DoD often produces data that lacks uniform metatags, follows no format, and is stored in various locations, such as file storage systems or Microsoft Teams environments. The absence of clean data significantly hampers the efficiency of AI systems like IBM Watson. Moreover, the DoD lacked trained data stewards who could add context to the data results. Developing and training competent data stewards is a time-consuming process, and during the height of the Global War on Terrorism, there was a reluctance to allocate manpower for data cleaning. Consequently, data cleaning tasks were often delegated to junior enlisted personnel who lacked the contextual understanding necessary for effective data preparation.

Data ownership presented another significant challenge for the successful deployment of IBM Watson within the DoD. Within a combatant command, the senior ranking commanding officer is typically the data owner, often delegating responsibility to the senior intelligence officer. In contrast, the senior communications officer owns the systems in which the data resides. However, the individual program offices and directories that develop these systems have contractual ownership over the data. For instance, if the Logistics Directorate develops a program to track material within their Area of Responsibility using a Federal Service Integrator, the data becomes locked behind several layers of bureaucracy. Accessing this data may require contract modifications to allow for an Application Program Interface (API) or new contracts to develop features within a legacy code base. Reviewing legacy code bases can also be burdensome due to issues like lack of comments, unsupported proprietary tools, or vendor lock-in.

The DoD's "Cloud First" approach, aimed at modernizing IT infrastructure through cloud computing, faces similar pitfalls. The "Cloud First" strategic initiative seeks to enhance the agility, efficiency, and security of DoD operations by prioritizing cloud computing technologies. However, this approach has hidden costs, such as egress fees, which are charges incurred when data is transferred from a cloud provider's network to another network. While there is little to no cost for data ingestion, high egress costs prevent combatant commands and services from being cloud-agnostic. Furthermore, lacking specialized talent to implement a cloud-agnostic approach hinders progress, as it requires in-depth knowledge of each Cloud Service Provider (CSP).

The promise of AI-led to rushed cloud migrations without proper data cleanup, resulting in data spillage and correlation issues. Data correlation issues arise when one or more data points can be correlated to gain more insights, often classifying the data at a higher level. To bypass these issues, combatant commands and services overclassify data, leading to higher labor costs due to the need for personnel with the necessary security clearances to access and analyze the data.

Talent retention is another challenge. The DoD underestimated the talent needed to maintain cloud infrastructures, assuming existing personnel could be repurposed. However, ongoing wars and deployment cycles limited time for training and certification. Even when personnel are trained, the private sector offers more lucrative opportunities, leading to a talent drain. Historically, low recruiting numbers have further widened this gap.

To address these challenges, the DoD must modernize contractual frameworks and legacy

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systems, implement a data-centric approach, standardize cloud infrastructure, invest in human capital, conduct realistic cost-benefit analyses, and align AI initiatives with warfighter needs. A data-centric approach prioritizes data quality, security, and interoperability, with comprehensive audits to guide cloud migration decisions.

Regular reassessments should be conducted to keep pace with technological advancements. Investing in human capital involves establishing knowledge management teams, comprehensive training programs, and attractive career paths to retain talent. Enhancing resilience includes deploying edge computing solutions like AWS Snowball to maintain data access during disruptions.

Realistic cost-benefit analyses should account for hidden costs and long-term implications, with continuous evaluations to justify investments. This approach ensures that resources are allocated wisely and that the DoD's AI initiatives are sustainable in the long run. Aligning these initiatives with warfighter needs requires clear communication between development teams and frontline personnel, prioritizing projects that enhance mission capabilities. Comprehensive metrics should assess the impact of AI on operational effectiveness.

In conclusion, the DoD's journey towards effective AI integration requires a strategic approach, addressing fundamental issues before adopting new technologies. By implementing these recommendations, the DoD can build a robust AI ecosystem that enhances operational capabilities. This approach demands patience, strategic thinking, and a commitment to learning and adaptation, ensuring the DoD remains agile, efficient, and effective in meeting current and future challenges. The successful integration of AI technologies can significantly enhance the DoD's ability to meet current and future challenges. Still, this potential can only be realized through careful planning, strategic implementation, and a continuous commitment to learning and adaptation.

Please read more of this article on: ussfa.org/news-publications/.

SFA THOUGHT LEADER COLUMN:

Edge Computing Set to Revolutionize Satellite Technology

BY MICHAEL RITCHSON, SFA TEXAS, VP

As space missions become more complex, the need for quick and precise operations has never been greater. Satellites are key players in defense, communication, and exploration, but they face growing pressure to perform autonomously and efficiently. Edge computing is stepping in as a game-changer, offering a new way for satellites to process and manage data directly in orbit. This technology is set to boost the Space Force's capabilities, helping the U.S. stay ahead in the increasingly competitive space race.

Image Source: https://www.parsons.com/2020/04/the-beginning-of-a-new-military-service-the-united-states-space-force/

Edge Computing: Pushing the Boundaries of Satellite Tech

Edge computing revolutionizes satellite operations by processing data right where it is collected—on the satellite itself. Traditionally, satellites sent vast amounts of raw data back to Earth, where ground-based servers would handle the analysis. This old method not only caused delays but also strained bandwidth and required substantial infrastructure. Now, with edge computing, satellites can instantly analyze and act on data in orbit, making them more responsive and self-reliant. This independence is critical for time-sensitive missions, from weather monitoring to defense, where immediate decisions can make all the difference. By enhancing satellites' ability to think and act on their own, edge computing is reshaping the future of space operations.

Changing How Satellites Operate in Space

The Space Race Speeding Up with Real-Time Decisions

In the fast-paced environment of space, timing is everything. Edge computing equips satellites with the ability to make crucial decisions in real-time, cutting out the need to send data back to Earth. This immediate processing is a game-changer for applications like missile detection, disaster response, and surveillance, where every second matters. By minimizing dependence on ground-based systems, edge computing significantly reduces latency, enabling satellites to act swiftly and efficiently in critical moments, greatly enhancing the Space Force's ability to maintain tactical superiority.

Upgrading Satellite Efficiency in Orbit

Satellites continuously generate massive volumes of data, much of which is redundant or unnecessary. With edge computing, data is filtered and analyzed directly in orbit, ensuring that only the most critical information is sent back to Earth. This not only conserves valuable bandwidth but also reduces energy use, helping to extend the satellite's operational lifespan. Equipped with onboard AI and machine learning, satellites can perform sophisticated analyses, spotting patterns and anomalies that previously required ground-based intervention, making the entire system more efficient and self-reliant.

Spacecrafts Empowered to Make Their Own Decisions

One of the most groundbreaking advantages of edge computing is the autonomy it grants to satellite systems. This capability is vital for missions operating in contested or remote environments, where communication links with Earth may be disrupted. Edge-enabled satellites can continue to analyze data, make decisions, and fulfill their missions independently, ensuring continuity even under adverse conditions. This increased resilience not only safeguards operations but also reduces the need for constant ground support, making satellite networks more robust and adaptable in the face of unexpected challenges.

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Solutions for Expanding Operations Get More Cost-Effective

As the Space Force scales up its satellite constellations, edge computing emerges as a cost-effective and scalable solution. By processing data onboard, satellites drastically reduce the amount of data that needs to be sent back to Earth, cutting down on transmission costs and minimizing the need for extensive ground infrastructure. This efficiency becomes increasingly valuable as satellite operations grow in complexity and scale, providing a more sustainable way to manage expanding missions without overwhelming ground resources.

Image Source: https://www.spoc.spaceforce.mil/News/Article-Display/Article/2572336/global-lightning-exercise-tests-multi-domain-space-capabilities

Strategic Impact on Military Satellites

The integration of edge computing into military satellite systems goes beyond a simple tech upgrade; it's a strategic leap that significantly enhances the Space Force's operational capabilities.

Securing Rapid Tactical Responsiveness in Space Operations

Edge-enabled military satellites can process surveillance data on the spot, rapidly identifying threats like missile launches or unauthorized activities. This immediate data processing allows for swift countermeasures, crucial for maintaining tactical superiority. By autonomously evaluating and responding to unfolding situations, these satellites lighten the load on ground control, enabling quicker, more agile operations that keep the Space Force ahead of potential adversaries.

Using Edge Computing to Shield Satellites from Threats

Edge-enabled satellites enhance security by processing data onboard, reducing the need for transmissions that could be intercepted by adversaries. This minimizes vulnerabilities in electronic warfare scenarios, where secure and resilient communications are vital. By keeping sensitive data processing in space, edge computing bolsters the Space Force's defensive posture. Additionally, this technology allows satellites to adapt to shifting operational conditions on the fly, ensuring continuous, secure functionality even in hostile environments.

Operating Independently: Strengthening Satellite Resilience Without Ground Support

Edge computing drastically cuts the need for ground-based installations, providing a critical advantage in scenarios where these facilities could be vulnerable. By processing data directly on the satellite, edge computing ensures that operations can continue seamlessly even when ground communications are disrupted or compromised. This autonomy enhances the resilience of military satellite networks, allowing them to function effectively in hostile or isolated environments, thereby maintaining mission continuity and strategic effectiveness without constant ground intervention.

Connecting Satellites: How Edge Computing and Inter-Satellite Links (ISL) are Powering Smarter, Faster Networks

The integration of edge computing with Inter-Satellite Links (ISL) is a major advancement in satellite technology. ISLs enable direct communication between satellites, creating a robust network that shares data and coordinates operations independently of ground stations. This interconnected system not only boosts data transmission speeds but also enhances the overall effectiveness of satellite constellations, enabling more synchronized and efficient operations. This approach improves responsiveness and operational capabilities, crucial for modern space missions.

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Through ISLs, edge-enabled satellites can seamlessly share and process data within their network, ensuring that each unit has up-to-date information. This capability is crucial for defense operations, where timely intelligence is key to making informed decisions. The system's ability to autonomously reconfigure in response to threats or mission changes enhances the overall resilience and adaptability of military satellite networks, allowing them to maintain effective operations even in dynamic and challenging environments.

Real-World Applications and Future Prospects

Edge computing is proving its worth in space missions today. For instance, the European Space Agency's Φ-sat-1 uses edge computing to filter out cloud-covered images before sending them back, saving bandwidth and improving data quality. Similarly, the Space Development Agency is planning a mesh network of satellites that relies on edge computing for real-time data processing and decision-making. These examples highlight the growing importance of this technology, signaling a future where edge computing will play a pivotal role in both commercial and military satellite operations.

The future of satellite operations looks even more promising as edge computing integrates with emerging technologies like 5G, AI, blockchain and quantum computing. These advancements will further elevate both military and commercial satellite capabilities, enhancing situational awareness, enabling rapid response, and strengthening defense strategies. For the Space Force, staying at the forefront of these technological developments will be critical to maintaining a competitive edge in space, ensuring that its systems remain agile, secure, and highly effective in increasingly complex environments.

Conclusion

As the Space Force pushes forward with its satellite operations, embracing edge computing is a game-changing step. This technology boosts the speed, efficiency, and autonomy of satellite systems, making them more resilient and capable. In a time when speed, security, and precision are critical, edge computing is poised to become a foundational element of future satellite technology, keeping the Space Force at the cutting edge of space innovation and strategy.

SMALLSAT REVOLUTION:

How Lower Costs & Faster Development Times are Driving their Growth

BY BRENT PAGE,
SFA LOS ANGELES

The use of small satellites has been on the rise recently as the cost of launching has decreased and the capabilities of smallsats have increased. These small, lightweight satellites offer several advantages over larger, more traditional satellites, including lower costs, faster development times, and the ability to be launched in large numbers.

One of the key drivers of the growth in smallsats has been the development of new launch technologies. In the past, launching a satellite into space was a complex and expensive process requiring a large, dedicated rocket. However, the emergence of new launch providers, such as SpaceX and Rocket Lab, has made it possible to launch smallsats on small, reusable rockets at a fraction of the cost of traditional launches.

In the past, smallsats were limited in their capabilities due to their size and weight. However, advances in electronics, power systems, and other technologies have allowed smallsats to pack more functionality into smaller packages. This has opened a wide range of potential applications for smallsats, from Earth observation and remote sensing to communications and scientific research.

A promising application of smallsats includes the field of Earth observation. Small satellites equipped with cameras and sensors can monitor the Earth's surface, providing valuable data ranging from weather patterns and natural disasters to agricultural productivity and urban development. The ability to launch large numbers of smallsats at a low cost makes it possible to create constellations of satellites to provide near-real-time data on a global scale.

In the field of communications, small satellites equipped with specialized antennas and other equipment can be used to provide connectivity in remote areas. This can be valuable in rural regions or developing countries where traditional terrestrial networks are not available or are unreliable.

Smallsats can be employed for scientific research in a variety of fields, including astronomy, planetary science, and atmospheric research. The ability to launch large numbers of smallsats at a relatively low cost makes it possible to deploy a wide range of sensors and instruments into orbit, allowing researchers to collect data on a wide range of phenomena.

Despite these advantages, there are some challenges with smallsats that need to be addressed to fully realize their potential. A key challenge is the need for new launch technologies that can accommodate the growing demand for smallsat launches. As more smallsats are launched into orbit, the demand for launch services is expected to increase, putting pressure on existing launch providers to keep up with demand.

Another challenge is the need for new regulatory frameworks that can accommodate the unique characteristics of smallsats. Unlike larger, more traditional satellites, smallsats are often launched in large numbers and are subject to different regulatory requirements. This can create several challenges for both launch providers and satellite operators and will require the development of new regulations and standards to ensure the safe and responsible use of smallsats.

The growth of smallsats has the potential to revolutionize the way we use space, enabling a wide range of new applications and services. From Earth observation and communications to scientific research, smallsats offer a number of advantages over larger, more traditional satellites. However, to fully realize the potential of smallsats, it will be important to address the challenges associated with launch and regulation. With the right support and investment, smallsats can play a major role in the future of space exploration and utilization.

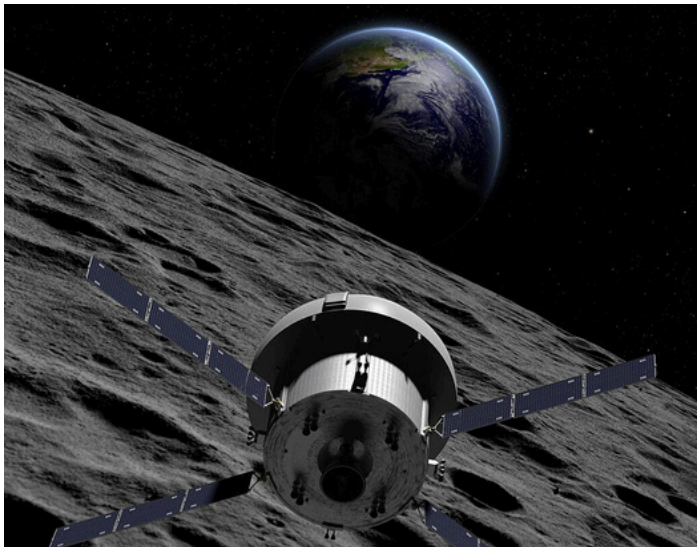
IN SPACE MANUFACTURING SOLUTIONS FOR DYNAMIC SPACE OPERATIONS:

BY BRIAN JOYAL,
DYNASOAR TECHNOLOGIES

While in-space refueling may hold promise for future Dynamic Space Operations (DSO), it's crucial to recognize that most commercial and military satellites are currently incapable of being refueled, limiting the ability of the United States Space Force (USSF) to dynamically respond to in-space threats. Programs like Victus Nox and the ability to rapidly place satellites into orbit within days of an identified threat offer short-term solutions for DSO, but the subsequent supply line will stretch for tens of thousands of miles through contested space. However, by learning from historical logistics operations, such as the World War II Persian Theater, we can apply similar strategies to our current space operations.

World War II Persian Theater – Moving the Lend-Lease Factory to the Theater

On March 11th, 1941, the United States committed to supplying war material to the Soviet Union via the enacted Lend-Lease Act. The War Department's challenge was delivering a sufficient supply of aircraft, locomotives, tanks, trucks, and other war materials thousands of miles away through contested territories.A massive logistics effort that required multiple supply line paths via the Atlantic and Pacific Oceans. This challenge only intensified when the United States entered the conflict later that year. By July 1942, German U-Boat Wolf Packs had nearly cut the Atlantic lifeline. At the same time, the effectiveness of the Pacific routes was curtailed by Japanese naval activity in the Pacific and the Soviet Union's neutral stance with Japan. To counter these long supply line challenges, the United States and its allies looked to alternate logistic' concepts to support the Soviet Union "at scale" on the Eastern Front. Knowing the war was going to last several more years, the war planners focused on moving the supply source closer to the area of need. The Douglas Aircraft Company, General Motors Overseas Corporation of Bombay, and other U.S. and British companies were contracted to build assembly plants throughout Iran and the Middle East. By creating assembly factories near the theater of operation, the war planners were able to maximize the ships' cargo volume by supplying subassemblies instead of complete



vehicles or aircraft. This provided the allies with additional scale because the factories could deliver far more vehicles and aircraft than could be brought on individual ships. It also diversified their supply line and reduced the impact that any one ship would have if sunk. These assembly plants produced everything from aircraft to trucks to jeeps to locomotives. By the war's end, these assembly plants had successfully delivered over 200,000 vehicles and 5,000 aircraft to the Soviet Union from 1942 to 1945. The Persian operation during World War II illustrated the advantage of moving the assembly of the vehicles closer to the theater of operation, a strategy that could be applied to current space operations.

Cislunar Theater – Moving the Satellite Factory to the Theater

Moving forward by eighty years and changing the geography from the Middle East to the astrography of the Cislunar regime, the United States faces a similar supply line challenge. In this case, the contested supply line stretches over 240,000 miles from the Earth to the Moon. Even though a rapid launch response capability like Victus Nox, may cut the launch turnaround time from months to days, the launch vehicles and their payloads would be vulnerable to weather, bad actors, and orbital dynamics. The same vulnerability the ocean-going convoys encountered crossing the Atlantic. As was done in the Middle East during World War II, the solution is to move satellite manufacturing into the theater of operations. Manufacturing satellites in orbit allows satellites to be deployed rapidly and at scale. Analogous to their World War II brethren, the In-Space Satellite Assembly Factories would initially be supplied with satellite components in mass from the

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Earth; then, the specified satellites would be robotically assembled into their final configuration from a demand signal and launched from the factories. By optimizing the use of available payload volume and mass, the launch vehicles will serve as ocean-going freighters to supply the factory. Components and sub-assemblies will be tightly compacted in the payload shroud, allowing for an order of magnitude greater in deployable satellites than any single launch vehicle could achieve. In addition, satellites manufactured in space would have the advantage of not having to meet the challenges of the launch environment, allowing for the final assembly to be lighter and more complex. Supplying satellites within the theater of operation greatly reduces the time and energy required to place the satellite into the specific orbital location versus their ground launched equivalent, thus reducing the time needed to bring the capability online. The disruptive nature of space-based manufacturing, particularly the concept of In-Space Satellite Assembly Factories, has the potential to be a game-changer in space deterrence.

SMALL SATELLITES AND AI:
THE NEW FRONTIER IN SPACE DEFENSE AND DETERRENCE

BY COL (RET) ELVERT GARDNER, USSF, VP SPACE OPERATIONS, APERIO GLOBAL LLC

Two defining characteristics of the so-called New Space Era are the advent of reusable launch vehicles and the increasing use of small satellites, or smallsats. Smallsats are the heart of a rapidly evolving satellite industry and significant paradigm shifts for national security space operations and acquisition. As the United States Space Force continues to mature, there is an opportunity to fully appreciate the evolution of smallsats and the benefits of this new suite of capabilities. There is also an opportunity to derive a competitive advantage in deterrence and defense by coupling the benefits and applications of smallsats with rapidly advancing technology, including artificial intelligence.

The Evolution of Smallsats

The inception of small satellites dates back to the launch of some of the very first satellites, such as Sputnik 1 in 1957 and Explorer 1 in 1958. Sputnik 1 was roughly the size of a beachball and weighed 83.6 kilograms.[1] Explorer 1 weighed only 30.66 pounds (13.907 kilograms).[2] These early satellites were relatively small due to the limited payload capacities of the launch vehicles. Over time, however, rocket technology evolved and payload capacity increased. The result was the ability to launch larger satellites into orbit, which subsequently began to replace smaller satellites.

Beginning in the late 20th century, there was a resurgence in the use of small satellites. This renewed interest was driven in part by a desire to reduce costs, and by the advancement of miniaturization technology. The result has been a shift from large satellites to smaller satellites capable of performing similar functions. Because smaller satellites weigh less, they are cheaper to launch, which has lowered the barrier of entry and resulted in an increase in the number of satellite manufacturing companies. The sharp rise in satellite providers has strengthened the space industrial base and yielded a diverse range of satellite

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[1] NASA. “Sputnik and the Dawn of the Space Age”, Available at: https://www.nasa.gov/history/sputnik/index.html#:~:text=History%20changed%20on%20October%204,Earth%20on%20its%20elliptical%20path.

[2] NASA. “Explorer 1 Overview”, Available at: https://www.nasa.gov/history/explorer-1-overview/#:~:text=The%20satellite%20itself%20was%20203,14%20kilograms%20(30.66%20pounds).

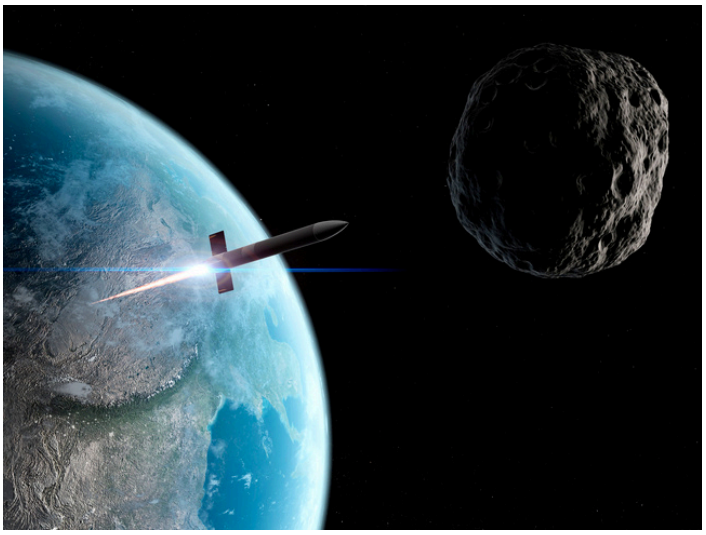
providers and innovative satellite capabilities. The national security implications of a vibrant industrial base capable of mass production of satellites cannot be overstated. This democratization of space provides extraordinary capacity and diverse options for defense and deterrence purposes.

The Benefits of Smallsats

Improved Persistent Surveillance: Smallsats substantially benefit the national security space community in many areas, one of which would be improved persistence for missions with tactical surveillance reconnaissance and tracking (TacSRT). Proliferated constellations of smallsats improve revisit rates and significantly diminish the adversary's capability to hide and obfuscate their movements and other militarily significant activities.

Resilience: Smallsats also enhance resilience through proliferation and disaggregation from legacy paradigms, for example large satellites in a single orbital regime. Smallsats enable a more flexible deployment of satellites, which minimizes the prospect of a catastrophic mission loss from the degradation or destruction of a single satellite.

Rapid Replenishment and Technology Refresh: Another benefit of smallsat technology is rapid replenishment. Historically, space architectures have been predominantly large, expensive, and complex satellite systems. These legacy satellites, while powerful, often took years to develop, launch, and position. The lower cost of building smallsats, coupled with the ability to launch tranches of satellites on a single rocket, now enables the ready replacement of ailing or otherwise degraded satellites. Additionally, the rapid replenishment capability, coupled with the shorter lifespan of small satellites, allows a rapid technology refresh rate, which reduces the prospect of technology obsolescence. In this era of great power competition, the ability to rapidly deploy state-of-the-art space technology is pivotal to maintaining a competitive advantage.



The Future of Smallsats and Implications for the US Space Force

As smallsats become increasingly sophisticated, their integration with AI technologies will enable a new era of space-based capabilities. AI-enhanced smallsats can autonomously process vast amounts of data in real time, offering actionable intelligence faster than ever before. This capability is critical for decision superiority in this era of great power competition. Ultimately, faster data processing, AI-enabled autonomous operations, and predictive analytics directly contribute to warfighters across all domains possessing a superior ability to sense, make sense, and act.

AI-enhanced constellations will eventually be able to support Guardians by ensuring they operate with unprecedented efficiency and effectiveness. Using change detection algorithms and predictive analytics, AI-enhanced constellations will also provide Guardians with the ability to analyze patterns, predict adversary movements, and identify courses of action to mitigate threats well inside adversaries' decision-making cycles. This real-time adaptability will allow the Space Force to maintain a tactical edge in contested environments.

Finally, the fusion of AI with smallsats represents a significant leap forward in space-based defense capabilities. AI-enhanced smallsats will enable the U.S. Space Force to sense with clarity, make sense with certainty, and act with conviction.

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IMPROVING RESILIENCY THROUGH RESPONSIVE ORBITAL LAUNCH

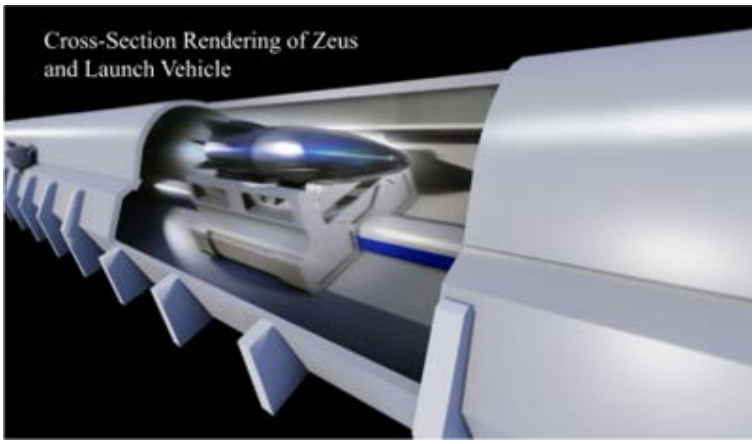
BY AURIGA SPACE STAFF

Over the past 30 years, hundreds of billions of dollars have been invested into developing the next-generation of American space launch vehicles. Alongside consistent support from national leaders, this investment has revitalized our national launch capability.

However, multi-stage chemical rockets are fundamentally limited by their high costs, lack of responsiveness, and susceptibility to weather events. In the face of renewed great power competition and the growing anti-satellite arsenals of China and Russia, these fundamental limitations are detrimental and a threat to continued American space dominance. To address these concerns, Auriga is developing a linear electromagnetic launcher, called Zeus, which will replace the first stage of a conventional rocket, thereby offering Government end-users a high-frequency, all-weather, and on-demand orbital launch capability.

Unlike traditional systems that rely solely on chemical reactions to generate thrust, Zeus uses electricity to accelerate a launch vehicle within a vacuum tunnel. The launch vehicle, mounted on a magnetically-levitated sled, undergoes controlled acceleration on an extended linear track. Upon reaching hypervelocity, the vehicle exits the launcher via an inclined ramp and proceeds on an unpowered ascent into the upper atmosphere. After reaching its target altitude, a small second-stage rocket engine inserts the satellites into their final orbit. By providing the initial velocity to escape the densest portion of Earth's atmosphere, Zeus will allow Auriga to improve response times, increase cadence, and reduce overall costs.

Ensuring that orbital assets are protected is a requirement for ensuring battlefield dominance during a conflict with a peer-state adversary. This is clearly stated in the 2022 National Defense Strategy, which states that space assets will be used to gain "operational, logistical, and informational advantages" in future conflicts. As expected, adversaries are rapidly developing orbital and terrestrial systems



capable of denying, degrading, and disrupting US space assets. For example, in 2022, Chinese military researchers announced the results of a simulated nuclear detonation in space that they believed could disable the Starlink constellation while leaving their own relatively intact. Not to be outdone, widespread reporting in 2024 hinted that Russia was in the later stages of deploying a modern nuclear anti-satellite weapon of its own.

The DoD is acutely aware of these threats and is working diligently to organize Tactically Responsive Space (TacRS) solutions. This effort has yielded tangible results through the 2024 Victos Nox mission, which launched a satellite within 27 hours of receiving the "go" order. While this is a remarkable achievement that provides the DoD with a novel capability, it is not possible to scale this methodology to the level required for reconstituting US assets after a large-scale attack.

There are several reasons for this, the first of which is cost. Even the most cost-effective orbital rocket in the United States costs over $7 million, notwithstanding modifications and special facilities required to support the missions. When scaled to the level necessary for reconstituting satellites after a major attack, the price tag could easily balloon into the hundreds of millions or billions of dollars. The second challenge is the launch cadence of conventional rockets. In the Victus Nox mission, it took more than a day to lift off after receiving the order to do so. That combined with the limited number of launch pads available across the country, it could take several weeks, or months, to deploy the satellites to the desired orbits. The third issue is susceptibility to weather. Events such as rainstorms, snow, hail, and strong wind gusts can cause a mission to be postponed for several days, which offers adversaries expanded windows of increased US vulnerability.

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The electromagnetic launch approach offers inherent advantages that will address these issues and meet both current and future Government requirements. Because Zeus replaces the first-stage booster of a traditional rocket with a piece of reusable ground-based infrastructure, the launch vehicle is simplified and dramatically reduced in cost. With the system connected to a continuous power source, launches can occur every hour once orders arrive. Because the launch vehicles will exit the Zeus system at hypersonic velocities, they will be immune to weather events that would otherwise scrub a traditional mission.

Not only will the truly responsive nature of the Zeus system allow replacement satellites to be deployed rapidly, but it may also discourage hostile action against them in the first place. This is because any nation launching a kinetic attack against American satellites runs the risk of losing their own due to retaliation or inadvertent orbital debris collision. As such, Zeus' ability to immediately redeploy lost satellites rewrites adversary decision-making calculus due to the rewards of such actions being greatly diminished, while overall risk remains unchanged.

RESILIENT BY DESIGN:

HOW SATELLITES, BUSINESSES, AND ANTS BUILD REDUNDANCY TO THRIVE

BY GINISIS GROUP

In business, as in nature, the smallest systems can offer the most powerful lessons. What if our expertise in building resilient companies could inform the next generation of satellite networks? While ants might seem an unlikely source of inspiration, their ability to build redundancy into their colonies at the lowest levels offers valuable insights for business and satellite operations. This article explores how principles of redundancy observed in nature can be applied to small satellite networks, with recommendations drawn from business strategies that have proven successful in building resilient organizations.

Drawing Parallels Between Business Resilience and Satellite Design

The Importance of Redundancy in Business Operations

Successful businesses, like those I've led, thrive by incorporating redundancy into their operations. Redundancy takes many forms, from cross-training employees to maintaining backup systems for critical functions. These strategies ensure continuity and resilience, allowing businesses to withstand disruptions from market fluctuations, supply chain issues, or technological failures. Just as these practices protect businesses from unforeseen challenges, they can also inform the design of resilient satellite networks.

Lessons from Ants: Redundancy at the Lowest Levels

Ant colonies, though simple, are excellent examples of adequate redundancy. Each ant performs specific tasks, but the colony's structure ensures that if one ant fails or is lost, others can immediately take over. This redundancy at the lowest levels is crucial for the colony's survival, particularly when faced with threats like predators or environmental changes. Similarly, small satellite networks could benefit from incorporating redundancy at every level, ensuring that if one satellite fails, others can quickly adapt to cover its functions, maintaining the overall system's integrity.

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Threats and the Need for Redundancy

Threats are ever-present and unpredictable in business, nature, or space. Businesses face threats such as economic downturns, cyberattacks, and supply chain disruptions. Ant colonies contend with natural predators, environmental changes, and resource competition. Likewise, satellites face risks from space debris, solar radiation, and system malfunctions. Building redundancy into these systems whether it's having multiple suppliers in business, multiple workers in an ant colony, or backup systems in satellites—mitigates these risks and ensures that operations can continue even when something goes wrong.

Recommendations for Satellite Networks Inspired by Business Success

Decentralized Operations: A Lesson from Business Management

One of the most effective strategies in business is decentralization, where responsibilities are distributed across teams to avoid single points of failure. This approach is equally valuable for satellite networks. By adopting a decentralized structure, satellite networks can ensure that even if one satellite fails, others can seamlessly take over its responsibilities, maintaining the system's overall integrity.

Building Adaptable Satellite Systems

Adaptability is critical to survival in business, nature, or space. In business, adaptability might mean pivoting strategies in response to market shifts. In ant colonies, it means quickly reorganizing tasks to respond to immediate threats. Adaptability can be achieved for satellite networks by designing systems with modular components that can be easily replaced or upgraded. This approach ensures the network can function effectively even as conditions change or new challenges arise.

Strategic Takeaways for Satellite Designers and Business Leaders

The Value of Cross-Disciplinary Thinking

Satellite designers can benefit from thinking like business leaders, incorporating lessons from the corporate world to enhance the resilience of their systems. Cross-disciplinary thinking allows for innovative solutions that combine the best practices of multiple fields, leading to more robust and adaptable satellite networks.

Future-Proofing Satellite Networks

The long-term benefits of building redundancy into satellite networks are clear. By taking a forward-thinking approach and considering the evolving challenges of space operations, satellite designers can create networks that are not only resilient but also adaptable to future needs. This approach, inspired by resilient business models, will ensure that satellite networks remain functional and efficient in the future.

Conclusion

No one can predict the future or mitigate all potential threats, whether in business, satellite operations, or ant colonies. However, building redundancy into these systems is critical to their success. Just as resilient companies are built to thrive in changing markets, and ant colonies survive through distributed and redundant efforts, satellite networks can be designed to withstand and adapt to the unpredictable challenges of space. By looking to nature and business, we can build systems designed to thrive in space and on Earth.

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Ginisis Group Inc.

SYNTHETIC APERATURE RADAR

SATELLITES ARE CRITICAL

BY BT CESUL, JASON MALLARE, JOE MORRISON, AND JON GALPERN, UMBRA SPACE

Dateline- Soon, near-peer crisis territory. An enemy nation with moderate space domain awareness has decided it's go time for a major military operation. US and Allied electro-optical (EO) imaging satellites enter the terminator condition, rendering them inoperable during nighttime hours. Action commences. Enemy missile launchers roll out from underground bunkers into launch positions, troop transports are loaded at naval ports, surface vessels in open water conduct hard turns into attacking vectors, airfields come alive with fueling, loading, and taxi operations. Adding to US worries, a weather front has rolled in- not enough to curtail enemy operations, but blanketing the land in a thick cloud cover, lasting into morning.

For the Allied forces, how to mitigate the above problem has been known for years,as overhead synthetic aperture radar, or SAR. As a technology, SAR has been around since the 1950s when researchers out of Ann Arbor, MI tested the first airborne systems. Since then, national governments have utilized SAR for national security (NatSec) and environmental remote sensing purposes, but with limitations on spatial resolution and revisit time due to singular asset duty cycles.

Image: Artist conception of Umbra X4 satellite transmitting to the ground and receiving reflected signals back. Credit- Umbra Marketing Team.

SAR sensors function by emitting radar pulses and capturing the reflected signals to measure doppler shifts and range, which are influenced by the relative motion between the sensor and the target. The performance of SAR—specifically its resolution, range, and image width—is determined by factors such as the frequency, bandwidth, and power of the radar transmission, along with the design of the antenna and the slant range to the target. A key advantage of SAR is its ability to produce clear imagery regardless of the time of day or weather conditions. This is because SAR is an active sensing phenomenology, meaning it does not depend on external light sources like the sun or on the target itself for illumination.

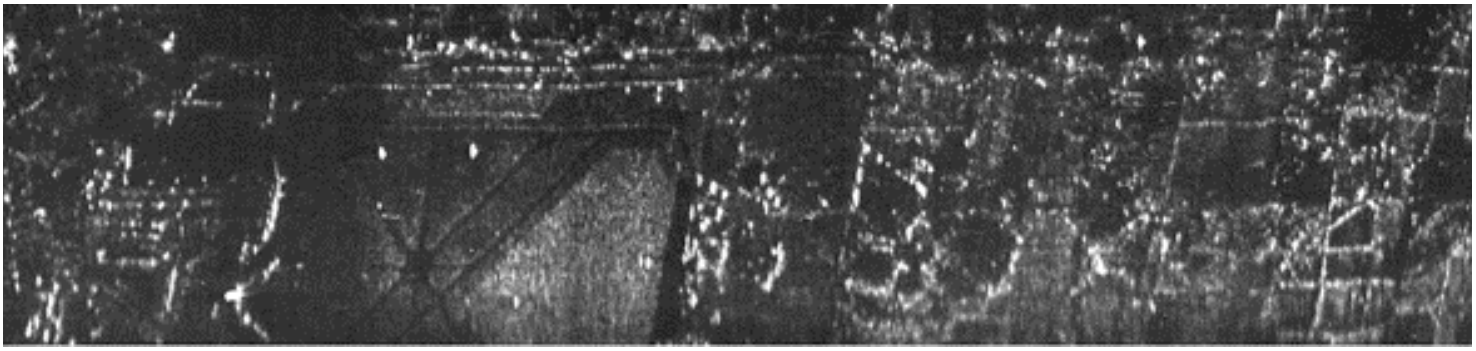

Image: First successful focused airborne synthetic aperture image, Willow Run Airport and vicinity, August 1957. Flown by Radar Laboratory, Willow Run Labs, University of Michigan. Best resolution about 50 feet (17 meters). Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

Continued on Page 29

In the military context described earlier, SAR satellites provide several critical advantages for NatSec missions. The all-weather, day-and-night capabilities address the limitations of EO sensors, reliant on solar reflection for illumination. When continuous, 24/7 monitoring of key areas is essential, the ability to track enemy movements at night or through cloud cover is non-negotiable—SAR technology meets this requirement. Additionally, placing SAR on satellites mitigates the risks faced by airborne platforms in hostile or denied areas, while also delivering broad coverage over large regions of the Earth with consistent, repeatable observation times.

In the past, SAR satellites struggled with lower resolution compared to their EO counterparts, and the data they produced was often difficult to interpret, hence the term 'blob-ology.' However, advances in microelectronics, small satellite engineering, and data processing techniques have significantly improved SAR capabilities. Today, commercial SAR satellites, like our cost-effective Umbra Block 2 satellites currently in orbit, deliver 0.25-meter resolution images across various modes, from spotlight to large-area strip maps, covering any location on the globe. As our constellations expand in size and distribution, revisit times continue to improve.

Recent experiences in real-world crisis zones have demonstrated that the performance of commercial SAR satellites are 'good enough' for military operations planning and execution. Advances in software and SAR processing techniques have transformed SAR data products from the art of 'blob-ology' into clear, interpretable imagery — delivering critical mission insights. At Umbra, our teams are actively developing SAR-enabled moving target indication capabilities that operate over large areas, regardless of dynamic weather conditions. Additionally, multi-static SAR collections, where receivers, perhaps multiple, are separate from the transmitting platforms, offer enhanced resolution and resiliency through advanced post-processing techniques.

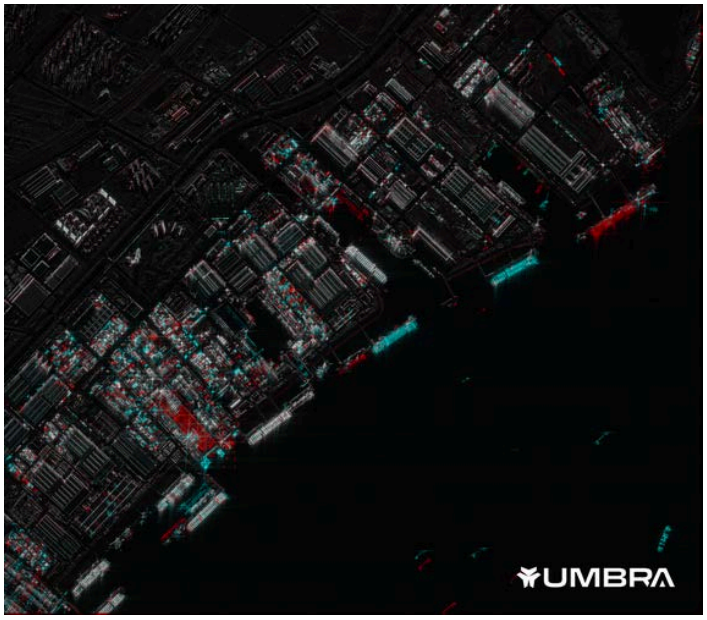

Image: 2CMV image of Jiangnan Shipyard in Shanghai, China. Source- Umbra Open Source Archive.

In non-earth imaging scenarios, SAR satellites offer a unique advantage by allowing operators to detect spacecraft features obscured by shadows, apertures, or solar illumination. This capability ensures that critical details, like a weapon system concealed under a solar array, cannot be easily hidden. By providing their own illumination, SAR satellites enable flexible observation angles, especially in rendezvous and proximity operations (RPO) mode, allowing for comprehensive inspection of the target.

Finally, it is important to note that SAR satellites are not immune to attack. Indeed they are threatened by direct ascent ASAT missiles and kinetic strike orbital ASATs like other orbital targets, but also by ground-based SAR jammers. However, skilled operators can counteract these threats by leveraging jamming signals to pinpoint targeting vectors, using SIGINT assets or the SAR satellite itself, similar to the tactics employed during Wild Weasel aircraft operations.

When an Umbra SAR expert was asked to summarize the key advantages of SAR over EO satellites for NatSec missions, he emphasized 'nighttime, all-weather' repeatedly. And that is the point. Space-based SAR allows customers continuous surveillance over a denied airspace area regardless of lighting or weather conditions. With commercial SAR technology now offering resolution comparable to EO satellites and an increasing number of assets in orbit, space-based SAR is becoming critical for maintaining situational awareness for the NatSec customer—while remaining cost-effective.

THE SPACEBOUND SKILLSET:
A JOURNEY TOWARDS EXTRAORDINARY

BY KIM GENNUSA, MANTECH

Bridging the skills gap: A perspective on the Space Industry Transformation

The space industry stands at the precipice of a dramatic transformation. Rapid advancements in AI, machine learning, and automation demand a fundamental shift in the workforce skills.

While current space professionals possess undeniable intellectual power - analytical expertise, problem-solving acumen, and technological mastery - these qualities alone are no longer enough. We aren't just solving technological, mathematical, or scientific problems. The cosmos beckons a new breed of talent: individuals who seamlessly blend scientific expertise with a deep understanding of human interaction, environmental stewardship and the complex interplay between technology and society.

Preparing organizations for this shift is crucial for leaders in the space industry, including space launch and small satellite providers. Fostering a culture of continuous learning and development is crucial. By investing in training programs that bridge the gap between existing and future skills, leaders can empower their teams to adapt and thrive. Creating an environment that encourages experimentation, risk-taking and collaboration is essential for driving innovation.

To navigate this complex landscape, leaders should consider three key areas:

- Strengthening foundational skills: Building upon existing strengths in critical thinking, problem-solving, and adaptability to provide a strong foundation for acquiring new skills.
- Cultivating a culture of innovation: Encouraging experimentation, risk-taking, and cross-functional collaboration to foster a creative and dynamic work environment.
- Prioritizing lifelong learning: Investing in employee development and creating opportunities for skill enhancement to equip teams with the tools they need to succeed in a transformational industry.

The move from exploring to equipping and from conceptualizing to colonizing new frontiers requires a shift in mindset. It's about recognizing that our greatest asset is our ability to learn, unlearn, and relearn. By embracing this philosophy, space leaders can not only survive but thrive in an era that will be defined by unprecedented challenges and extraordinary opportunities.

A Shift Towards Holistic Skill Sets

The space exploration skill set of the future is evolving beyond the traditional realms of math and engineering, embracing a holistic approach that includes societal readiness for adapting and living in space. While technical expertise remains crucial, future space exploration demands a diverse array of skills. For instance, psychological resilience and cross-cultural communication are becoming increasingly important as missions grow longer and more international. Understanding group dynamics and conflict resolution will be essential for maintaining harmony in confined, isolated environments like space stations and Mars habitats.

In 2020 the focus was primarily on problem-solving, critical thinking and creativity, capabilities that are now complemented by a broader range of competencies. By 2025, there will be a shift toward emphasizing analytical thinking, innovation and active learning, highlighting the growing importance of adaptability and continuous learning in a rapidly evolving field.

Looking ahead to 2035, advancements in technology will redefine the necessary skills for the space workforce. Technologies like digital engineering and digital twinning will be prominent pillars enhancing efficiency, innovation, and collaboration across the industry.

As space projects become increasingly interdisciplinary, professionals must possess a broad understanding of various engineering disciplines. A spacecraft orbiting Mars will have a digital twin on Earth, enabling real-time monitoring and predictive simulations. Proficiency in data analytics will be crucial to interpreting and leveraging vast amounts of generated data and rely on expertise in modeling, simulation and systems thinking.

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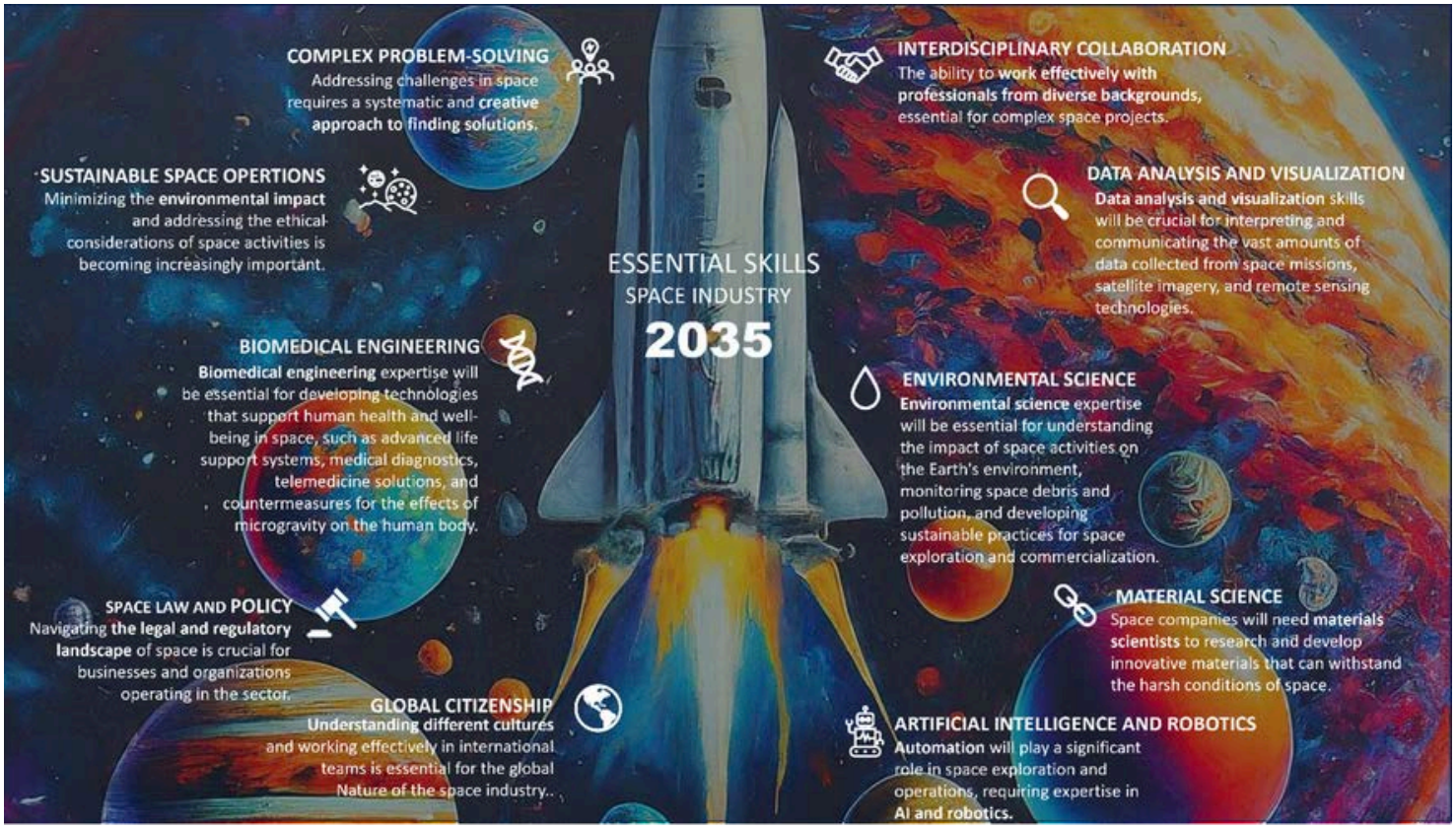
By 2035, the space industry will demand a truly interdisciplinary skill set. As humanity prepares for a future where space travel becomes more commonplace, fostering adaptability, creativity, and collaborative problem-solving will be just as important as engineering prowess. A strong foundation in systems thinking will be paramount to understanding the intricate interactions between components. These skills are increasingly intertwined with human-centric disciplines such as sustainable space operations, interdisciplinary collaboration, artificial intelligence and robotics. This evolution reflects the growing complexity of space exploration and the need for a comprehensive approach that considers the ethical, social, and environmental implications of space activities.

Cultivating the next generation of space pioneers

In the grand tapestry of space exploration, human ingenuity and collaboration are the guiding stars. The space industry of 2035 demands a unique blend of skills – from the technical prowess to navigate celestial bodies, to the ethical compass to guide our exploration.

As we venture deeper into the cosmos, we must cultivate a generation of space pioneers equipped with a more diverse skill set. From biomedical engineering to environmental science, and from data analysis to global citizenship, each discipline will play a vital role in shaping the future of humanity beyond our planet.

This is a call to action. Are you ready to be part of this extraordinary journey? Then explore the possibilities, learn more about space careers, and join the space community.



SMALL SATELLITES

BY BLUE CANYON TECHNOLOGIES

Since the first launch of its hardware in 2015, Blue Canyon Technologies continues to expand the possibilities of spacecraft research, design and innovation through world-class technical performance on bus platforms, components and subsystems. In contrast to the typical high costs, longer development cycles and limited flexibility of traditional satellite systems, Blue Canyon's high-performance, flight proven and reliable product lines offer greater resilience, responsiveness and affordability.

With the launch of 70+ small satellites, Blue Canyon has amassed a wide variety of mission and product line successes, including:

- Low jitter, arcsecond-class on-orbit pointing systems across our suite of bus platforms and subsystem offerings;
- On-orbit operations in VLEO, LEO, GEO, Lunar and deep space missions, including attitude control systems on the first interplanetary CubeSats;
- An impressive flight heritage of more than 100 years on-orbit for spacecraft, 200+ years for avionics assemblies and 2,100+ for components
- Proven ability to integrate custom capabilities into standard products to achieve mission success, including optical imaging, commercial SAR, exploration astronomy, autonomous formation flying, weather observation, communications, defense applications and more.

Blue Canyon's largest spacecraft bus, the Saturn-200 minisatellite, features robust power systems, secure data handling and industry-leading guidance and navigation with high payload volume, while remaining rideshare-compatible. This bus platform was selected by the Defense Advanced Research Projects Agency (DARPA) as the basis for its Blackjack program, leveraging advancements in commercial space technology to develop and deploy a constellation of small satellites that can deliver military-grade capabilities at a fraction of the cost and time typically associated with traditional satellite programs.

Harnessing COTS components, rapid manufacturing processes, and innovative mission architectures, DARPA utilized Blue Canyon's industry-trusted bus platform to demonstrate the potential of LEO satellite constellations to meet the diverse needs of the defense community more effectively and efficiently.

In addition to DARPA, the Environmental Defense Fund turned to Blue Canyon's Saturn-200 bus platform for its MethaneSAT project, the only grassroots-funded satellite of its kind for its groundbreaking mission to protect the climate through the first truly comprehensive, global picture of methane emissions.

Blue Canyon's vertical integration allows for increased control of its supply chain, with all components and spacecraft designed within its 140,000+ square-foot satellite factories, which are specifically designed with the manufacturing capability to handle large constellations of small spacecraft systems. In addition, both design and manufacturing are performed in-house and in collocated facilities, ensuring smooth transitions between program phases with additional support available during integration efforts. And, as part of RTX, Blue Canyon is able to leverage the resources of more than 185,000 global employees to push the limits of technology and science to redefine how we connect and protect our world.

Blue Canyon Technologies continues to grow, using flight-proven bus platforms and components to enable space missions that expand the frontiers of science and defense. In the next few years, the company plans to improve spacecraft agility through its Control Moment Gyroscopes, exploring the cislunar highway and increasing the capabilities size of its small satellites, including the Saturn-400.

EDGE COMPUTING FOR SMALL SATS: TRANSFORMING SPACE MISSIONS FOR NATIONAL SECURITY AND BEYOND

BY BOSCO LAI, LITTLE PLACE LABS

The rise of small satellites has revolutionized space missions, while edge computing is reshaping data processing across industries. Together, these technologies unlock new opportunities for enhancing national security, commercial operations, and autonomous space missions. This article explores the transformative potential of edge computing for small satellites, with applications in defense, disaster monitoring, illegal fishing detection, and critical infrastructure management.

Overcoming Challenges with In-Orbit Processing

Traditional satellite operations require transmitting large volumes of raw data to ground stations for processing, leading to delays and significant bandwidth consumption. For defense operations, these delays can compromise decision-making. Edge computing addresses this challenge by allowing satellites to process data directly in orbit, reducing latency and enhancing responsiveness. This minimizes dependence on ground-based infrastructure, improving operational efficiency in time-sensitive scenarios.

Intelligence, Surveillance, and Reconnaissance (ISR)

ISR is crucial for national security, providing timely intelligence on potential threats and adversary movements. Edge computing allows small satellites to analyze data in orbit, detecting anomalies and classifying objects in real time. This reduces delays inherent in traditional satellite operations, enabling defense forces to act faster and more accurately in dynamic environments. By processing ISR data onboard, satellites provide immediate insights, such as troop movements or equipment deployments, offering a tactical advantage in combat situations.

An example is Little Place Labs, a startup supported by AFWERX to advance ISR capabilities by developing machine-learning applications that can be deployed and run on satellites to generate real-time insights for maritime domain awareness through vessel detection and classification. Their work highlights the potential of edge computing to improve surveillance and response times in critical defense operations. Read more on Space News.

Missile Defense and Threat Detection

Missile defense relies on rapid detection and response. Edge-enabled satellites can detect missile launches, calculate trajectories, and relay critical information to defense systems instantly. This real-time processing minimizes latency and improves response times, particularly in contested environments where communication links may be compromised.

By processing missile threat data in orbit, these satellites ensure that defense systems remain agile and ready to intercept threats efficiently.

Tactical Communications and Battlefield Insights

Real-time, secure communication is essential for military operations. The Department of Defense's Proliferated Warfighter Space Architecture (PWSA), developed by the Space Development Agency (SDA), is designed to enhance global, real-time communications through a network of small satellites in low-Earth orbit.

The PWSA progresses through "tranches," with early-stage tranches like Tranche 0 demonstrating capabilities like beyond-line-of-sight (BLOS) targeting and missile detection. Tranche 1 will enhance these capabilities with regional persistence, and future tranches will expand global coverage. Edge computing enhances this architecture by enabling onboard data processing, reducing latency, and improving real-time battlefield awareness. More details can also be found on the SDA FAQ page.

Space Domain Awareness (SDA)

With space becoming increasingly congested, Space Domain Awareness (SDA) has become vital for national security. Current systems often struggle with merely cataloging space objects rather than detecting emerging threats. Edge computing changes this by allowing satellites to process real-time data on space objects, predicting their behavior and reducing the risk of collisions or threats.

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Edge computing offers a way forward by allowing satellites to process data about space objects in real time. This improves the ability to detect, track, and predict the behavior of debris or potentially hostile satellites, reducing the risk of collisions and ensuring the operational security of military assets. By using edge computing, the U.S. can shift from merely tracking objects to actively preventing collisions and responding to threats more quickly.
For a more detailed understanding of the challenges related to SDA, visit SDA Data Lab.

Autonomous Operations and Efficiency
Edge computing also enables autonomous satellite operations, allowing satellites to execute automated health checks, manage systems independently, and perform diagnostics without waiting for ground control. This leads to more efficient and longer missions.

Tip-and-cue systems powered by edge computing allow satellites to autonomously collaborate with other assets, such as drones or ground sensors. For example, a satellite detecting unusual maritime activity can tip a drone to investigate further, creating a network of real-time, autonomous responses. Additionally, satellite swarms can operate together, coordinating missions and sharing data, improving operational efficiency with minimal human intervention.

Non-Defense Use Cases: Disaster Monitoring, Maritime Surveillance, and Critical Infrastructure
Beyond defense, edge computing offers advantages in disaster monitoring and infrastructure management. In disaster monitoring, edge-enabled satellites provide real-time insights on wildfires, floods, and hurricanes. By processing imagery onboard, satellites can detect fires early and predict their spread, enabling faster deployment of emergency resources.

In the maritime domain, edge computing assists in illegal, unreported, and unregulated (IUU) fishing detection and maritime domain awareness (MDA). Satellites monitor vast ocean regions, classify vessels, and detect suspicious activities like unauthorized fishing. Real-time data allows coast guards and maritime agencies to act quickly to mitigate illegal activities.

For critical infrastructure monitoring, edge-enabled satellites detect real-time anomalies in pipelines, power grids, and energy production facilities. These satellites help prevent costly failures by providing immediate alerts about structural damage or environmental changes.

Future Prospects and Challenges
While edge computing offers significant advantages, challenges remain, such as developing energy-efficient hardware and software to withstand the harsh space environment. Advancing onboard processing algorithms and ensuring system resilience are key priorities for both defense and commercial organizations.

Looking ahead, further innovations in microelectronics, AI, and satellite technology will drive the evolution of edge-enabled satellites. Future developments may include machine learning algorithms for adaptive data processing and more sophisticated autonomous satellite networks. To achieve these advancements, closer collaboration and alignment between government agencies and industry are essential. Organizations like the Space Force Association (SFA) and the Defense Innovation Unit (DIU), as well as Space Systems Command's Front Door, are fostering these partnerships and pushing the boundaries of what space missions can achieve.

SPACE OPERATIONS IN THE YEAR 2079:
A CASE FOR EXPANDING THE US SPACE FORCE

BY LT COL MARK D. "NIX" NATALE, US SPACE FORCE

One morning while driving to work, a song I had not heard for a long time came on the radio. It was "In the Year 2525" by Zager and Evans. It was one of my favorites from the late 1960s. The song was released at the height of the space race and was the number one song on the Billboard Hot 100[1] just four days before mankind first set foot upon the moon. Now, in 2022, I found myself paying closer attention to the lyrics' apocopic for the first time: "In the year 2525, if man is still alive, if woman can survive." Why did the artists imagine that humanity may not survive the next 500 years? This made me think about the current condition of the world; recent political events, impending warfare, climate change, and the future of space. I asked myself, how could the US Space Force ensure the survival of the American way of life? Or even more importantly, the survival of humanity? What follows is a futurist look at the next 57 years.

The US Space Force is at a crossroads in 2079. The future of American space dominance hangs in the balance, as a multi-polar world with several spacefaring superpowers emerge. China has pushed the boundaries in a new space-race. They have emerged as one of the top space-nations and challenged the US military terrestrially, in proxy wars, in orbit, and by economic means over the last 50 years. The Space Force has been assigned a myriad of human space-based warfare tasks. China and the US are on the verge of a full-scale war, on Earth and in orbit. How did the Space Force get to this critical point in history?

This thought experiment was derived from the current events unfolding in the Ukraine, tensions over Taiwan, NASA's mission to divert an asteroid[2], and the recent natural disaster of Hurricane Ian, which devastated my hometown of Fort Myers, Florida. How did we not see these events coming? And what part did the US Space Force, USSPACECOM, NASA, and the commercial sector have to play in these events? Could we avert a future crisis? These recent events are what spurred this thought experiment and begged the question; what would the US Space Force be asked to do in the next 50 years?

What events are we planning for, and what events will surprise us because we have a lack of imagination? Below are the events leading up to a fictional space-war with China and other Nostradamus-like predictions we will have to combat in the Space domain:

-2025: US Space Force grows to nearly 20k Guardians[3], several new Deltas are established and every Combatant Commander now has a robust space component. Leaps in commercial space travel drives the Space Force to field capabilities to enforce freedom of navigation and rescue in the cis-lunar regime. The Space Force takes on new missions to include; planetary defense, PNT and SATCOM beyond terrestrial domains, globally responsive space lift, and developing new technologies of expeditionary power through space based solar power and on orbit maintenance of spacecraft.

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[1] https://www.billboard.com/charts/hot-100/1969-07-12/ US Billboard Hot 100
[2] https://www.jpl.nasa.gov/edu/news/2022/9/22/the-science-behind-nasas-first-attempt-at-redirecting-an-asteroid/#:~:text=In%20a%20successful%20attempt%20to,no%20threat%20to%20our%20planet. NASA's First Attempt at Redirecting an Asteroid 20 OCT 2022
[3] https://www.military.com/daily-news/2021/05/28/space-force-only-military-service-set-grow-under-bidens-budget-plan.html Military News, By Stephen Losey 28 May 2021

Continued on Page 36

-2027: First US-made hypersonic weapons[4] deployed in regular combat operations in the middle east and South America against key leaders of emerging terror groups. Most notably was the strike in Ethiopia, against the leader of the Tigrayan People's Liberation Front (TPLF). NY Times published the story, disclosing this secret program. These terrorist targets proved the weapon's ability to minimize collateral damage and be undetected by other nations' space-based observation platforms.

-2028: NASA's Artemis program delivers astronauts back to the moon, the first time in 56 years. Kathleen Rubins[5], an American microbiologist and Astronaut becomes the first woman and 13th person to set foot upon the moon. The popularity and commercial interest in Artemis III leads Congress to approve NASA's funding request for Artemis VII-XI. Massive leaps forward in a permeant lunar base are underway.

-2031: China surpassed the US as the leading global economy and Chinese military expansion puts it on par with the U.S. for global presence, influence, and force projection[6]. The US responds with economic sanctions against China for human rights abuses and brokers new trade deals with Europe, Africa, and South America, setting the stage for an ideological conflict to resolve tension over decades of economic and military competition. China also faces a second "People's Rebellion" as domestic protests increase across the country, similar to the failed protest attempts in 2022.[7]

The first footprint on the moon, during the Apollo 11 mission. *Courtesy NASA*

-2033: A private American enterprise lands on Mars, a several year delay from SpaceX's initial goal of 2029[8]. A limited crew of eight astronauts establish a research and reception base. The colony grows on average of 5x colonists per year. In 2040, an average of 550-600 colonists are on mars at any given time.

-2034: The James Webb Space Telescope (JWST) is damaged[9] by Chinese optical laser attack. Intelligence suggests that the Chinese were attempting to interfere with the telescope's operation to embarrass the US space program and tout the new Chinese Lóngyǎn-7 (Dragon Eye) deep space telescope, which launched earlier that year. The damage, however, appears to be significant. The Chinese claim they were conducting "experiments", however the distance of the JWST in Lagrange point and efforts required to reach it suggest this was a calculated attack. The US decides to launch a repair mission to test a prototype repair spacecraft[10] and extend the life of the JWST. The first ever fully autonomous repair and replenishment mission was a success, and the addition of liquid helium coolant modules extend its lifespan to 2059.

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Continued on Page 37

-2035: The Russian Federation collapses swiftly, similar to the fall of the Soviet Union in 1991. After more than a decade stalemate in Ukraine and unproductive expeditionary operations in Syria and the Levant, the collapse of the ruble, strangling economic sanctions, and the death of President Putin. The Russian Space program grinds to a halt and new leadership considers participating in the international space station, after their exit in 2024[11], to preserve national prestige and sustain the flagging military industrial complex.

-2036: Artemis X[12] establishes a permanent base on the moon. Lunar Base "Armstrong" (LBA) now has a crew of 12-19 fulltime Astronauts. Recent cyber-attacks, a near-miss collision initiated by the Chinese landing a rover on the moon, and one incident of suspected sabotage on LBA has spurred NASA to request a security detachment for the base. Efforts are made to fast-track a training program for USSF Guardians to be certified as astronauts.

-2037: First detachment of Guardians arrives at LBA. US Space Force is now responsible for security on manned spaceflights, escort of manned missions, and protection of manned installations. These Guardians will train as astronauts with NASA at several locations, to include the newly established Joint Zero Gravity warfare school in Yuma, AZ. The school, originally stood up by the Advanced Space Operations School, 319th Combat Training Squadron,[13] will train military small arms tactics from facilities in vacuum and in space suits in the desert environment to simulate the terrain on the moon and mars. Additionally, Guardians will train in a zero-gravity rifle range onboard the newest version of the KC-135 Zero-G aircraft. This will simulate tactical engagements in zero-G and microgravity environments. These security forces are ready for initial deployment by the end of the year. These space qualified Guardians (13Z) are assigned to security rotations on the LBA, the Martian colony, and in Earth orbit stations by 2040.

Artist's concept rendering of Artemis Base Camp. *Courtesy NASA*

-2040: SpaceX's commercial Space Port "Starbase"[14] shuttles approximately 112 passengers to LEO each month for experience flights, and transport dozens of people and cargo to LBA and the Mars colony as a subcontractor for the US government. The Texas space port has been the target of several cyber-attacks, causing delayed launches and technical problems. The attacks originate from the Chinese mainland and Chinese owned satellites. Elevating tensions in the region. SpaceX requests several security detachments from the US Space Force's terrestrial security units to provide security to the launch facilities and commercial terminal of the port.

2041: Australia backs out of US-AUS space launch endeavor[15] to side with China, due to the military and economic stranglehold China has on the Australian economy. Australia succumbs to regional pressure and finally breaks with traditional western alliances. Initially they remain ideologically and politically neutral, but NATO projects eventual military cooperation with PRC. The proposed US-AUS space launch site located at the Arnhem Space Centre was scrapped for a cheaper Chinese proposal of launching rockets from floating barges and repurposed oil rigs in the Coral and Tasmania Seas.

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US Space Force and AUS -Defence Space Command continue to conduct combined exercises, but Chinese presence in the area reduces US participation and Chinese political pressure leads to decline of these efforts.

-2045: The Egyptian Space Agency[16] partners with South Africa on a manned launch into LEO and a joint spacewalk, to deliver microsatellites for the African continent. The initial launch and deployment of the satellites was a success, but the astronauts died on reentry. This accident highlights growing safety concerns with the Egyptian-made spacecraft and reignites criticism over commercial spaceflight safety standards. The Chinese step in and become the exclusive space lift and space control provider in Africa for the next 100 years. The Chinese also leverage their existing mineral rights in Africa to secure several launch sites with a 200-year lease on the land. China has secured over 70% of the Space Flight and Launch market, internationally[17], a dramatic increase from the 13.6% share of space assets China had in 2020[18].

-2050: US economic market starts to head toward a recession in 2052, due to China's manipulation of currency, technology manufacturing, and theft of intellectual property for space applications. Tensions rise again and the US Presidential election in 2052[19] revolves around the US-Chinese Space Race and weaponization of space. Other campaign issues revolve around statehood for US territories, the economy, US Space Force's deployments to space bases, and social-media currency legislation.

2051: Escalating climate change generates the largest hurricane ever on record[20]. US Space Force and NOAA weather satellites provide early warning to people in the region, however state and local governments are late to order mandatory evacuations. Unprecedented damage to road, rail, port, and airport facilities inhibits the flow of relief resources. The insufficient pace of evacuation, lack of power, dehydration, and the proliferation of a novel virus named T2-Ni[21] ravages the survivors throughout FEMA camps, adding additional chaos to this natural disaster. All told the death count exceeds 300k across several US states. Public outcry demands a US Government capability to deliver electrical power and relief supplies by the ton anywhere in the world in under 24 hrs. Space Force research efforts are fast tracked and the USSF is given responsibility and resources to provide on-orbit depots to deliver payloads with pinpoint accuracy, including rectennas[22] to receive megawatts from Space Force operated space based solar power satellites.

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[22] https://www.intechopen.com/chapters/69576 Rectenna Systems for RF Energy Harvesting and Wireless Power Transfer

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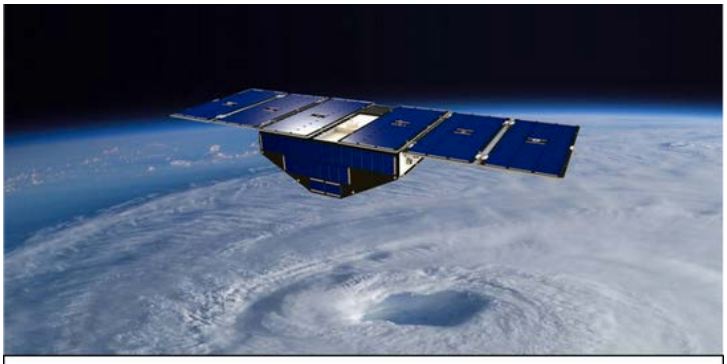

Illustration of one of the eight CYGNSS satellites in orbit above a hurricane. *Courtesy NASA*

2053: The Chairman of the Joint Chiefs signs a new standing Space ROE, authorizing autonomous drones, lethal unmanned systems, and space-to-space based weapon systems[23]. This was in response to China's published space war doctrine, allowing unfettered, full-scale war in the space domain. This US led set of international standards was required to combat China's use and development of fully autonomous lethal drones without consequence. US and other European allies finally agree on a standard; however, it is far more stringent and restrictive than China, Iran, and Russia's usage of these systems. Between 2038 and 2053 the Chinese developed a suite of space-based weapon systems that have been clandestinely put into orbit. The T2-Ni virus, first seen in 2051, has been largely contained and most of its variants have been addressed through vaccines. However, members of the US delegation to NATO test positive for T2-Ni during the conference, leading to a media/psyops campaign by the Chinese to implicate the US as a bioweapon terror state. They suggest the US will use a space-based platform to deliver a bioweapons payload.

-2054: Chinese hackers down a Boeing 7X7 commercial airliner[24] flying from Chile to Dubai with a software vulnerability attack. The virus was sent via a Chinese satellite to the onboard flight computer, simulating a change in altitude and crashing the plane, killing all 1,250 on-board. The largest and most modern civilian aircraft crashed in the South Atlantic near the US 2nd and 4th fleets conducting a Joint exercise at the time. JTF 4-2 Carrier Battle Groups in the region stop the anti-submarine exercises in order to start recover operations of the downed aircraft. Intelligence suggests that the Chinese did not want the plane to crash, but rather test their ability to manipulate an aircraft while inflight. Although the outcome appears unintentional, the Chinese exploit the attention in the Atlantic to reposition their aircraft carrier and submarine fleets in the pacific.

-2057: In a first act of blatant aggression, the Chinese use a new kinetic and laser weapon system on a US Space Force satellite[25]. The White House discusses retaliatory options and the Chinese government claims "self-defense". Meanwhile, US intelligence discovers that the Chinese made these new weapon payloads standard on all Chinese and African satellites put into orbit for the past several years. The US protests that it is a violation and disruption to freedom of navigation in the super-global commons and a direct attack, violating the recently approved Geneva Convention rules for space weapon systems. Emergency UN meetings are called.

Rescue divers search for survivors following the crash. *Courtesy REUTERS*

-2058: The US Congress pushes to increase the armament and defensive capabilities of LBA and other space stations as a response to the recent Chinese aggression[26]. The Chinese plan on landing a Russo-Chinese research habitat later this year, after a decade of delays[27]. It is discovered that the US has been stringently adhering to international policy and space norms in regard to weaponizing space. The Chinese and other adversaries have not followed the same rules, at this point the Chinese outmatch and outnumber the US in space weapons 10-to-1.

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Artist's concept of a space-based weapon system. *Courtesy Getty Images*

-2061: The US develops the first stealth technology satellite[28], able to be constructed, armed and maneuvered undetected while in orbit. Unique spacecraft geometry and radar/IR absorbing material cover the outside of the space craft. Nuclear thermos-electric power plants and an enclosed weapons bay make it equivalent to a stealth fighter jet in space.

-2066: First alloy and composite 3D printers are installed on a satellite to act as an autonomous repair platform[29]. These drones are able to conduct minor repairs and refueling operations. The US Space Force now has 12 of these repair spacecrafts conducting round the clock operations, protecting key satellites. The US is the only country with this capability and offers limited satellite repair support to key allies.

-2069: A coup d'état and violent civil war force the US to engage in two separate major military operations, one in Nigeria[30] and one in Myanmar[31]. The coup in Nigeria was instigated by the Chinese and a pro-communist leader, sympathetic to Beijing, is installed. To combat China's influence in the region, 120k allied troops are deployed to Nigeria. 70k troops are deployed to Myanmar and surrounding Asian countries to provide humanitarian assistance and civil support during the civil war. The Chinese protest the actions in both theaters and the international community call for a de-escalation. The US Space Force celebrates its 50th anniversary by mobilizing over 10k Guardians (1/3 of the total force) to hostile fire zones in support of these operations.

-2070: Repeating their successful pattern of expansion in the South China Sea, Chinese business have been buying islands in the Caribbean since 2002[32] and started start a process of land reclamation. The state sponsored land reclamation program establishes new, man-made islands within striking distance of the US, mainland. Leading some to believe we are at the brink of a new "Cuban Missile Crisis". Over time these islands became armed with air and space defense weapons[33]. Concurrently, global warming contributes to a 12–15-inch rise in the sea level by the end of the decade, submerging many islands and coastal areas in the US and Europe[34].

Chinese efforts to reclaim these islands are advertised as a humanitarian effort and legitimate salvage operation, when in fact, they are exploiting their civil airfields, ports, and facilities as dual-use military capabilities.

Restore-L (silver), a spacecraft capable of robotically repairing satellites (gold) in orbit. *Courtesy NASA*

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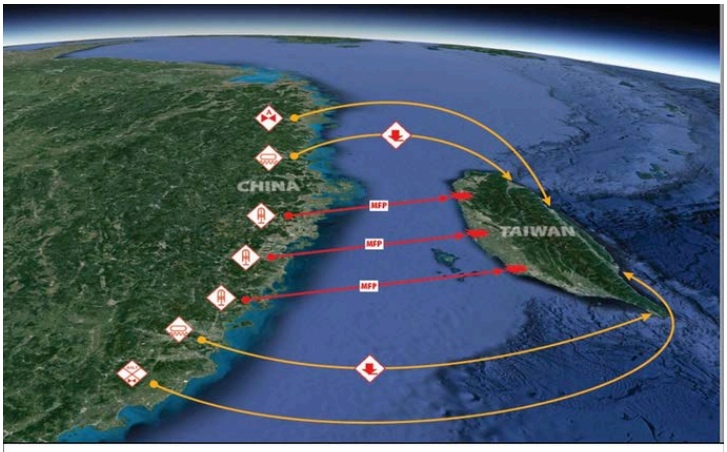

Military graphic showing a Chinese invasion of Taiwan. *Courtesy Small Wars Journal, https://smallwarsjournal.com/jrnl/art/next-ninety-days-and-chinas-coming-invasion-taiwan-3-november-2020-possible-d-day*

-2071: To mark the 150th anniversary of the Chinese Communist Party, a political envoy is sent to Taiwan to demand reuniting with China. A weak political leader in Taipei, strangling sanctions and a rigged referendum vote all force Taiwan to agree to repatriation with China. The US-Taiwanese security agreements are rendered null-and-void, because the government elects to side with China "willingly". The US is unable to assist or intervene due to Taiwan's new policy stance[35].

-2074: China and the US are stabilized in a relative stalemate in several different theaters and on different fronts. China leads on economic terms and global influence, but the US maintains superiority with military armament and leverages superior space capability to counter their influence. Russia, after decades of hardship becomes more open to NATO and European influence, disengaging from China. Asia, the Middle Eastern, and African nations sign new security pacts. The world is divided between these countries and the US, European, and South American alliances. Operations in Nigeria and Myanmar come to an end and the US seeks an economic and global peace with China. After years of negotiations, newly appointed leaders in China and the US meet for the first time and draft an agreement on a path to peace and cooperation.

-2076: China and the US agree on economic terms[36] terrestrially, and a new multi-planetary economy is formed. Joint US-Chinese bases and space stations are established on the Moon, Mars and in orbit. A Lunar-Martian currency and economy emerge[2]. By averting armed conflict and leveraging space capability, the US rebounds and rises to be the premiere space provider by the end of the decade.

2079: The US plans on building orbiting space stations around the Moon and Mars, to service and refuel spacecraft enroute to deep-space missions. US Space Force celebrates its 60th anniversary and currently grows to a strength of 50k Guardians. The Space Force becomes responsible for the additional mission sets of: manned space warfare, off-planet tactical security, stealth spacecraft piloting, satellite repair, space debris clearance, and commercial spaceflight research and partnership. Approaching 2080, the world's population is over 10.1 billion, the global and space economy exceeds $176T, 50k people live on Mars, 150k work on the moon on any given day, manned military spacecraft patrols are commonplace and campaigns to explore other planets and deep space are being planned. However, nothing we do in 2079 will ever go as far into the cosmos as the Voyager 1 spacecraft. First launched in 1977[37], Voyager becomes the farthest manmade object ever sent into space. In 2079 it is approximately 48.75 billion miles from earth, traveling over 37,000 mph. It is currently powered down, unreachable, and unobservable from Earth as it leaves the galaxy on an endless journey of the cosmos. Will we follow?

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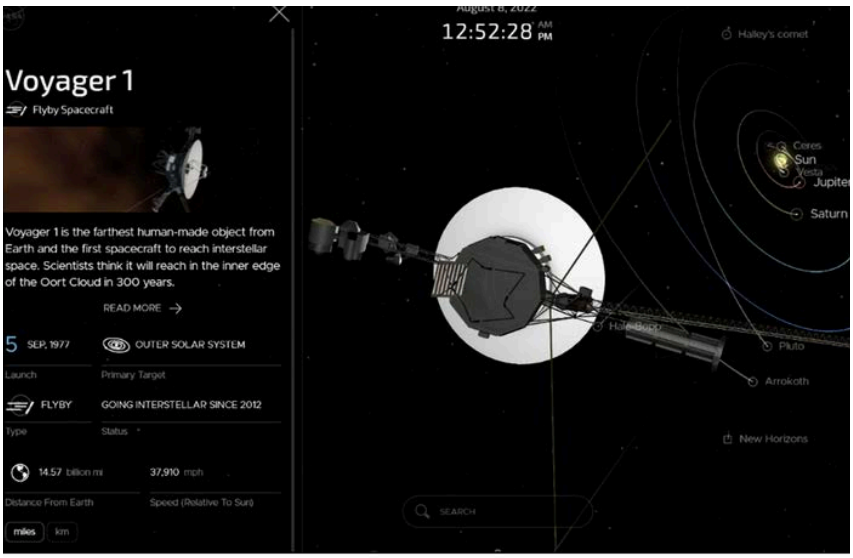
This thought experiment not just highlighted the need for a Space Force, but illustrated the challenges they would face in the next fifty to sixty years. Similar to the tests and trials that the US Air Force faced after its creation in 1947. The Space Force will have new challenges in this modern inter-war period of the 2020s – 30s. I propose it's important to anticipate some of these roles, and challenges, before strategic failures or crises force them. The road to a Chinese Space War, as theorized above, is littered with critical moments in history in which the absence of a Space Force would surely guarantee a US defeat in the Space domain. From the enemy testing new space weapon systems to Chinese cyber-attacks on SpaceX, the US prevailed in my experiment because we had a robust Space warfighting branch…the US Space Force. The Space Force didn't necessarily stop any of these events from happening, but it did provide a combat focused organization capable of dealing with these challenges in deterrence, parity, establishing space norms, ensuring freedom of navigation and access to space. Image how this experiment would have gone if we did not have a Space warfighting branch?

Although this vignette mainly focuses on the threat of a Chinese hegemony, new emerging threats from Iran, Russia, the Middle East, and Africa cannot be ignored. Current trends suggest it is not a far-fetched idea that in the next 50 years lunar bases are commonplace, trips to mars could be booked online, and our reliance on space assets and capabilities quadruple. With that conclusion, we must all agree space will become a target rich environment, able to be exploited by hostile governments and subjugated for its resources. Similar to the article I published in the Indo-Pacific research journal, Fortior Simul - Stronger Together, which states; we need a NATO-like organization in Asia to balance China, the Space Force must act as a deterrence against China in space and balance their will to control this domain. We must also become comfortable with the fact that space is ALREADY weaponized. Although we want to maintain the moral high ground over our enemies, a space "arms race" may force our hand into putting defensive weapons into orbit. Not unlike cold war nuclear arms race of the 1960s.

As a warfighting branch, charged with protecting space, we may one day be called to put forces on the moon to defend it. There is no substitute for a Soldier on the ground, and in the future, it may be a Guardian in space. In the next 50 years we will need more Guardians prepared to fight remotely via satellite and face-to-face with the enemy. The Space Force should not withdrawal from the thought of conflict in space, rather we should be prepared for it. The human condition and examples from history show that conflict in space is a forgone conclusion, so we shouldn't ignore it. With all of the future requirements theorized, the Space Force must grow to meet them. This is why we need a Space Force, not because we want war in space, but rather because we want peace.



The Voyager 1 real-time tracker, current distance from earth is 14.5 billion miles. *Courtesy NASA, JPL:* *https://voyager.jpl.nasa.gov/mission/status/*

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