



SPACEWATCH

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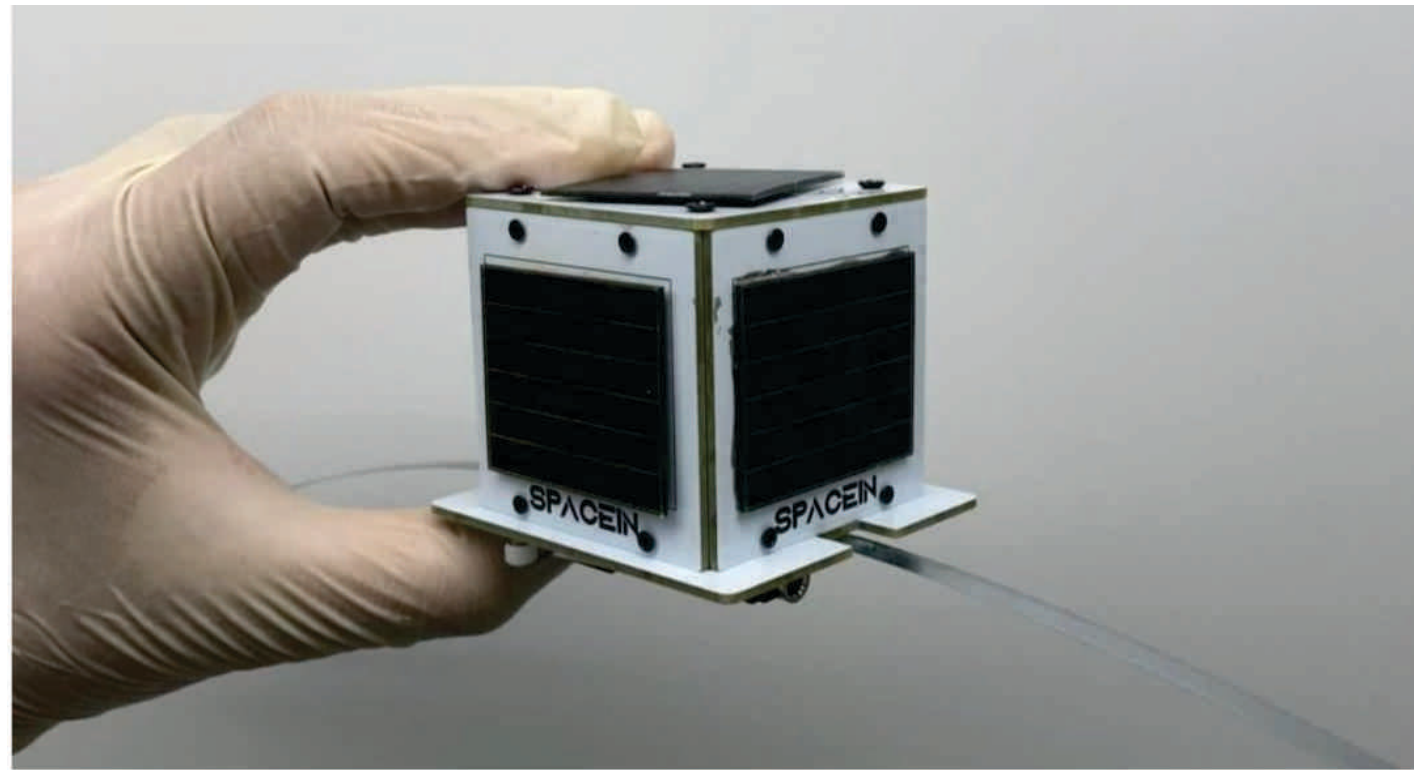
SPECIAL REPORT

**Why satellite
technology will
become mainstream
asset of automobile
industry?**

Spacewalk!



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AFRICA REPORT

Rooibos popularly known as fuel of South Africa's athletes' endurance heads to space



In the icy Atlantic waters between Robben Island and Blouberg, endurance swimmer, Karen Kennedy, recently completed a feat no woman had achieved before, a quadruple Robben Island crossing in skins, covering nearly 30 kilometres in just over 10 hours.

Her swim, undertaken without a wetsuit, is now pending official ratification by Guinness World Records as the first and fastest female to complete the challenge. While the verification process is known to be rigorous and time-consuming, requiring strict adherence to detailed guidelines and protocols, Kennedy's achievement has already resonated far beyond the swimming community. At its heart, her swim carried a message that transcended sport.

If you've ever sipped a warm cup of Rooibos and thought, "Mmm... there's nothing else quite like this," you'd be right. Rooibos has a flavour fingerprint that's 100% South African and completely unique. But have you ever wondered why Rooibos tastes the way it does? Why does it have that naturally sweet, slightly nutty, honey-like taste with hints of caramel and earthiness?

Pull up a chair, because we're about to dive into the fascinating world of terroir, fermentation and processing, the three magical factors that give Rooibos its one-of-a-kind flavour.

Approaching her 60th birthday, Kennedy set out not only to test her physical and mental limits, but to inspire other women, particularly those over

50, to pursue ambitions they may have long set aside. "Dreams do not have an expiration date," she said after completing the swim. "If you're thinking about it, don't let anything or anybody stop you.

"For a long time, many of us were conditioned to believe there are certain roles we should play or limits we shouldn't push as women, but those boundaries aren't fixed. When you challenge them, and your own doubts, you realise just how much more you're capable of.

"My hope is that women give themselves permission to dream bigger and go after what truly excites them." Kennedy's journey to this moment was anything but linear. Once a promising provincial swimmer

in her youth, she stepped away from the sport for more than two decades, leading what she describes as an inactive lifestyle.

It was only in her early 40s that she returned to the water, and even later – after relocating to Cape Town – that she embraced the challenge of cold-water ocean swimming.

The quadruple crossing required her to complete four consecutive swims between the mainland and Robben Island, exiting the water at each end before re-entering to begin the next leg. The conditions were unpredictable, with shifting currents, icy water and marine life adding to the already formidable physical and mental demands.

Yet Kennedy reported no major incidents during the

swim, a testament to both her preparation and the experienced support team that accompanied her throughout the challenge.

A dedicated support boat, jointly funded by the South African Rooibos Council (SARC) and Kennedy's swimming partner, Graham du Toit, played a critical role. Typically used to guide swimmers, ensure safety and provide scheduled nutrition and hydration, the vessel enabled Kennedy to maintain a strict feeding routine essential for endurance swimming of this scale.

South Africa's ocean endurance athletes

With the open-water season now underway, endurance swimmers are gearing up to test their limits once more, facing icy swells, strong currents and unpredictable weather. As they take on South Africa's toughest stretches, from Robben Island to the English Channel – earning its reputation as a trusted hydration partner among endurance athletes. According to Tracey Steyn, Chairperson of the Cape Long Distance Swimming Association, drinking Rooibos with honey or maple syrup, sometimes mixed with maltodextrin, a source of rapidly absorbed carbohydrates has become an integral part of the country's open-water swimming culture.

She says Rooibos can be found on most support boats and is regarded as a standard element of feeding protocols.

"While it's especially popular among South African marathon swimmers, it's also used by a number of international athletes. The practice is not exclusive to South Africa, yet it's become a well-established and distinctive part of our open-water swimming culture," remarks Steyn.

Though no one knows exactly when Rooibos became the drink of choice for endurance swimmers, Steyn explains that the tradition evolved organically.

"Rooibos provides sustained hydration and is gentle on the stomach. It's advice that's been passed down by coaches, boat skippers and seasoned swimmers over many years. When combined with a little honey, it also helps counteract the salty taste from hours in seawater.

Being naturally caffeine-free, it doesn't contribute to a drop in body temperature and, when served warm, helps maintain body warmth and energy levels – making it ideal for icy swims like the Robben Island Crossing or False Bay challenges, where water temperatures can drop to between 11°C and 15°C, depending on the season and currents.

"Traditional sports drinks can sometimes cause nausea or become overly sweet after prolonged use," says Steyn. "Rooibos, by contrast, is light, hydrating and easy to tolerate over long durations, making it a

preferred choice for endurance swimmers."

Swimmers typically sip Rooibos every 30 to 45 minutes during a long swim. It's usually brewed strong, served warm in small bottles and sometimes mixed with electrolytes, honey or a pinch of salt. Many also drink it before a swim to pre-hydrate and after finishing to aid recovery.

She says what began as a distinctly local custom has spread to international waters as many visiting swimmers who compete in South African events adopt the Rooibos habit, including some of the sport's biggest names.

"Several prominent international swimmers have incorporated Rooibos into their nutrition strategies among them Alison Streeter, known as the 'Queen of the Channel', who famously included Rooibos in her feeding programme," notes Steyn.

Rooibos heads to space

The Rooibos in Space project is an exciting, first-of-its-kind mission for South Africa, exploring how Rooibos seeds respond to the unique conditions of space. By sending Rooibos seeds on a journey beyond our atmosphere, researchers hope to unlock valuable insights into plant resilience, growth and the future of agriculture.

In a first for the country, Rooibos seeds will be sent to the International Space Station (ISS), combining space-based plant science with hands-on Science, Technology, Engineering and Mathematics (STEM) education.

The project also forms part of global research exploring which crops and plants may one day be grown off-planet.

Led by the South African Rooibos Council (SARC), the project aims to spark curiosity, inspire young minds and shine a spotlight on South African innovation. More than a science experiment, Rooibos in Space is about bringing science to life for learners, showing how agriculture, space science and sustainability intersect in exciting and unexpected ways.

In partnership with MaxiQ Space, the project is supported by the South African National Space Agency SANSA, which promotes space science engagement and STEM Science, Technology, Engineering and Mathematics education outreach to make science more accessible, engaging and inspiring for learners across the country.

From launch to landing, the Rooibos seeds' incredible space journey is captured in the infographic below, showing every stage of the mission.

The launch took place at Parklands College's Innovation Centre in Cape Town and brought together representatives from government, academia, education, agriculture and the emerging space economy.

It connects Rooibos to a growing international focus on plant biology in space and the development of sustainable agricultural systems

beyond Earth.

Using Rooibos, a unique and indigenous South African plant, the project engages learners in cutting-edge space science while exploring the potential role of plants in future space exploration and off-Earth living systems.

As part of the programme, Rooibos seeds will be launched to the ISS in October, where they will be exposed to microgravity and space radiation for several weeks before returning to Earth. On their return, they will be planted alongside control seeds, in a comparative study examining germination, growth, resilience and yield.

The experiment will be carried out by learners from seven schools in the Cederberg region – the birthplace of Rooibos. Working with local Rooibos farms, learners will collect and analyse data as part of a structured scientific investigation. A parallel experiment at Parklands College will provide additional comparative data.

Recent years have seen a renewed global emphasis on plant research in space, driven by upcoming long-duration exploration missions and programmes, such as NASA's Artemis missions. International space agencies are increasingly prioritising the development of self-sustaining life-support systems for future deep space travel, including the cultivation of crops capable of producing food, supporting oxygen generation and contributing to crew well-being on extended missions.

Within this context, Rooibos joins a growing body of plant research conducted in space. Experiments aboard the ISS have demonstrated that crops, such as lettuce can grow in microgravity, while studies on peas and soybeans have provided insight into how plants respond to altered gravity and environmental stressors. These findings are contributing to advances in both future space-based food systems and agricultural resilience on Earth.

According to Dawie de Villiers, Director of the South African Rooibos Council (SARC), the project reflects the industry's focus on innovation, education and applied research.

"Rooibos has long been part of South Africa's agricultural heritage. This project places it within a broader scientific context, where plant biology, space research and education intersect. It also reflects the importance of investing in scientific literacy and skills development for the next generation of researchers and innovators."

Beyond the scientific component, participating schools will engage in an extended STEM education programme introducing learners to space science, plant biology and sustainable agriculture. The programme is aligned with curriculum outcomes and designed to connect classroom learning with practical scientific application.

Judi Sandrock of MaxiQ Space said the initiative aims to strengthen access to authentic scientific learning experiences.

"The value of this project lies in giving learners exposure to real research processes linked to space science. It provides a structured opportunity to develop scientific thinking, data

analysis skills and an understanding of how experimentation works in practice."

To broaden national participation, learners across South Africa will also be invited to design the official Rooibos in Space mission patch during July and August, extending engagement beyond participating schools.

The project aligns with South Africa's growing involvement in space science and innovation. Speaking at the launch, Deputy Director-General for Curriculum and Assessment Management in the Western Cape Education Department, Bertram Loriston, noted the importance of cross-sector partnerships in expanding access to STEM opportunities.

He highlighted the role of initiatives that connect education, agriculture and emerging scientific fields in making science more accessible to learners.

The scientific credibility of the project is further supported by SANSA. Thandile Vuntu, who leads SANSA's Science Engagement Unit in Hermanus, said space science is increasingly integrated into everyday applications and continues to expand opportunities for young people entering STEM fields.

"Space science is becoming more integrated into areas that affect daily life, from communications to environmental monitoring. Initiatives, such as this help build awareness of the skills required for future participation in the sector, but also align with national priorities around skills development, innovation capacity and strengthening South Africa's position in emerging scientific fields. They further highlight the importance of collaboration between industry, government, academia and the science sector in building a strong pipeline of future scientists, engineers and researchers," he said.

Adding a personal perspective, Dr Kelebogile Gasealahwe, a South African Radio Astronomy Observatory (SARAO) postdoctoral fellow at the University of Cape Town (UCT) whose research focuses on X-ray binaries, shared her journey from humble beginnings in Kimberley to her current role in cutting-edge astrophysics, underscoring the importance of curiosity and persistence in scientific careers.

She also highlighted the role of facilities, such as MeerKAT in advancing South Africa's contribution to global astronomy research and encouraged learners to remain open to diverse pathways within STEM fields.

Closing the event, organisers noted that public engagement will continue beyond the launch phase as the project moves toward its October ISS flight. Members of the public will be able to follow the Rooibos in Space journey through updates, learner activities and mission milestones.



SPECIAL REPORT

How Spire Global wins \$12.4 million arbitration award



"Last month, an arbitral tribunal of the International Court of Arbitration of the International Chamber of Commerce issued a final and binding award of approximately \$12.4 million in favor of Spire Global in a dispute with Space Services customer NorthStar Earth & Space.

The tribunal dismissed all of NorthStar's claims related to alleged breaches and misconduct under a 2022 Framework Agreement and upheld Legacy Spire's counterclaims, including amounts due on a \$4.5 million promissory note and costs tied to an interlocutory injunction and arbitration, with the total payment immediately due, while Spire evaluates the award's operational and financial implications.

Defendant NorthStar Earth & Space, Inc. moves to compel arbitration of the disputes Plaintiff Spire Global Subsidiary, Inc. raises in

its motion for summary judgment in lieu of complaint, and to stay this case during the pendency of arbitration. Spire resists. The Honorable Jennifer H. Rearden referred this non-dispositive Motion. The Motion is GRANTED, and this case is STAYED during the pendency of the arbitration.

Any dispute or claim arising out of or in connection with this Agreement or its subject matter or formation including non-contractual disputes or claims shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with the said Rules. Any dispute or claim shall be resolved by a sole arbitrator unless the Parties fail to appoint a sole arbitrator within the delays provided in the Rules of Arbitration of the International Chamber of Commerce, in which case the dispute or claim shall be resolved by three arbitrators appointed in accordance with

such rules. ICC.

NorthStar is "a business corporation incorporated under the federal laws of Canada," and Spire is "a company incorporated in the State of Delaware". Spire "operates a constellation of nanosatellites and a network of earth stations to collect shipping, aircraft, and weather data from around the Earth." It "hosts bespoke payloads on its satellites as part of its 'Space Services' product." NorthStar "requires images from space to sell its services to its customers, for which [it] has patented specifications."

On March 1, 2022, the parties entered into a "Constellation Services Framework Agreement", under which NorthStar "may order satellites" from Spire "to obtain a certain number of images per day" depicting "space debris and objects in orbit in low light conditions." Under the Framework Agreement, Spire was to "manufacture, launch, and operate three satellites to deliver a certain number of images per day to NorthStar."

The satellites were supposed to meet specifications "for NorthStar's patented Concept of Operations that it uses to locate, identify and track potential threats from space." The Framework Agreement requires Spire to remedy satellite non-functionality within eleven months.

However, the Framework Agreement contains an arbitration provision at Section 49.1: Any dispute or claim arising out of or in connection with this Agreement or its subject matter or formation including non-contractual disputes or claims shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with the said Rules. Any dispute or claim shall be resolved by a sole arbitrator unless the Parties fail to appoint a sole arbitrator within the delays provided in the Rules of Arbitration of the International Chamber of Commerce, in

which case the dispute or claim shall be resolved by three arbitrators appointed in accordance with such rules.

The two-year arbitration battle between a pair of promising Luxembourg space companies ended with a tribunal ordering NorthStar Earth & Space to pay Spire Global \$12.4 million (€10.8 million) without requiring replacements for four failed satellites.

Why the satellites companies went to court

In March 2022, NorthStar and Spire signed a Constellation Services Framework Agreement under which Spire, a Vienna, Virginia-based space data company listed on the NYSE agreed to manufacture, launch, and operate four 16U CubeSat satellites fitted with low-light imagers. The satellites were designed to detect and track space objects as small as 5 centimeters, about 2 inches in low Earth orbit, feeding NorthStar's patented space situational awareness (SSA) data platform. NorthStar paid approximately \$14.46 million for the initial manufacture and launch phase.

The "Four of a Kind" mission launched from New Zealand aboard a Rocket Lab Electron on January 31, 2024, and was celebrated by both companies as a milestone: NorthStar positioned itself as the first commercial SSA provider to monitor space from space.

The celebration did not last. One of the four satellites was subsequently lost in space. The remaining three failed to produce images meeting the contractual specifications set out in the Service Level Agreement attached to the Framework Agreement, a performance gate the contract called "Checkout & Commissioning."

Under Section 12.1 of the agreement, satellites that cannot pass that process are designated in "Block Failure," triggering an obligation on Spire to use "all commercially reasonable efforts" to ensure replacement satellites complete the same process within eleven months. The contract's structure obligations were later examined in detail by Ontario's Superior Court of Justice.

Spire did not indicate it would provide replacements by the December 31, 2024 deadline. NorthStar went to court.

On January 31, 2024, Spire launched the Block 1 Satellites. Of the four Block 1 Satellites, one was lost in space while the other three functioned "but at levels that cannot produce transmittable images that meet" the requirements of the Framework Agreement. Spire informed NorthStar that it could not remedy the satellite's non-functionality within the eleven-month period required by the Framework Agreement.

On September 20, 2024, pursuant to the Arbitration Provision, NorthStar initiated an international arbitration proceeding in the International Court of Arbitration of the International Chamber of Commerce to remedy Spire's alleged breach of the Framework Agreement, specifically Sections 12.1 and 12.2, which set forth Spire's obligations if the functionality of a satellite or block of satellites fail.

NorthStar sought \$14,777,506.25, and, among other things: an order requiring Spire to continue operating satellites until it remedies the breach "and until any damages sought and awarded to NorthStar have been paid"; an order requiring Spire to disgorge any fees NorthStar paid under the Framework Agreement, and

to pay "any Set-up Fees or fees paid to Spire under the Framework Agreement or under the ISA or at all"; an order declaring that NorthStar "need not pay Spire any further sums relating to services to be performed by Spire pursuant to the Framework Agreement, whether under the Framework Agreement, Note, or otherwise"; monetary damages for breach of the Framework Agreement; "a declaration that, as a result of Spire's material breaches of the Framework Agreement ... any obligation of NorthStar to make payments to Spire under the Note is null and void"; and, an order "requiring Spire to pay interest at an appropriate commercial rate on all damages or fees awarded. NorthStar also requested an expedited arbitration.

Spire then filed an opposition in which it disputed NorthStar's factual allegations, opposed NorthStar's requested relief, asserted a counterclaim against NorthStar seeking declaratory and monetary relief, and argued that, pursuant to the Note rather than the Arbitration Provision, the New York courts, not the ICC, were the proper tribunal.

How the dispute escalated

What followed was a fight conducted simultaneously in three jurisdictions. In September 2024, Spire briefly halted data delivery to NorthStar, citing a service transition arrangement it had made with a third-party ground station operator, Kepler Communications Inc. NorthStar rushed to Ontario's Superior Court of Justice, which in September 2024, ordering Spire to maintain data flow, finding that there was "a reasonable possibility" NorthStar would succeed on the merits and that halting the service risked permanent and irreparable harm.

NorthStar formally initiated ICC arbitration on September 20 2024. Separately, Spire moved in the U.S. District Court for the Southern District of New York to enforce a \$4.5 million promissory note it had extended to NorthStar as vendor financing under the deal. A federal judge compelled that dispute into the ICC arbitration in February 2025, after which NorthStar filed a Revised Request for Arbitration expanding its claims to \$45.9 million adding allegations of willful misconduct and fraudulent misrepresentation on top of breach of contract.

An evidentiary hearing before the ICC tribunal took place in January 2026. The award followed on July 31.

And the tribunal's ruling

The tribunal's ruling was categorical. All of NorthStar's claims were dismissed including its contentions that the Framework Agreement was induced by fraudulent misrepresentation and that Spire breached the Space Services contract.

The tribunal granted Spire's counterclaim on the promissory note, and separately awarded Spire costs it incurred defending the Ontario injunction and the costs of the arbitration itself. The total payment of approximately \$12.4 million owed by NorthStar is, per the Spire 8-K, "immediately due and payable."

NorthStar publicly stated after the ruling that it continues to believe it is owed four replacement satellites under the original agreement — a position that preserves the company's negotiating posture even as the arbitration itself has concluded.

The legal significance of the ruling extends well beyond NorthStar and Spire. The "commercially reasonable efforts" standard ubiquitous in technology contracts, licensing agreements, and now SpaaS deals does not obligate the performing party to take any step that

would make the economics of compliance unreasonable from that party's own standpoint. Legal analysts studying satellite dispute frameworks have noted that it is explicitly not a "best efforts" obligation, which would require leaving no stone unturned. And it does not, as the ICC tribunal has now found, require a spacecraft operator to manufacture entirely new spacecraft at its own cost to remedy a hardware failure.

Linklaters LLP partner Matthew Hodgson, analyzing the NorthStar dispute in Via Satellite before the award was issued, wrote that the case demonstrates the importance of careful contract drafting specifically that satellite constellation agreements must be built to anticipate every scenario from launch to orbital placement, including partial performance in orbit.

NorthStar's space-based sensors scan the skies near Earth looking for danger from debris or Russian spy satellites. It boasts that its "asset light" approach of paying to install its space-scanning sensors on other companies' satellites instead of buying and launching its own spacecraft has allowed it to hold down capital costs, the company's disclosure said. But that has been a problem when it comes to Spire, NorthStar said.

"Our ongoing litigation with Spire Global Inc. arising from an alleged failure by Spire to operate satellites in accordance with our hosting agreement illustrates the operational and legal risks attendant on this dependency," NorthStar's disclosure statement said.

NorthStar struck a deal with Spire four years ago to make advance payments that helped the US company manufacture, launch and operate four satellites. Spire agreed its satellites would deliver images and data from space to NorthStar. The deal included a vendor financing agreement in which Spire gave NorthStar a \$4.5 million (€3.9 million) credit to be used to pay Spire. That credit was to be repaid at 14% annual interest.

But after Spire launched its satellites in January 2024, one was lost and the others failed "to function in accordance with the agreement's requirements," NorthStar explained to potential stock-market investors. Spire then broke their agreement by failing to manufacture and launch four new satellites within the required time and by refusing to keep operating the three underperforming satellites already in space until replacements became operational, NorthStar said.

A decision by the arbitration court is expected within the next three months, NorthStar said. Spire is based outside Washington, DC, and employed 81 in the Grand Duchy during 2023, the company said in its most recent annual accounts. In 2025, Spire sold its maritime-tracking division, which had been in Luxembourg, to Brussels-based intelligence firm for \$241 million. Spire did not respond to questions from the *Luxembourg Times* about its current local employment or whether it agreed that NorthStar's description of their dispute was accurate.

NorthStar's go-public conversion could mark a success for Luxembourg's efforts to back promising small businesses.

The company got at least €42 million from the Luxembourg Future Fund (LFF) and its co-

investors over at least two rounds. The LFF distributes money into Luxembourg's private equity or venture capital funds which then invest in promising companies like Spire and NorthStar.

The LFF's early investment into NorthStar included loans of undisclosed amounts paying about 6% to 8% interest per year, which are also convertible into equity in the space company. The fund will have about 6.7% to 10.4% of the company's shares, depending on how many others cash out after the merger, NorthStar's disclosure said.

Although NorthStar requests a stay of this action pending arbitration pursuant to the Court's inherent powers, a stay pursuant to 9 U.S.C. § 3 is appropriate. The Court is "satisfied that the issue involved in this suit is referable to arbitration," and stays the action pending arbitration.

The new FCC satellite licensing order

The timing of the ruling is notable for a second reason. On July 22, 2026 nine days before the ICC award the Federal Communications Commission adopted its Part 100 Space Modernization Order, which includes a newly mandatory requirement that all space station operators share real-time ephemeris data with an approved SSA provider. That rule directly expands the commercial market for SSA services the market NorthStar is trying to serve even as NorthStar now faces the financial and operational consequences of its failed first constellation attempt.

For NorthStar, the ruling lands at a financially fragile moment. The company reported \$10.6 million CAD, approximately \$7.5 million USD in total services revenue for 2025 and an accumulated deficit of \$211.6 million CAD, approximately \$150.5 million USD as of March 31, 2026. According to NorthStar's filings, the \$12.4 million it now owes Spire exceeds its full-year 2025 services revenue by more than \$4.8 million.

The company is in the midst of a planned merger with Viking Acquisition Corp. I, a SPAC, in a transaction valued at approximately \$300 million pre-money with a \$30 million PIPE investment, which would take NorthStar public. The shareholder meeting date has not yet been set; Viking's deadline to close a business combination is November 3, 2027.

The disclosure of the ICC award \$12.4 million immediately due is now part of the SEC registration statement that potential SPAC investors are reviewing. Viking filed an F-4 amendment disclosing the arbitration as a risk factor, noting that replacing an underperforming host satellite operator from scratch "can take 12 to 24 months" and that NorthStar's next sensor deployment phase is now targeted for late 2027 or early 2028. NorthStar has acknowledged it "cannot assure you that similar disputes with current or future hosted-payload partners will not arise."

NorthStar's publicly stated plan shifts its operational model decisively away from the SpaaS approach. The company says it is building a 96-sensor fleet on satellites it will own outright rather than lease from third-party operators. That model avoids the contractual dependency that produced this dispute, at the cost of requiring far greater capital investment.

On the revenue side, Spire's filings indicate more than \$ 200 million in remaining performance obligations, with approximately \$70 million expected to be recognized as revenue in 2026. For Spire, the ICC award provides financial and reputational certainty in one arena, even as other legal fronts remain active.



Why the military must rely on Unattended Ground Sensor technology on the battlefield



Transnational terror groups know how to find weak spots that are isolated because countries do not cooperate militarily or share intelligence. They move along lightly guarded borders. They seek out people who feel underserved and forgotten by their government. They look for communities beset by cultural and political divisions.

These are the ingredients necessary for terrorism to thrive, and the mixture is quite strong in the Sahel. In recent years, the Sahel has been the global epicenter of terrorism, accounting for nearly half of the world's terror-related deaths. Military coups in

Burkina Faso, Mali and Niger were launched in the name of stopping violence but have done nothing to slow its expansion. Partnerships with foreign mercenaries have led only to more bloodshed and chaos.

Now, terror groups affiliated with al-Qaida and the Islamic State group are pushing toward the West African coast.

The Sahel is not terrorism's only hot spot. Terrorist groups also operate in Somalia, the Lake Chad Basin, the Great Lakes region and Mozambique. In the past decade, terrorists in Africa killed 150,000 people. The most devastating statistic about terrorism is the

number of people killed or harmed in attacks. Terrorist groups are responsible for more than 150,000 deaths on the continent in the past decade, with more than 22,307 fatalities linked to these groups from July 1, 2024, to June 30, 2025, according to an Africa Center for Strategic Studies report. That death toll represents a 60% increase from 2020 to 2022.

Nearly half of all fatalities from 2024 to 2025 were in the Sahel. Somalia accounted for about a third of fatalities in that period. The Sahel, Somalia and the Lake Chad Basin accounted for 99% of terrorist deaths. Terrorism and related unrest also lead to people

leaving their homes to escape violence and threats. As of mid-2025, Burkina Faso, Mali, Niger and Nigeria were four of only five African nations that had seen increases in displaced people in the past year. Sudan, which was in the midst of a civil war, was the only other country to have an increase, according to the Africa Center for Terrorism studies.

Supporting line-of-sight, non-line-of-sight deployments

However, in recent and current conflicts,

experience from fast technological developments bring lessons and consequently problems which must be mitigated during counter terrorism operations.

Elsewhere, protecting critical military infrastructure is increasingly challenging; the rising popularity of forward operating bases only increases the pressure. Traditionally, militaries have relied on manned lookout posts and patrolling to spot incoming threats. However, that model comes with a range of operational costs, and inevitably puts personnel in the firing line. Jon Ross, a Defence Sales Manager at Bertin Exensor, highlights the unparalleled quality and robustness of its sensor systems, specifically designed for military applications. Unlike repurposed wildlife or nature sensors, Bertin Exensor's systems are built from the ground up to meet the rigorous demands of military use. With a proven track record in the most arduous and extreme environments, these systems offer unmatched reliability and functionality, ensuring that military users can depend on them in critical situations.

A case in point is Flexnet. an Unattended Ground Sensor (UGS) capability which dovetails a range of battery-powered wireless sensors and cameras together in one cohesive system. Together, they permit the rapid detection, classification, and identification of incoming targets, along the way keeping flesh-and-blood troops out of harm's way.

In practice, meanwhile, that flexibility means troops can shape Flexnet to their needs, whether it's a sniper team requiring rear protection, a fully-fledged subsurface observation post or an FOB. *"The only limit to the kit's effectiveness,"* says product and operations specialist Andy Newell, *"is the user's imagination of how they use it."* This adaptability is bolstered by the range of products in the Flexnet toolbox.

Consider the Scout X. A stand-alone HD camera, it's ideal for remote surveillance in dead ground, especially when its 'wake up' feature permits it to remain operational for up to 20 days straight. Boasting advanced motion detection technology, the Scout Mk3 camera is equally sophisticated, even as it's tested to rugged MIL-STD-810 standards. Other Flexnet sensors are similarly impressive. The Mini Mk3, for instance, is designed to detect seismic vibrations and sound waves. The resulting data is analysed using advanced algorithms, before findings are passed on the wider surveillance system.

All these systems are interconnected: the Scout Mk3 camera, for example, is activated by sensors, either via a cable or wirelessly. Capitalising on its long manufacturing history, Bertin Exensor also works to craft its products around emerging threats. A good example is UAV detection, with the global drone market expected to reach \$160bn by the end of the decade. The company's seismic acoustic sensors already have in-built microphones to detect helicopters, which are being "fine-tuned" to capture drones.

In order to meet the dynamic and complex challenges of contemporary battlefields, military forces have seen their roles evolve. With some of their main objectives being counter-mobility operations, force protection, and securing of critical infrastructure, they must rely on intelligent, autonomous, and most importantly field-proven systems, able to reduce their operational burden.

During military operations, Unattended Ground Sensors are required to mitigate threats and monitor targets across an area of interest. This enables units to respond proportionately whilst remaining unobserved and ensure the safety of friendly forces.

Even as soldiers are out on a patrol, Unattended Ground Sensors need to be deployed to protect stationary vehicles against potentially hostile elements. "Information on potential approaching threats can be obtained for the tactical commander on site to evaluate the situation, make a fact-based decision and take necessary action".

"Soldiers on operations must fully focus on their mission, says one analysts". Using Unattended Ground Sensors to cover their back, they can focus on key tasks, assured that any approaching threat is detected. Deployable both locally and in large areas, it is well suited for any setup, whether mobile, semi-fixed or fixed.

Yet if the global market for military sensors is expected to reach the \$17bn mark by 2030, not all platforms are equal. By relying on the latest technology, and honing close relationships with militaries, the best operators are offering flexible systems to keep soldiers safe as one operator is elegantly proving.

With the resurgence of conflicts between states, homeland security issues, and terrorism, our ability to react and anticipate in a proper and timely manner is more challenged than ever.

After several decades of rather obscure awareness in military operations, the use of passive sensors for remote battlefield applications is becoming more popular. Driven by modern Digital Signal Processing, sensors are become smaller, yet much more accurate and sophisticated.

These technological advances have made the development of advanced, multi-sensor Unattended Ground Sensors possible. Existing in various sizes and forms, Unattended Ground Sensors contain several sensor technologies, deployed at the area of operation, detecting, classifying and reporting target information via wireless links to a remote control center. Unattended Ground Sensors systems use small, low cost and robust sensors expected to last in the field for weeks or even months. Other systems are providing communications,

processing, as well as target verification and identification services.

Unattended Ground Sensors systems utilize a combination of detectors, including seismic detectors, used to identify ground vibration caused by vehicles or pedestrians. Magnetic detectors monitor movement of metal objects such as weapons or vehicles. Acoustic sensors are used to detect targets by specific acoustic signatures especially noise of engine, tracks while passive infrared sensors detect movements of objects in a narrow field of view. Input from all these detectors is collected by the gateway, processed by its on-board signal processors. When signatures are correlated into verified target detection, an alarm is triggered and transmitted automatically by radio to a central monitoring point in order to alert reaction forces on the suspect area.

Talk to the user

No less important, Bertin Exensor's Surveyor device has been compressed from roughly the size of a shoebox to now having a weight of only 1.4kg. Not that miniaturisation hampers the Surveyor's capabilities: it can still detect, classify, and identify a range of military vehicles to an accuracy of 95% using its own internal database. The company's customers, for their part, have opportunities for input too. Like every trade show, Bertin Exensor's presence at the upcoming Eurosatory event will be a chance to understand client concerns.

Just as important, Ross argues, are regular user conferences. *"You have to talk to the user,"* he says, *"because a threat that is around now might not be around in six months' time."* Certainly, this focus on customer demands, dovetailed with Flexnet's inherent versatility, can have positive practical consequences. Among other ventures, Bertin Exensor recently partnered with the Federal Office of Bundeswehr Equipment to upgrade the German military's sensor capabilities.

Newell emphasises there was a lot of scope for "technological advancement". Together with a plethora of integration options – that focus on usability ensures that cameras and sensors can easily slot into existing battle management systems – Bertin Exensor seems sure to secure similar contracts in future. For hard-pressed troops, that's just as well.

Unmanned Aerial Vehicles and Ground Surveillance Systems

Drones have been shown to be a universal tool for facilitating law enforcement tasks in recent years. Unattended Ground Sensors technologies compatible with Unmanned Aerial Vehicles are supply law enforcement agencies with instant intelligence through ongoing monitoring, mapping, imaging and video feed using thermal, video, photo cameras and

multispectral cameras with high-resolution 360-degree day and night observation capabilities on board, as well as software solutions to analyze the data. For these purposes, micro up to 5 kg and mini of up to 10 kg UAVs, either fixed-wing or rotary-wing, have recently been utilized.

Once the UAV takes off to map the surrounding area to seek grounds, the area is mapped through video and thermal cameras mounted onboard to provide video feed and imaging day and night. A command center is set up several miles away from the area of interest to monitor the situation through UAV flight control and management systems as well as the Unattended Ground Sensor system administration and management software installed on a rugged laptop. The emergency response unit is quartered nearby.

With this, personnel deploy several seismic sensors underground on the approach routes to the field. The operator records the sensor's GPS coordinates on a portable receiver. The circular detection zone of seismic sensors reaches up to 300 m in diameter, so that sensors capture seismic signatures of intruders within their detection zone, classify the intrusion (a human or a vehicle) and then send alarms to the command center.

The system can be supplemented by unattended video, photo, or thermal cameras to capture video feed or imaging day and night. Cameras start imaging when one of the seismic sensors is triggered by an intruder. When a motorized or biped intruder reaches the area of interest through one of the approach paths, his motion signature in the detection zone triggers one of the deployed seismic sensors, and then an alarm is sent to the command center. The sensor can also trigger an unattended TV camera for quick visual verification. The service and alarm information are displayed on a map in real-time through UGS system management and administration software. To supply law enforcement agencies with instant intelligence, the sensor's GPS coordinates are used to develop a drone route plan on a map and launch the drone when the seismic sensor is triggered.

The UAV takes off manually and flies to the point. The operator receives an ongoing video feed on the display of the UAV's receiver or a laptop to verify the intruders. When the UAV is out of its communication range, video is stored in its internal memory. After the intrusion was verified, the emergency response unit is ready to address the possible threat to apprehend criminals and combat organized illicit drug cultivation or harvesting. Unattended ground sensor systems

were considered to be an effective solution for aiding UAVs in various law enforcement activities including countering terrorism and illicit drug trafficking, distribution and cultivation.

Unattended Ground Sensors market outlook

According to latest research, the Unattended Ground Sensors market size reached USD 1.53 billion in 2025 at the global level. The market is expected to exhibit a robust CAGR of 6.9% from 2026 to 2034, leading to a projected market size of USD 2.79 billion by 2034. This significant growth is primarily driven by escalating security concerns, continuous advancements in sensor technology, and the rising adoption of autonomous surveillance systems across both military and civilian applications worldwide.

One of the primary growth factors propelling the Unattended Ground Sensors market is the increasing emphasis on border security and perimeter surveillance by governments across every continent. As geopolitical tensions and cross-border threats have intensified through 2025, military and defense organizations are committing record investment to advanced surveillance solutions designed to enhance situational awareness and accelerate threat detection. UGS systems, which encompass seismic, acoustic, magnetic, and infrared sensors, offer a cost-effective and reliable means of monitoring expansive and remote areas without requiring constant human presence.

This capability lowers operational costs substantially while minimizing personnel risk, making Unattended Ground Sensors solutions highly attractive for modern defense strategies and homeland security programs. For operators seeking a broader surveillance picture, imaging sensor solutions for ground surveillance are increasingly being integrated alongside traditional Unattended Ground Sensors platforms to deliver richer target identification.

A major secondary driver is the rapid progression of sensor miniaturization, power efficiency, and wireless communication technology. Modern sensors deployed in 2025 deliver high-accuracy detection and real-time data transmission even under demanding environmental conditions, from arctic tundra to tropical rainforest. The deep integration of artificial intelligence and machine learning algorithms into sensor networks has fundamentally enhanced their ability to analyze complex data streams and identify threats with greater speed and precision.

These breakthroughs have expanded Unattended Ground Sensors application scope far beyond traditional military uses, encompassing critical infrastructure protection, industrial asset monitoring, disaster management, and environmental surveillance, thereby broadening the total addressable market considerably.

Why satellite technology will become mainstream assets of automobile industry?



In today's fast-evolving world, where connectivity has become a fundamental enabler of innovation, efficiency and safety across numerous industries, vast parts of the globe still suffer from inadequate or non-existent connectivity, particularly in remote regions. This connectivity gap presents significant challenges, particularly for industries such as automotive, agriculture

and transportation, where operational efficiency, safety and data-driven decisions depend on seamless communication.

In May 2025 the world's first automotive-grade SIM to integrate terrestrial and non-terrestrial networks (NTN) was showcased at a 5g Automobile Association event in Paris. This ability to switch seamlessly between cellular

and satellite is a milestone in the journey towards ubiquitous connectivity and is unlocking new possibilities for car automakers, drivers, farmers, distributors and other sectors in underserved areas. Today's car has the computing power of 20 modern PCs, features about 100 million lines of code, and processes up to 25 gigabytes of data per hour. As the

computing capacity of cars develops further, not only is programming becoming more complex and processing speed getting faster, but also the entire nature of the technology is shifting. While automotive digital technology once focused on optimizing the vehicle's internal functions, the computing evolution is now developing the car's ability to digitally connect with the outside world and enhance the in-car

experience. This is the connected car, a vehicle able to optimize its own operation and maintenance as well as the convenience and comfort of its passengers using onboard sensors and internet connectivity.

In a recent interview with the Wall Street Journal, Apple CEO Tim Cook stated that

the auto industry is in for a "massive change" with software becoming "an increasingly important part of the car of the future." Connected cars are a key result of this industry disruption, and will become mainstream globally beginning from 2025.

For car makers, the ability to offer always-on connectivity is no longer just a competitive advantage; it's becoming a necessity. Vehicles are evolving into complex, interconnected systems where real-time data exchange is critical for vehicle performance, driver safety and user experience. From over-the-air software updates to autonomous driving capabilities, continuous, low-latency communication is a backbone of the software-defined vehicle. The promise of ubiquitous connectivity, delivered by both satellite and cellular technologies, enables car manufacturers to ensure that every vehicle, regardless of location, remains connected to the network, offering benefits like predictive maintenance, safety features and access to real-time traffic data.

The demand for ubiquitous connectivity in the automotive and other sectors is growing at an unprecedented rate, fuelled by a combination of technological advancements, shifting consumer expectations and evolving industry trends. As the landscape for software-defined vehicles and other devices continues to transform, connectivity has become a cornerstone of functionality, safety and user experience.

Considering the connected software-defined vehicle first, the growth in the number of computing-enabled cars, trucks, motorcycles and other vehicles is one of the primary drivers behind the heightened demand for seamless, reliable and global connectivity. According to Transforma Insights, there will be a total of 1.4 billion vehicles with embedded connectivity at the end of 2034, up from 463 million in 2024.

It is not, however, only the volume of connected vehicles that is increasing, so too is the criticality and complexity of the applications being delivered. Connectivity in vehicles is going from a nice-to-have to being an essential. Today's vehicles rely on connectivity for everything from navigation and infotainment to advanced safety systems like collision avoidance and driver assistance. Connectivity also plays a crucial role in enabling real-time communication between vehicles, infrastructure and cloud-based services, ensuring that cars can share critical data for enhanced performance and safety. With increasing reliance on connected systems, any disruption to connectivity can negatively impact the user experience and the vehicle's ability to operate at full potential.

Rising demand for connected services

Modern consumers expect their vehicles to provide the same level of connectivity they experience with their smartphones, tablets and other devices. The car has become the 'fourth screen' after the smartphone, PC and TV. According to a Cubic3 survey of 8,000 consumers and 60 original equipment

manufacturers leaders, OEMs, one in four drivers have paid for digital services in their vehicles, rising to 44% of 18-24-year-olds. Connected services such as infotainment, safety assistance packages, navigation, remote locking and remote parking assistance are becoming increasingly ubiquitous on new vehicles. This demand is further amplified by the increasing presence of multiple screens within vehicles, the greater use of services during waits at charging stations and, with the car being increasingly used as a third living space, with the consequent greater demand for connectivity.

Drivers across all 10 markets show strong awareness of connected car services, though familiarity varies significantly by service type. The total unduplicated reach and frequency analysis shows that a combination of five services is enough to reach 84% of consumers, with 'emergency call' alone reaching 43%, the single highest of any studied service. Adding 'local hazards and traffic information', 'audio and voice entertainment', 'traffic management during disasters' and 'remote car control' brings the cumulative reach to 84%. And these results are consistent across economy and luxury car classes, as well as frequent and rural drivers. Only 9% of respondents say they are completely unaware of any connected-car security and safety services. Awareness of other connected-car services such as 'convenience services' 19% and 'entertainment' 11% remains relatively low, underscoring that core connectivity functions largely define driver expectations.

When asked where they see predictive intelligence transforming connected cars during a survey, respondents' most popular response was for vehicle maintenance which was chosen by 76.3% of respondents, this was followed by using predictive intelligence for avoiding traffic jams, which was selected by 74.9% of respondents. Location-based services were the next most frequently selected capability, chosen by 64.6% of respondents. This was followed by applying predictive intelligence for navigation based on user behaviour, which was selected by 62.8% of respondents. Less popular was using predictive analytics for upselling content and applications, which was selected by 29.3% of respondents, suggesting privacy concerns among respondents.

In addition, respondents also see as the most exciting, new innovative IoT initiative in connected car research and development. Autonomous driving was the most popular category and was selected by 31.3% of respondents. It was closely followed by smart cities, smart highways, which were selected by 28% of respondents. After this the relative share of respondents selecting each initiative started to tail off. 18.7% selected advanced driver assistance systems, 11.7% chose smart mobility services and just over 6% chose in-car services.

With huge fear in the industry about connected cars taking driver awareness away

from the road, respondents were asked how automation and connectivity can still ensure safety and to choose between regulation, standardisation, legislation and technical innovation as means to ensure safety. The majority of respondents said they thought technical innovation would be the enabler of ensuring connected car safety. 47.9% felt that standardization would be the enabler, while 41.2% thought it would be regulation and 33.6% legislation. This indicates that technical solutions are still expected to address the concerns of the market and only partial reliance is being placed on regulators, legislators and standards initiatives.

Benefits of ubiquitous connectivity

The evolution of vehicle connectivity has moved in clear stages, from unconnected, standalone machines to connected platforms, and now toward a future of ubiquitous connectivity. Each step has expanded the scope of what vehicles can do, transforming them from isolated systems into intelligent, data-driven platforms that improve performance, enhance user experiences and support entirely new business models.

The introduction of basic cellular connectivity enabled a host of core services such as over-the-air software updates, remote diagnostics, real-time navigation and infotainment enhancements. These connected features allowed manufacturers to improve vehicles post-sale, reduce service visits and extend product lifespans. At the same time, they gave car makers access to real-world performance data, enabling predictive maintenance, design refinement and better understanding of driver behaviour.

However, as connectivity becomes essential to nearly every aspect of vehicle operation, the limitations of terrestrial networks become more apparent, especially in rural, remote, or cross-border contexts. The next major step is the shift to ubiquitous connectivity, enabled by the combination of terrestrial cellular and satellite networks. This integrated model ensures that vehicles maintain a reliable, high-quality connection regardless of location.

Customers expect not only the device and SIM, but also the overall experience, including billing and traffic management to meet their expectations. In that sense, we believe Cubic3's platform, Cubic3 Cloud, plays a central role. Combining our cellular technology, NTN expertise and Cubic3's platform, we aim to deliver a unified, high-quality experience to our customers, Takenori Kobayashi Vice President and Head of Product Technology Division, SoftBank Corp.

With this advancement, new services

become viable. Over the air updates can now be delivered without interruption, even in regions with limited cellular coverage. Telemetry data becomes truly continuous, improving the accuracy of predictive maintenance and fleet management. Safety features such as eCall become more universally available. Real-time services such as live traffic-aware navigation, voice communications, usage-based insurance and vehicle tracking are no longer constrained by network availability.

For commercial fleets, the benefits are even more pronounced. Enhanced connectivity allows for better route optimisation, remote diagnostics, driver performance monitoring and fuel or energy management, all of which reduce operational costs and increase uptime. For electric vehicles, ubiquitous connectivity supports smart charging, battery health monitoring and integration with energy infrastructure.

In a ubiquitous connectivity environment, personalisation and user engagement also reach new levels. Vehicles can deliver tailored services and content based on user preferences and location, remembered across journeys and geographies. Voice interfaces, dynamic media and real-time commerce can be consistently supported.

Organisations adjacent to car makers can also benefit. Insurers can offer more accurate, behaviour-based policies. Cities can use aggregated vehicle data for traffic and infrastructure planning. Advertisers and content providers can target in-vehicle audiences with location-aware offerings. And beyond the car market, many other sectors gain value from this evolution, including agriculture, transportation and energy.

Ultimately, ubiquitous connectivity is more than an extension of existing services. It is a foundational enabler of the next phase of automotive innovation. It underpins the shift to software-defined vehicles, supports evolving business models and ensures that as the industry advances toward electrification, automation and shared mobility, the digital connection between vehicle, driver and ecosystem remains uninterrupted.

Expanding service offering

Car makers are witnessing a noteworthy increase in paid subscriber penetration rates which highlights the rising consumer interest in using connected vehicle services.

For instance, General Motors GM had a significant paid customer penetration rate of 26% in 2021; out of 16 million connected vehicle users in North America, 4.2 million were paying for subscription services. GM also expected a more than 1,000% increase in its in-car subscription revenue by the end of 2030, up from USD2 billion in 2021 to USD25 billion in 2030. Stellantis, which owns the Chrysler, Citroen, Fiat, Opel and Peugeot brands, amongst others had 5 million users of its subscription-based products in 2023, out of a connected car fleet of 13.8 million. The



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group witnessed software revenue growth of 150% and a monetisable fleet growth of 15% between 2021 and 2024. It expects USD22 billion in software-enabled annual revenues by 2030.

With better margins in software services than in traditional car sales and sustainability initiatives set to lead to a reduction in new cars being bought in the coming years, original equipment manufacturers OEMs are moving away from hardware as a main line of business, towards aftermarket services.

In addition, the ongoing deployment of NTN is making it increasingly practical and cost-effective to extend connected-car services beyond the limits of terrestrial coverage. This enables vehicles to maintain critical service continuity when cellular signal drops via a hybrid experience regardless of the driver's location, according to Viasat report.

Among respondents who would consider subscribing to a connected-car services bundle, nearly 95% say they would also be willing to pay for a satellite-based connection, equating to three-quarters 75% of all respondents. As in previous findings, willingness to pay varies by market maturity, with India (94%) and Indonesia 89% leading for satellite-based connectivity. This reinforces the link between time spent driving, exposure to coverage gaps, and the perceived value of continuity.

That willingness to pay is also reflected in the level of subscription premiums that drivers are prepared to consider for satellite enablement. And with 62% of respondents willing to pay a 5% to 10% premium for an upgrade to satellite-enabled services, the data highlights a clear sweet spot for initial pricing strategies.

This suggests hybrid cellular-satellite service delivery can function not only as a competitive differentiator, but also as a meaningful revenue lever for automotive OEMs.

And while subscription premiums of 5-10% have the broadest appeal, there's also evidence of higher willingness to pay among drivers of premium vehicles. These users report greater willingness to pay for more data-intensive, high-bandwidth entertainment services, such as 4K/8K streaming and gaming.

These higher bandwidth applications, which require broadband NTN connectivity are expected to take longer to reach mass market deployment due to the increased integration complexities and costs associated with fully integrating broadband NTN. Initially, services dependent on broadband NTN are likely to only be offered as an optional extra add-on and remain the preserve of the luxury segment.

Broadband NTN services introduce an additional layer to this segmentation: while narrowband safety and security services remain the highest priority for most drivers, nearly half of respondents 45% report they would consider a one-time payment for an antenna capable of supporting broadband services.

Yet within this group, a smaller but distinct luxury and premium segment emerges, with these respondents indicating a willingness to pay up to three times more for broadband-enabled experiences such as 4K/8K video streaming, gaming or remote driver-assist scenarios. However, broadband NTN services typically require greater technical adaptation than narrowband or wideband services, including more significant changes at the chipset and system level.

OEMs may therefore need to vary their approach by segment, balancing commercial opportunity against technical readiness and investment priorities. According to the Technical Report "Maximizing the benefits of satellite communications for Automotive", it would indeed need a different technical approach for delivering broadband data rate services than for narrowband and wideband data rate services. But taken together, this framework allows OEMs to anchor connected services strategies around safety and service continuity for all drivers, while selectively using broadband-enabled services to differentiate, upsell and engage the upper end of the market.

Similarly, car makers also use vehicle data to improve their business efficiency. Analysing data from millions of vehicles can allow them to provide better understanding of faults or problems to be corrected immediately or in future models, understand how use of each model differs to allow for enhancements to future features and functionality, allow for greater customisation of products and to understand how connected services are being used by drivers to further enhance those.

As the automotive industry increasingly embraces electric vehicles (EVs), the need for connectivity grows even further. At the moment, range limitations still affect many electric cars and charging stations are still not always easily accessible. Connectivity in electric vehicles allows drivers to easily adapt journeys to their vehicles' needs through the use of navigation services that can direct them to the nearest available charging station or schedule of charging. In addition, it can remind users to charge their stationary vehicle and allow remote activation of air conditioning while the vehicle is plugged in, thereby reducing load on the vehicle's battery.

Looking toward the future, the need for ubiquitous connectivity will continue to evolve in line with emerging technologies like vehicle-to-vehicle and vehicle-to-infrastructure communication. These technologies will enable cars to communicate with each other and with road infrastructure, creating a more coordinated and efficient driving environment. This connectivity will also be crucial for autonomous driving, as self-driving cars will need to exchange data with other vehicles,

traffic systems and cloud-based platforms in real time to ensure safe navigation. The ability to connect vehicles to each other and their surroundings is a key part of the smart city, and will be essential for reducing accidents, improving traffic flow and enhancing the overall driving experience.

The automotive opportunity in the great connectivity convergence.

Connectivity has become fundamental to modern vehicles: from navigation and safety alerts to entertainment and remote diagnostics, the applications drivers rely on all depend on a continuous connection to mobile networks. It's this assumption that automotive OEMs built their connected car strategies around.

While cellular networks deliver that connectivity across the routes most drivers travel, they have limits. And until recently, extending connectivity beyond those limits meant integrating proprietary satellite hardware, managing separate subscriptions and signing up to secondary service contracts and absorbing those additional costs. This made satellite a difficult proposition for the mass passenger vehicle market.

D2A changes that by enabling vehicles to connect to both terrestrial and satellite networks with only limited hardware modifications. As a result, satellite-enabled connected car services become a practical and scalable option for the first time.

Since October 2022, the 5G Automotive Association 5GAA has publicly communicated how important ubiquitous and seamless connectivity is for the automotive sector, with satellite connectivity seen as a complementary extension of terrestrial networks. This saw 5GAA develop what it calls the NTN roadmap, integrating use cases, service-level requirements and potential deployment timelines to better align the connectivity ecosystem behind a joint vision. The latest 5GAANTN roadmap is available on the next page.

In the meantime, the necessary standardization framework for integrating NTN with terrestrial network is in place. Hardware capable of communicating across both terrestrial and non-terrestrial networks are in development, and many satellite operators have committed to switching from proprietary to standards-based technologies.

Terrestrial cellular networks are insufficient for providing the universal coverage needed to realise ubiquitous connectivity, due to their reliance on land-based infrastructure, which is limited to populated areas.

Today, cellular networks only cover approximately 20% of the earth's surface in total, and around one-third of land. While this addresses the needs of 95% of the world's population for mobile services, many connected IoT devices are permanently remote, for instance

in agriculture or forestry, or temporarily so, such as vehicles. The use of satellites to connect IoT devices has been established for some time, primarily supporting the tracking of high-value assets in remote locations, without terrestrial cellular coverage. However recent developments, particularly through the deployment of constellations of LEO satellites and the availability of 3GPP-based non-terrestrial networks, are expanding the potential role of satellite connectivity across a broader range of IoT use cases. In this section we explore the technology and capabilities of satellite technology for connecting cars and other IoT devices.

As a result, major car manufacturers are now developing satellite connectivity strategies to cater for the need of service in areas out of coverage. For instance, Tesla's strategy centres on a connected vehicle ecosystem with over-the-air updates and data collection to boost performance and safety. They plan to integrate Starlink connectivity, initially enabling emergency text and call features using Gen 2 satellites Starlink has also developed enhance mobility antennas for optimized satellite-to-vehicle connection.

Another leading case study in this field is Geely, which has taken an active role in satellite deployment. The Chinese automaker launched its first set of low earth orbit LEO satellites in 2022 and has since expanded its constellation further with the launch of an additional 11 satellites. This expansion enhances Geely's ability to provide high-precision navigation and communication for autonomous vehicles. The company has ambitious plans to deploy 72 satellites by end of 2026, with a long-term goal of establishing a constellation of 240 satellites.

Similarly, US multinational automobile manufacturer Ford is embracing this convergence by partnering with telecommunications company AT&T to bolster vehicle connectivity through cellular and 5G, while recognising the importance of satellite connectivity for expanding navigation, entertainment, and diagnostics service.

Meanwhile South Korea's Hyundai is strengthening its connected car ecosystem with a connected car Operating System OS that enables over-the-air updates and personalised services, such as the Hyundai Digital Key that transforms the user's smartphone into a key for their vehicle. Additionally, their collaboration with a recognized graphics processing unit manufacturer NVIDIA enhances infotainment and performance while ensuring vehicles can leverage both satellite and ground-based networks for seamless connectivity. Volkswagen is increasing the availability of their services by leveraging satellite technology integrated with terrestrial networks.

Their partnership with Microsoft is driving the Automotive Cloud (AC) for vehicle data management, while their collaboration with ISAR Aerospace, which is responsible for launching satellites produced by EightyLEO, focuses on satellite-based internet for their vehicles, reflecting their commitment to a hybrid connectivity model.

Toyota is reinforcing this shift by investing in satellite technology to enhance navigation and autonomous driving. At the same time, their partnerships with telecommunications companies such as American Telephone and Telegraph Company AT&T, Nippon Telegraph and Telephone Corporation NTT, and Kokusai Denshin Denwa International KDDI ensure stronger in-vehicle connectivity services, further demonstrating the industry-wide move toward an integrated satellite-terrestrial ecosystem.

This collective push highlights a pivotal transformation in the automotive sector, where satellite and terrestrial networks are no longer separate but rather complementary forces driving the future of mobility. In response to this growing demand, European OEMs have also explicitly expressed their support for C-V2X direct communications to pave the way towards automated driving.

Additionally, at Mobile World Congress MWC 2024 in Barcelona, during the first-ever 'Satellite and Non-Terrestrial Networks Summit,' ESA and the GSMA Foundry launched two major funding opportunities under the Space for 5G/6G programme line, one of which was the '5G Mobility Makerspace' initiative. This initiative's focus is to accelerate the development of solutions, regulations, and industry standards for future vehicle connectivity. Participating companies were encouraged to focus on three key areas: the development of smart mobility antennas, the real-world validation of 5G interfaces, and the cross sector applicability of NTN technology for broader transport applications, all of which are poised to greatly improve connectivity for the connected vehicles industry.

ESA has further collaborated with OHB Systems to demonstrate vehicle-to-everything V2X services and since 2022, ESA and the BMW Group have a Memorandum of Understanding MoU with a view to share knowledge and ideas, create awareness, and promote opportunities for collaboration on hybrid and seamlessly integrated connectivity.

In Europe, SatixFy is involved in the development of advanced digital beamforming antennas that can be embedded into vehicles and dynamically track LEO satellites. Hensoldt Nexeya, primarily known for defence applications, is adapting their ruggedised antenna systems to support commercial vehicular connectivity, especially in heavy-duty remote-use scenarios. These antenna systems typically support multiband operation across Ku, Ka, and L bands, ensuring compatibility with a range of satellite networks and optimising performance under various environmental conditions.

In-Car, data regarding driving behavior is already stored onboard the vehicle to some extent, but greater connectivity will create an immediate feedback loop giving select third parties access to data such as driving speed, route, and time. This will significantly reduce the hurdle to offer telematics-based tailored tariffs like "pay-as-you-drive" and "pay-how-you-drive." Already today, despite the need to install an external device in the car, telematics car insurance has started to gain a foothold especially in the United States.¹

From these, the gap between what connected car



services promise and what terrestrial networks can reliably deliver is often felt most acutely in the moments that matter most.

NTN offers OEMs an opportunity to close that gap, with narrowband and wideband roadmaps already developing at pace. The mass market case has been made and drivers across 10 markets have indicated willingness to pay a premium for satellite-enabled continuity. 5GAA's internal members survey demonstrates that OEMs are listening to this feedback, with a number of OEMs stating a plan to deploy NTN services starting from 2029 onwards.

That means the direction of travel is the same for the satellite and automotive industries: build for the mass market first, with safety and continuity as the anchor and develop the premium services opportunity in parallel for the segment of drivers willing to pay for it.

Implications of 3GPP NTN for connected car services

Until recently, satellite and terrestrial mobile networks operated as largely separate ecosystems, built for different conditions to serve distinct use cases. However, with the 3rd Generation Partnership Project 3GPP writing satellite into the global mobile standard for the first time, that's all changing.

3GPP Release 17 introduced a standardized framework for non-terrestrial networks NTN. This gives manufacturers, network operators and satellite providers a shared technical baseline to build to, replacing bespoke workarounds with something built to scale.

Devices can now connect to satellites using the same protocols they already use for cellular, and this is driving the convergence of these two connectivity layers. For the automotive industry, it

means vehicles will now be able to switch between terrestrial and satellite connectivity. This is the basis for direct-to-automotive D2A satellite services, and its implications for OEMs and the broader automotive sector are the reason why the question of driver demand and willingness to pay matters now.

In 2017 3GPP, the standards body for mobile communications, started to examine the potential for integrating satellites into 5G. Non-terrestrial network functionality was introduced first in Release 17 of the cellular standards, in 2022. There are two versions namely, IoT over NTN, which is effectively extending NB-IoT narrowband connectivity, and 5G NR over NTN, which does the same for 5G New Radio, especially broadband 5G over satellite.

With this functionality, the existing baseband connectivity chipset for terrestrial cellular will also be able to send and receive via satellites, albeit with some diminution in functionality, poor in-building coverage and an increase in connectivity cost,

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relative to the terrestrial counterpart technology. Subsequent 3GPP releases will include significant enhancements to NTN.

With the ongoing developments, NTN supports all orbit types including LEO, MEO and GEO as well as high altitude platform stations (HAPS), which involve aircraft flying in the stratosphere. The first NB-IoT service was launched over satellite in June 2021 by Skylo in collaboration with Inmarsat. Several others have followed, including OQ Technology and Sateliot. The broadband equivalent, NTN-NR, is perhaps a further three years from commercial availability, meaning that a need for broadband connectivity will need to be met through one of the other alternatives for the time being. There has been a notable shift from many satellite providers towards focusing attention away from proprietary technologies and towards 3GPP.

The later iterations of the 3GPP standard, including the forthcoming Release 19, introduce several developments in satellite communications that carry significant implications for car manufacturers aiming to

enhance vehicle connectivity and operational resilience. The inclusion of regenerative payload support allows satellites to process data onboard, reducing latency and dependence on ground stations. This benefits applications such as real-time vehicle diagnostics, dynamic traffic updates and critical safety communications in remote areas.

Support for GNSS-independent location services is also crucial, as it enables more reliable positioning in environments where traditional satellite navigation signals may be weak or blocked, such as urban canyons, tunnels or mountainous terrain. This enhances continuity for location-based services, including emergency response and route optimisation.

Improvements in uplink performance and broader service coverage in higher frequency bands expand the range of use cases vehicles can support, such as high-throughput over-the-air software and map updates, or vehicle-to-

cloud data exchange. Enhanced multicast and broadcast capabilities facilitate efficient delivery of common content across many vehicles, reducing network load and improving update distribution.

Together, these developments position satellite-based NTN as a complementary connectivity option to terrestrial 5G, enabling car makers to design vehicles with more robust, globally available communication features that support advanced automation, predictive maintenance and improved customer experience, regardless of location.

Integrating 3GPP non-terrestrial networks with terrestrial 5G, as envisaged in a world of ubiquitous connectivity, enhances vehicle connectivity by enabling seamless coverage, especially in remote or rural areas. This extended reach supports more reliable over-the-air software updates, real-time telematics and continuous vehicle tracking. Enhanced service continuity ensures navigation

and emergency systems remain operational outside urban environments. The satellite element also improves resilience and redundancy in data transmission, contributing to safer autonomous driving and better predictive maintenance.

Intelsat's use of the Ku-band spectrum, which is already used to support broadband use cases globally, provides many advantages.

It is defined across all regions so devices operating on this band can rely on consistent access to the same spectrum anywhere in the world and Ku operates across more than 3GHz of spectrum so in addition to global coverage, broadband throughput and applications are easily supported and services are not limited to text and voice.

One key application is teleoperated driving, where high-bandwidth, low-latency video transmission is crucial for remote vehicle control. This will allow for safer deployment of autonomous and semi-autonomous vehicles, especially in environments where full autonomy is not yet feasible and human

intervention is required.

Cubic3's partnership with satellite services provider to provide broadband NTN will also enable advanced in-vehicle entertainment systems, Car passengers will be able to enjoy ultra-high-definition (4K/8K) video streaming, immersive cloud gaming and virtual reality (VR) experiences, even in remote or rural areas where terrestrial networks are weak or unavailable. For OEMs this will enable them to transform cars into connected digital spaces and ensure they meet consumer expectations for seamless, high-quality digital experiences on the move.

Working with Viasat, Cubic3 is focused on how NTN connectivity can deliver increased information gathering and sharing for OEMs. This capability will initially allow vehicles to notify recovery services in the event of a breakdown or accident, manage hazards by communicating real-time safety alerts, allow for remote access in the event of lost keys and will even allow voice calls.

Viasat's approach to D2A

Much like it takes a village to raise a child, bringing an emerging technology market at a meaningful scale requires an ecosystem. No single entity can turn technical capability into something that works reliably, safely, and consistently for real users. That ecosystem needs a dependable foundation, including infrastructure and shared standards that allow different players to build together. It also requires regulators and policymakers to ensure services align with national priorities, safety requirements, and the public interest.

But more than anything, it depends on a wide mix of industry participants: automotive OEMs and Tier 1 and Tier 2 suppliers, alongside chipset and module manufacturers, platform and operating system providers, software and cloud partners and the broader group of automotive solution providers.

Collectively, these players bring the pieces together and build the applications and services drivers actually use. No single layer can deliver D2A alone; the value comes from the way these layers connect. This is why we believe in an open, standards-based approach to D2A. Shared standards create a common platform for growth, giving the ecosystem a foundation for interoperability and making it easier for organizations to integrate satellite capability without bespoke workarounds.

Viasat operates within established relationships and regulatory frameworks, creating a trusted foundation for new participants while respecting the sovereign interests of nations. That approach draws on decades of experience delivering safety-critical connectivity across aviation and maritime environments, where reliability is essential. This experience shapes how we approach NTN in automotive, with resilience, compliance, and long-term trust built in from the start.

And with our global satellite network, existing infrastructure and established relationships, Viasat is already helping automotive players navigate the world of D2A.

As wideband satellite connectivity develops overtime, high-definition HD map data collection and sharing is expected to emerge. This ability to provide vehicles with the most accurate and current

information, will ensure autonomous driving and advanced driver-assistance systems are future-proofed regardless of where the vehicle is in the world.

The in-car experience will also be enhanced. Being able to streamline over-the-air updates through satellite networks will mean fewer dealership visits as software improvements and new features can be delivered to cars globally, regardless of location. Entertainment services like audio and standard-definition video streaming will be enhanced while assistive services like augmented reality video can deliver personalised support and navigation, elevating convenience and safety.

Challenges of ubiquitous connectivity for automakers

Firstly, the most obvious challenge is establishing and maintaining reliable network infrastructure to support global connectivity. While many regions have robust 4G and 5G networks, rural, remote and mountainous areas still suffer from limited or no coverage, especially in developing countries. Furthermore, network coverage may vary by country or even by city, making it difficult to ensure continuous connectivity for vehicles traveling across borders or through areas with sparse infrastructure. Today, around one-half of the world's population is covered with 5G, while over 90% have access to 4G/LTE.

Much of the satellite functionality that relates to NTN deployments, and in the context of ubiquitous connectivity there is a definite benefit to using a technology that is common across both the terrestrial and non-terrestrial elements. However, we do not yet have a mature set of satellite networks deployed to support. Currently NTN-IoT is available in a limited way, and predominantly via GEO satellites. A full deployment of NTN-NR is approximately three years away.

Another challenge is ensuring interoperability between different telecommunications providers, network types, platforms and standards across various regions. The requirement to support global deployments necessitates the use of multiple cellular networks and probably more than one satellite network, each with their own platforms and operated by different companies. Cars that require connectivity must be able to seamlessly switch between cellular networks both 4G and 5G or other forms of communication especially Wi-Fi or satellite without disrupting services. This requires a robust roaming agreement infrastructure, as well as eSIM management, which can be complex and costly to implement globally. Therefore, relying on such a complex landscape, it will be challenging to ensure a seamless user experience.

As a side-function of the relative complexity of deployments spanning multiple operators

and technologies, there are also potentially additional costs associated with supporting ubiquitous connectivity. Satellite connectivity is inherently more expensive, so any proposition will need to allow for that. Furthermore, managing connectivity across multiple providers requires an agile approach to managing partner networks.

In addition, ubiquitous connectivity must ensure a consistent, high-quality user experience for both drivers and passengers, particularly for critical functions like navigation, safety features and remote diagnostics. Connectivity disruptions, such as slow speeds, dropped connections or insufficient bandwidth, can negatively affect the vehicle's performance and the overall user experience. Achieving this level of reliability across diverse environments urban areas, rural regions, highways and remote locations poses a significant technical challenge.

Supporting the same applications over satellite and cellular networks for vehicles presents several challenges due to differences in network performance, reliability and cost. Cellular networks typically offer lower latency and higher bandwidth, making them ideal for real-time applications like navigation and telematics, whereas satellite networks, especially GEOs, have higher latency and lower bandwidth, which can affect performance for data-heavy tasks.

Additionally, satellite connections are more susceptible to disruptions, such as weather interference, while cellular networks excel in urban areas but may be lacking in remote regions.

Adapting applications to perform seamlessly across both network types requires handling data buffering, adaptive quality in the area of video streaming, and smooth failover between networks. Security protocols must be robust across both, with attention to encryption and threat detection.

Power consumption is another concern, as satellite communication typically demands more energy than cellular, impacting vehicle battery life, particularly in electric vehicles. Ultimately, the challenge lies in creating intelligent applications that can be optimised to reflect the deployment parameters such as connectivity, power consumption, security and costs, all while providing consistent and reliable service regardless of the network type.

Regulatory compliance has long been a component of IoT, particularly in relation to device certification and product safety. However, as IoT is increasingly deployed in critical infrastructure and sensitive environments, and governments focus more attention on the issue, the scope and complexity of regulatory requirements are growing. This shift underscores the importance of making compliance a core element of any IoT strategy, rather than treating it as a secondary consideration. Different countries have distinct regulatory requirements for telecommunications, data protection, safety and vehicle standards.

Security remains one of the primary challenges in deploying IoT systems. The more connected a vehicle is, the greater the risk of cyberattacks and data breaches. A globally connected vehicle that is continuously transmitting data poses significant cybersecurity risks, such as unauthorised access to sensitive vehicle systems, tracking of user

locations or theft of personal information. Securing communication channels and ensuring the integrity of the data being transmitted is a substantial technical challenge. Additionally, regulations surrounding data privacy, such as the General Data Protection Regulation GDPR, impose strict rules on data storage and usage, creating the need for robust encryption, data anonymisation and compliance mechanisms that are consistent worldwide. In order to address these risks, a Secure-by-Design approach is recommended. This involves considering security at every stage of development and deployment, ensuring that protections are integrated into the entire IoT ecosystem.

Conclusions

The world's demand for connectivity continues to grow, driven by newer use cases like the connected car. This is reflected both in the growing number of connections and the increasing criticality of the associated connected applications. Not only are there hundreds of millions of connected vehicles expected to be connected in the coming decade, accounting for almost 55% of vehicles in 2034, but the services are becoming more and more intrinsic to the driving experience and automotive OEM business models.

The growing demand translates into additional requirements for highly available and ultra-resilient networks to support an increasingly diverse and demanding set of applications. This places greater requirements on the providers of telecommunications networks to ensure 'ubiquitous connectivity'. 5G is delivering qualitatively better services for IoT, beyond what have been seen before. The capabilities of network slicing, ultra-low latency, quality-on-demand and other functionality provide rich capabilities that have great potential for supporting many IoT use cases, particularly for software-defined vehicles.

Satellite is key to delivering ubiquitous connectivity. While it's not new to use satellites to monitor remote assets, it is increasingly a requirement to fill in the substantial gaps in coverage of terrestrial networks for the growing requirement for constant connectivity to support critical applications. Therefore, the ability to transition seamlessly between terrestrial and non-terrestrial networks will form the bedrock of ubiquitous connectivity. This becomes a reality with the arrival of NTN, in combination with 5G.

Similarly, the arrival of 3GPP non-terrestrial networks, both NB-IoT and New Radio, offers a new paradigm for ensuring connectivity of cellular devices even outside of coverage of traditional terrestrial networks. Collectively these technologies are able to address both low and high bandwidth connectivity use cases, being particularly adept at integrating both satellite and terrestrial coverage.

Lastly, the benefit of ubiquitous connectivity for automotive and transportation is substantial. In the automotive sector alone, it enables additional safety features, continuous product improvement, enhanced user experience and new service-based revenue models by supporting real-time updates, remote diagnostics, personalised features and data-driven product development for car makers. It also drives operational efficiency and broader ecosystem value through fleet optimisation, predictive maintenance, energy integration for Electric Vehicles and data monetisation by stakeholders such as insurers, municipalities and content providers.



INDUSTRY REPORT

Iran hit far more U.S. military assets than reported, satellite images show



Iranian airstrikes have damaged or destroyed at least 228 structures or pieces of equipment at U.S. military sites across the Middle East since the war began, hitting hangars, barracks, fuel depots, aircraft and key radar, communications and air defense equipment, according to a Washington Post analysis of satellite imagery. The amount of destruction is far larger than what has been publicly acknowledged by the U.S. government or previously reported. The threat of air attacks rendered some of the U.S. bases in the region too dangerous to staff at normal levels, and commanders moved most of the personnel from these sites out of the range of Iranian fire at the start of the war, officials have said.

Since the start of the war on Feb. 28, seven service members have died in strikes on U.S. facilities in

the region, six in Kuwait and one in Saudi Arabia and more than 400 troops have suffered injuries as of late April, the U.S. military said. While most of the wounded returned to duty within days, at least 12 suffered injuries that military officials classified as serious, according to U.S. officials who, among others, spoke on the condition of anonymity due to the sensitivity of the issue.

Satellite imagery of the Middle East is unusually difficult to acquire at present. Two of the largest commercial providers, Vantor and Planet, have complied with requests from the U.S. government their biggest customer to limit, delay or indefinitely withhold the publication of imagery of the region while the war is ongoing, making it difficult or impossible to assess Iran's counterstrikes. Those restrictions began less than two weeks into the war. Vantor said

its access-control decisions were made independently and were not mandated by the government. Iranian state-affiliated news agencies, however, have from the start regularly published high-resolution satellite imagery on their social media accounts that claimed to document damage to U.S. sites.

For this examination, one of the first comprehensive public accounts of the damage to U.S. facilities in the region. The Post reviewed more than 100 high-resolution Iranian-released satellite images. The Post verified the authenticity of 109 of those images by comparing them with lower-resolution imagery from the European Union's satellite system, Copernicus, as well as high-resolution images from Planet

where available. The Post excluded 19 Iranian images from the damage analysis because comparisons with the Copernicus imagery were inconclusive. No Iranian imagery was found to have been manipulated.

In a separate search of Planet imagery, Post reporters found 10 damaged or destroyed structures that were not documented in the imagery released by Iran. In all, The Post found 217 structures and 11 pieces of equipment that were damaged or destroyed at 15 U.S. military sites in the region.

Experts who reviewed The Post's analysis said the damage at the sites suggested that the U.S. military had underestimated Iran's targeting abilities, not adapted sufficiently to modern drone warfare and left some bases under-

protected. "The Iranian attacks were precise. There are no random craters indicating misses," said Mark Cancian, a senior adviser with the Center for Strategic and International Studies and a retired Marine Corps colonel, who reviewed the Iranian images at The Post's request. The Post previously revealed how Russia provided Iran with intelligence to target U.S. forces.

Some of the damage may have occurred after U.S. troops already left the bases, making protection of the structures less vital. Cancian and other experts said they do not believe the attacks have significantly limited the U.S. military's ability to conduct its bombing campaign in Iran.

U.S. Central Command, which has responsibility for the Middle East, declined to address a detailed summary of findings from The Post. A military spokesperson disputed the characterization of base damage by experts as extensive or evidence of failures, saying assessments of destruction are complex and can be misleading in some cases, but declined to provide specifics. Military leaders will be able to provide fuller context for the Iranian attacks after the conflict ends, the spokesperson said.

Unveiling US targets

When US forces began striking Iranian-linked targets under Operation Epic Fury, a Hangzhou-based AI company MizarVision began publishing annotated satellite imagery tracking roughly 2,500 American military assets across the Middle East including carrier groups, missile defence batteries, B-2 bombers, individual aircraft on their ramps, updated in near real-time, posted to Weibo and X for anyone who wanted to look. The Defence Intelligence Agency assessed that Iran's Revolutionary Guard was using MizarVision's datasets to refine strike planning. As a result, the US State Department sanctioned the company on May 8, 2026 under its legal name, Meentropy Technology Hangzhou Co., Ltd. However, MizarVision operates no satellites. Not one.

The company sources imagery from commercial providers, even as the exact constellation of suppliers remains disputed, with European operators including Airbus implicated by technical analysis, Chinese constellation Jilin-1 named by other analysts, and both Maxar and Planet Labs formally denying any sales to the firm and processes it through AI pipelines that annotate military hardware with the same systems that annotate container ships and agricultural fields. Whatever the confirmed sourcing, the entire operation ran on purchased commercial data. What the State Department framed as an espionage problem was, mechanically, a market transaction. MizarVision bought a product. The product tracked American forces. The suppliers were commercial satellite operators.

For most of the Cold War and into the first decade after it, satellite reconnaissance was among the most expensive capabilities a state could possess. A KH-11 Keyhole

reconnaissance satellite the kind the National Reconnaissance Office operates for tasked imaging of specific sites costs several billion dollars per unit. Recent-generation Keyhole satellites have been publicly assessed at well above \$4 billion each. A government that wanted to know what was building up on the other side of a border had two options: build this infrastructure, or negotiate access to a government that had.

The damage

In the first weeks of the war, several news outlets published reviews of damage, including the New York Times, which found strikes at 14 U.S. military sites or air defense installations. In late April, NBC News reported that an Iranian jet bombed a U.S. base in Kuwait, the first time in years that an enemy fighter plane has hit a U.S. base, and cited research it said showed 100 targets had been struck by Iran across 11 bases. CNN reported last week that 16 U.S. installations had been damaged.

But the review by The Post based on images dating from the war's start through April 14, reveals that scores of additional targets were struck at the sites, which are predominantly used by the U.S. military but shared with the host nations' military forces and allies.

The images show that airstrikes damaged or destroyed what appear to be numerous barracks, hangars or warehouses at more than half of the U.S. bases that The Post reviewed. "The Iranians have deliberately targeted accommodation buildings across multiple sites with the intent to inflict mass casualties," said William Goodhind, an investigator with the open-access research project Contested Ground who reviewed the imagery. "It is not just equipment, fuel storage and air base infrastructure under fire, but also soft targets, such as gyms, food halls and accommodation."

The Post also found that the attacks hit a satellite communications site at al-Udeid Air Base in Qatar, Patriot missile defense equipment at Riffa and Isa air bases in Bahrain and Ali al-Salem Air Base in Kuwait, a satellite dish at the Naval Support Activity Bahrain which serves as the headquarters of the U.S. 5th Fleet, a power plant at Camp Buehring in Kuwait and five fuel storage bladder sites across three bases. The Iranian imagery also documented previously reported damage or destruction of radomes at Camp Arifjan and Ali al-Salem Air Base in Kuwait, and at the 5th Fleet headquarters; Terminal High Altitude Area Defense (THAAD) missile defense radars and equipment at Muwaffaq Salti Air Base in Jordan and two sites in the United Arab Emirates; a second satellite communications site at al-Udeid Air Base, and an E-3 Sentry command and control aircraft and a refueling tanker at Prince Sultan Air Base in Saudi Arabia.

More than half of the damage reviewed by The Post occurred at the 5th Fleet headquarters, and the three bases in Kuwait — Ali al-Salem Air Base, Camp Arifjan and Camp Buehring. Camp Arifjan is the U.S. Army's regional headquarters.

Some of the damage could have been the result of U.S. choices or deception, Cancian said. To help preserve valuable interceptors, U.S. forces can choose to allow an incoming missile to strike if it seems likely to hit an unimportant target, he said, and its also possible commanders sought to deceive Iranian forces by making emptied base locations appear occupied.

A changed battlefield

Experts said the vulnerability of the military sites to Iran's attacks was likely the consequence of numerous factors. Some Persian Gulf nations have refused to allow the U.S. military to conduct offensive operations out of their bases. A U.S. official said bases in Bahrain and Kuwait were two of the hardest hit, possibly because they permitted attacks from their territory, including the use of High Mobility Artillery Rocket Systems that can fire missiles at ranges exceeding 310 miles. The Post's review represents only a partial count of the damage based on available satellite imagery.

Chief among them, experts said, is that Iranian forces have been more resilient than the Trump administration may have anticipated. Kelly Grieco, a senior fellow at the Stimson Center, a think tank, said plans to destroy Iran's missile and drone forces fast enough to prevent them from inflicting serious damage underestimated "the depth of Iran's pre-positioned targeting intelligence on fixed U.S. infrastructure."

Grieco said the strategy also failed to account for the degree to which U.S. and Israeli air defenses had been used up during the 12-day conflict in June between Iran, Israel and the United States. According to an estimate from the Center for Strategic and International Studies, the military used at least 190 THAAD interceptors and 1,060 Patriot interceptors between Feb. 28 and April 8, representing 53 percent and 43 percent of their prewar inventories, respectively. Justin Bronk, senior research fellow for airpower and technology at the Royal United Services Institute based in London, said U.S. and allied air defenses had done an impressive job intercepting attacks, but "at an enormous cost in terms of surface-to-air missile interceptors and air-to-air missiles." In addition, experts said the U.S. military had not adequately adapted to the use of one-way attack drones, something they said planners should have learned from observing the war in Ukraine.

"While drones have small payloads some of these did not do that much damage, they are more difficult to intercept and much more accurate, making them a much bigger threat to U.S. forces," said Decker Eveleth, an associate research analyst at the Center for Naval Analyses. They also pointed to structural challenges, including a shortfall of fortified shelters that could protect troops and equipment at key positions and likely targets. For example, the tactical operation center in Kuwait, where six U.S. service members were killed by an Iranian drone attack in early March, offered little overhead protection or concealment, one of several issues being examined by Democratic lawmakers probing the fatalities. In one case, it appeared that the E-3 Sentry command and control aircraft at Prince Sultan Air Base in Saudi Arabia was destroyed after being repeatedly parked in the same location on an

unprotected taxiway, satellite imagery shows.

U.S. Central Command declined to address questions on experts' analysis of the damage. The strikes on U.S. bases in the region have left military planners considering new trade-offs, said Maximilian Bremer, a nonresident fellow at the Stimson Center and a retired Air Force officer: Pull troops back to safer locations and limit their ability to fight or maintain the bases as they were and accept the potential of future casualties.

A U.S. official said that damage at the Naval Support Activity is "extensive" and that the headquarters there relocated to MacDill Air Force Base in Tampa, Florida, the home of U.S. Central Command. It is unlikely that troops, contractors or civilian employees will return to the base "anytime soon," the official said.

Two other officials said U.S. forces may never return to regional bases in large numbers, though no final decision has been made. "We have moved from an age of stealth to one where the entire battlespace is translucent and increasingly transparent," said Bremer. "It feels like we should be on offense, but we are definitely playing defense around these bases."

Access to satellite imagery

While MizarVision, a Hangzhou-based firm founded in 2021, has disseminated imagery and analysis of U.S. force movements, public reporting on Planet and Vantor imagery has mainly focused on post-strike imagery and battle-damage assessment. Planet moved from near-immediate archive availability to conflict-specific delays, first 96 hours and then 14 days, before later shifting to a more restrictive managed-distribution model. The question is whether some forms of commercial satellite support remain protected civilian activity and whether others move close enough to hostilities to alter the legal position of the people and systems involved.

The recent access restrictions by Planet and Vantor show how a small number of firms can affect military awareness, journalism, and humanitarian visibility. MizarVision also appears to function as a geospatial intelligence integrator, combining commercial imagery with AI and open-source aircraft and vessel tracking. The harder cases may involve not merely the publication of images, but the fusion of multiple data streams into an operationally meaningful product. In a commercial constellation, that may require analysis of direct damage in orbit and foreseeable terrestrial consequences. Where feasible, means and methods that affect only the military-use portion of a system, or a more discrete node, rather than a broader constellation should be chosen.

Planet and Vantor's policies are revealing. Planet initially imposed a 96-hour delay on imagery collected over the Gulf States, Iraq, Kuwait, and adjacent conflict zones, then expanded the restriction to a 14-day delay covering all of Iran, nearby allied bases, the Gulf States, and existing conflict zones. By early April, Planet said it would indefinitely withhold imagery of Iran and the region of conflict in response to a United States government request, while Vantor said its own controls were independently imposed under existing policy. These choices show that commercial operators perceive operational consequences in the timing, scope, and audience of their imagery, and that when access is delayed or restricted, the consequences may be borne not only by adversaries but also by journalists, researchers, and humanitarian observers who depend on timely imagery to verify damage in conflict.



INDUSTRY REPORT

Drone startup TEKEVER Confirmed as Europe's Newest Unicorn



Tekever is Europe's leading aerial intelligence company, transforming maritime surveillance and critical infrastructure monitoring whilst proving indispensable in modern defence operations. Tekever builds advanced surveillance drones that function as "data centres with wings," serving both civilian and defence applications. Their software-first approach uses proprietary machine learning for target detection, autonomous navigation, and real-time analytics - capabilities that prove invaluable across diverse use cases from maritime surveillance to military intelligence.

The company's Intelligence-as-a-Service (IaaS) model has changed how governments and corporations approach surveillance challenges. They manage comprehensive Channel surveillance for the UK's Home Office, daily pipeline inspections for Shell, whilst simultaneously providing long-range intelligence systems to Ukraine.

Co-founder and CEO Ricardo Mendes has built Tekever over 20 years with a "good enough, fast enough" philosophy that prioritises solving real operational challenges across both civilian and defence sectors. The company's clear mission focus has helped attract committed talent whilst building partnerships with customers ranging from humanitarian organisations to military forces.

TEKEVER has announced the raise of a new funding round. Fully committed by existing investors, including round leader Ventura Capital, Baillie Gifford, the NATO Innovation Fund, Iberis Capital and Crescent Cove, the round confirms TEKEVER's valuation above £1 Billion. This milestone cements TEKEVER as a European DefTech leader and fuels its continued expansion across Europe, as the company pursues global leadership in

AI-driven autonomous defence and security.

The funding round coincides with the launch of TEKEVER's ambitious five-year £400 million development program for the UK, known as OVERMATCH, aimed at transforming the UK's defence industry and ensuring the UK and its allies remain at the forefront of vital autonomous, AI-driven technology.

The investment in research, infrastructure, and defence technology will generate more than 1000 high-skilled jobs and lay the foundation for a sovereign capability in next-generation warfare. The project will expand production of TEKEVER's family of UAS (unmanned aerial systems, popularly known as drones), including the AR3 and AR5, in the UK, supporting the development of sovereign defence systems.

Building on three years of frontline innovation in partnership with the UK Ministry of Defence and Ukrainian forces, TEKEVER's systems have accumulated over 10,000 combat flight hours and contributed to the destruction of over £3bn worth of Russian military assets — including two of Russia's advanced S-400 air defence systems. OVERMATCH is the next step: scaling this battlefield-proven success into a sustainable, strategic capability for the UK.

OVERMATCH is structured around four core pillars. The first is BUILD, through which TEKEVER will establish Centres of Excellence for Autonomy in the UK — hubs designed to unite academia, industry, and government in the pursuit of defence innovation. The second, NETWORK, involves the expansion of a pan-European testing and evaluation infrastructure, including new facilities built upon existing operations in the UK. The third pillar, **SCALE**,

will deliver next-generation production hubs capable of responding with speed and flexibility to evolving operational demands. Finally, the **PARTNER** pillar reflects TEKEVER's commitment to fostering an inclusive ecosystem, promoting collaboration between large and small players, and encouraging greater cross-border cooperation among like-minded nations.

At the heart of TEKEVER's strategy is the creation of a defence innovation ecosystem that will bring together European businesses, particularly small to medium-sized enterprises, to integrate, test and scale new defence technologies to support the armed forces in the delivery of complex missions. A key lesson from the war in Ukraine is that success requires being constantly one step ahead. A new type of government-industry relationship, that puts operational output front and center, embraces new technologies faster than ever before, and iterates those capabilities faster than our adversaries is essential. With **OVERMATCH**, TEKEVER is stepping up and committing its full support in driving forward this critical agenda.

Ricardo Mendes, CEO of TEKEVER, commented: "The future of Europe relies on more than just increased defence spending; we need to transform our industrial base and be smarter about investments. TEKEVER's experience deploying autonomous systems in Ukraine has shown us that the future of defence is about agility more than anything. That's why we are launching our new strategy focused on establishing a defence innovation ecosystem that empowers companies of all sizes to innovate at pace and scale with the shared mission of securing the future of Europe. This latest funding round will help us deliver that mission. The continued backing from our investors, including Baillie Gifford and the NATO Innovation Fund, reflects their confidence in our vision, technology and long-term success."

TEKEVER recently revealed the latest

expansion of its growing product offering with the launch of the AR6 family into the autonomous heavy lift market. TEKEVER, widely recognised as the European leader for ISR platforms, aims to address a core market gap in the heavy lift drone segment delivering a platform that can 'lift more and fly further'

As part of TEKEVER's £400 million industrial expansion programme to scale manufacturing capacity, accelerate the development of next-generation autonomous capabilities and strengthen the UK's sovereign defence industrial base, the company signed a MoU with iCOMAT to further explore opportunities for collaboration and partnership in relation to advanced composite manufacturing.

The partnership forms part of TEKEVER's strategy to build a resilient, high-performance UK supply chain by working with specialist British manufacturers,

strengthening local industrial capability while supporting the company's continued growth. The collaboration leverages iCOMAT's manufacturing operations in Gloucester and Swindon, further reinforcing the UK's defence manufacturing ecosystem. Scott McClelland, Deputy Director, TEKEVER Defence Unit, said: "Delivering autonomous capability at scale requires a resilient industrial ecosystem. As we continue to expand production through our OVERMATCH initiative, partnerships with companies like iCOMAT help us strengthen the UK supply chain and ensure we can deliver operational capability to our customers at pace. Their expertise in advanced composites makes them a valuable partner as TEKEVER continues to grow.

TEKEVER's solution provides a significant step-change to a market that is dominated by electric VTOL platforms typically capable of lifting up to 100kg only over very short distances (1-5km). By leveraging specialist advances in hydraulic and propulsion technology, TEKEVER AR6 aims to set a new standard delivering 200kg over 500km. Built for harsh environments, the platforms will be able to operate in both very hot and cold conditions with minimum maintenance and sustainment costs.

The AR6 family will serve both civil and military markets and open up a wide variety of new use cases previously unavailable to heavy lift electric quadcopters. Civil use cases include logistics, offshore operations, medical support, search and rescue and disaster relief. Military use cases include casualty evacuation, forward logistics, and combat wingman concepts — such as the UK Apache teaming concept under Project Nyx. The AR6 combines novel technology with TEKEVER's core suite of competences — its 'as a service' operations, rapid design iteration, proprietary autonomy stack and lessons from Ukraine. The military variant of AR6 will be able to fully operate without any GNSS reliance and include advanced 'Mission Autonomy' features for multi-platform swarming, crewed teaming and survivability.

"AR6 represents the next evolution of our autonomous capability," said Ricardo Mendes, CEO of TEKEVER. "For years, we've helped customers move information. Today, we're extending that capability to moving what matters most. Autonomous Lift opens a new category of missions for TEKEVER and, more importantly, for our customers."

"The future of autonomy is about delivering operational outcomes," said Karl Brew, Head of TEKEVER UK. "AR6 expands the envelop enabling us to leverage all of the experience we have built up in Ukraine and around the world into a whole new set of use cases."

The AR6 family builds on TEKEVER's extensive operational experience and mission-driven approach to innovation, further expanding the company's autonomous capabilities across defence, security and civil applications.

Partnership with UK Ministry of Defence TEKEVER, has been selected by the UK Ministry of Defence to deliver CORVUS, the British Army's new surveillance capability based on the AR5 autonomous system. Under the programme, the British Army will leverage TEKEVER's proven AR5 system in a contract worth up to £400 million over the next ten years. The full contract will sustain and create hundreds of highly skilled jobs across TEKEVER's UK sites, strengthening the UK's defence and technology sector while supporting the reindustrialisation of Britain's industrial base.

Selected to replace the Army's Watchkeeper capability, the AR5 offers significantly improved endurance, sensor capability and reliability while carrying up to 50 kg of surveillance payloads, including cameras and sensors. The system will provide persistent surveillance and reconnaissance through round-the-clock intelligence gathering, delivering real-time data to support battlefield decision-making and help protect British forces.

More than a new surveillance capability, CORVUS reflects TEKEVER's approach to delivering military capability by combining proven operational systems with continuous capability evolution. The programme enables emerging technologies and battlefield learning to be integrated throughout its service life. The selection of CORVUS reinforces confidence in this model as a faster and more effective way to deliver enduring operational advantage. The programme builds on TEKEVER's growing role as a long-term capability partner to the UK and follows the company's continued investment in sovereign manufacturing, engineering and operational support across the United Kingdom through its £400 million OVERMATCH strategic investment programme.

Powering Canadian wildfire detection

TEKEVER, is supporting Phoenix Heli-Flight as it begins a new contract to provide wildfire detection services in Canada. The contract marks a significant milestone in the partnership between TEKEVER and Phoenix Heli-Flight, building on an earlier collaboration ongoing since 2023 to develop advanced uncrewed aerial capability for wildfire detection and response in Alberta.

Following a successful evaluation, Phoenix Heli-Flight will use TEKEVER's AR3 uncrewed aerial system - integrated with specialist sensor technology to support the detection and monitoring of wildfire activity. The capability brings together TEKEVER's long-endurance uncrewed aircraft, advanced payload integration and Nova Maps software platform to help deliver timely intelligence from the air.

Alberta has faced significant wildfire challenges in recent years, including major fires that have required extensive emergency



response efforts and placed communities, infrastructure and emergency services under intense pressure. Against that backdrop, the deployment reflects growing interest in how uncrewed aircraft can complement existing aviation, ground and emergency response capabilities by helping operators identify areas of concern earlier, improve situational awareness and support better-informed decisions in complex and fast-moving environments.

Phoenix Heli-Flight is a multi-role aviation operator with significant experience supporting industrial, emergency response and wildfire operations in Alberta. By combining Phoenix's local operational expertise with TEKEVER's autonomous systems, sensor integration and real-time intelligence capabilities, the contract will support a more persistent and data-led approach to wildfire detection and monitoring.

The activity also comes as TEKEVER continues to strengthen its international presence and expand its global operations. Together, these developments reflect the company's growing role in supporting customers across defence, security, emergency response, and environmental monitoring missions worldwide.

Strengthening maritime surveillance in Portugal

TEKEVER has also won the tender launched by the National Maritime Authority for the supply of an uncrewed autonomous aerial platform system designed to strengthen the Maritime Police's operational capabilities. This is TEKEVER's first contract with the AMN and marks another step in the deployment of technology developed and produced in Portugal to support the protection and surveillance of the national maritime domain. The solution includes AR3 EVO platforms, a ground control station, specialised operator training, and technical support and maintenance services, ensuring the system's availability and sustainability throughout its life cycle. This project will enable the Maritime Police to develop its own capability to operate

autonomous aerial systems. TEKEVER will provide the training, knowledge transfer and technical support required for its implementation and sustained use, contributing to strengthening the autonomy, readiness and response capability of the National Maritime Authority. The system will support surveillance, detection, reconnaissance, identification, and search and rescue missions in the maritime areas under national sovereignty and jurisdiction, including the territorial sea and areas of Portugal's Exclusive Economic Zone. By expanding the area under monitoring and providing relevant information in real time, it will contribute to a faster and better-informed response by the authorities.

Pedro Petiz, Director of Strategic Development at TEKEVER, said: "This contract places autonomous technology developed and produced in Portugal at the service of protecting our maritime domain. Beyond supplying the system, we will transfer knowledge and support the National Maritime Authority in developing its own operational capability. This is a model that strengthens the autonomy, readiness and response capability of the Portuguese authorities."

TEKEVER systems have accumulated thousands of flight hours in maritime missions, including coastal patrol, persistent surveillance, border protection, detection of suspicious activities, environmental monitoring, and search and rescue operations.

This experience has been consolidated through missions carried out for entities such as the UK Home Office and the European Maritime Safety Agency (EMSA), among others, across different operational contexts and European maritime areas. **Diogo Chalbert Santos, Partner at Iberis Capital**, commented: "TEKEVER stands out in the rapidly evolving defence and security sector with its unmatched innovation in autonomous systems. As the geopolitical landscape becomes increasingly complex, their ability to deliver scalable, advanced solutions positions the company as a leader in the defence and security ecosystem."



C O N T E N T S

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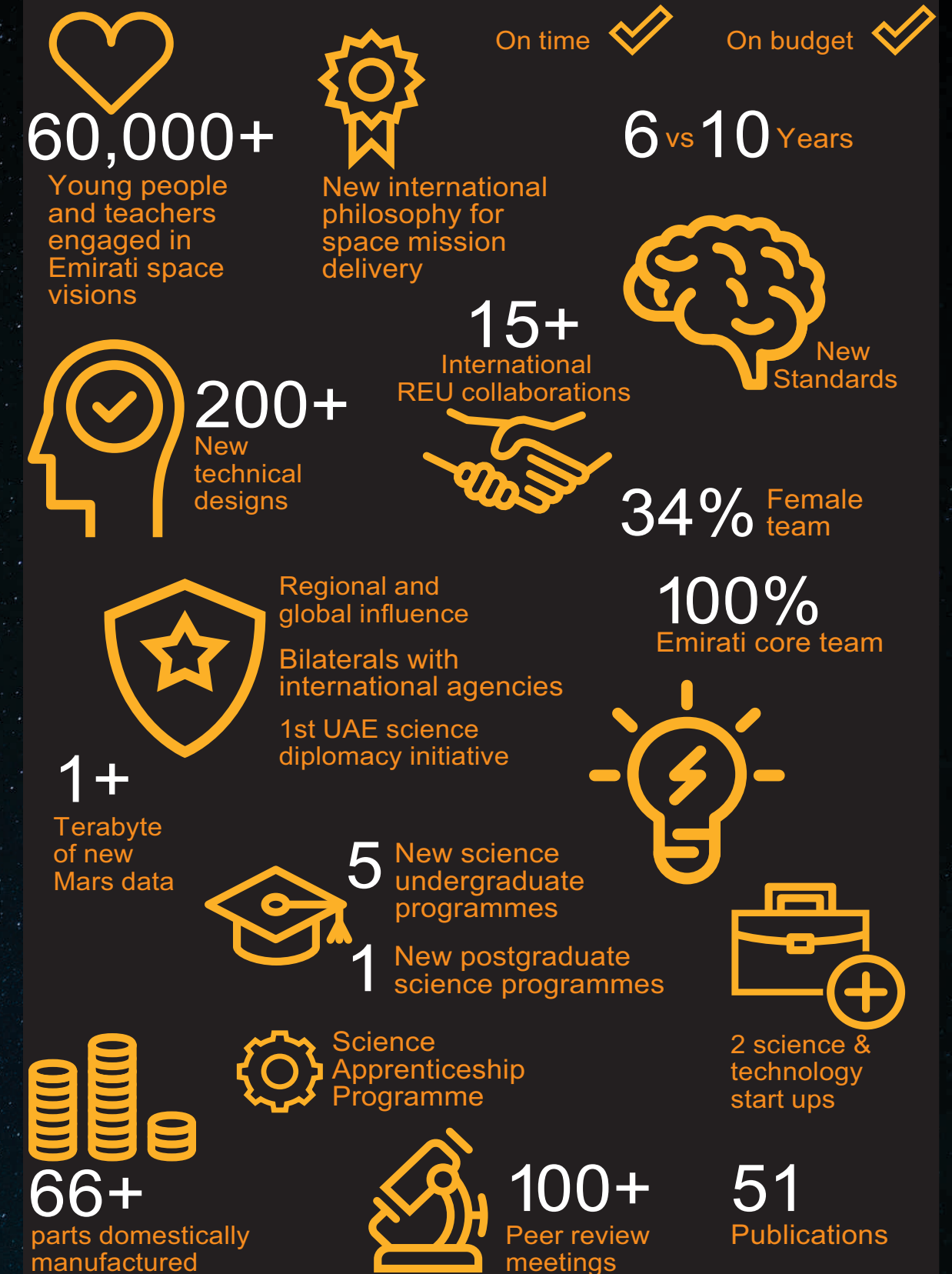
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Nigeria's GEOINT trajectory



When Nigeria's National Space Research and Development Agency (NASRDA) was formally established on 5th May 1999, it was a moment that carried aspirations far beyond the purely scientific. The agency's founding coincides with the return of civilian democratic government under President Olusegun Obasanjo as it signaled a conscious attempt to place space-based technologies at the center of national development and, implicitly, national security. What this founding moment could not have fully anticipated was the form and ferocity of the security challenges that would subsequently demand precisely the kind of spatially informed intelligence that NASRDA was chartered to develop. By the first decade of the twenty-first century, Nigeria faced a qualitatively different threat

environment. The insurgency launched by Jama'atu Ahlis Sunna Lidda'awati wal-Jihad, known internationally as Boko Haram, beginning around 2009 introduced a dimension of territorial violence that conventional military doctrine was ill-equipped to address. Nigeria shares borders totaling more than 4,000 kilometres with Benin, Niger, Chad, and Cameroon, and the porous nature of these borders has been a persistent enabler of Boko Haram and ISWAP's operational resilience. As a result, arms trafficking, fighter movement, and logistical supply across these borders sustained the insurgency through periods of intense military pressure. Monitoring these corridors is a task uniquely suited to satellite and UAV-based

surveillance: it covers vast distances, requires persistent rather than episodic observation, and cannot be feasibly addressed through fixed ground-based posts alone. While operating from the dense forests of Borno State, particularly the vast Sambisa Forest, and exploiting the porous borderlands of the Lake Chad Basin, the group conducted asymmetric warfare across difficult, often unmapped terrain. The challenge was not simply one of military capacity but of intelligence, specifically, the capacity to see, locate, and understand adversaries operating across landscapes that traditional ground-based surveillance could not adequately penetrate.

In these moment, geospatial intelligence emerges as a critical analytical category. GEOINT is broadly defined as the intelligence derived from the exploitation and analysis of imagery, geospatial data, and information describing, assessing, and visually depicting physical features and geographically referenced activities became an increasingly important instrument in Nigeria's evolving counterinsurgency toolkit. Satellite imagery, Unmanned Aerial Vehicles, Geographic Information Systems, and spatial data analytics have collectively transformed the informational landscape of military operations in ways that earlier kinetic-centric approaches could not achieve. Yet the story of GEOINT in Nigeria is neither linear nor

triumphant. One lesson, Nigeria has learned in its counter insurgency battles is that possessing satellites and surveillance drones does not, of itself, produce intelligence-driven counterinsurgency. What matters equally perhaps more, is how these systems are integrated into command structures, how their data is processed and shared across agencies, how technical personnel are trained and retained, and how technological inputs are reconciled with the granular, relational knowledge embedded in local intelligence networks. In developing states, there is growing fault lines that borders on the growing incidences of intelligence failure, where most

consequential breakdowns occur not at the point of collection, obtaining the raw data but at the points of processing, fusion, analysis, and dissemination. Data collected by a satellite is useless if it arrives at a command post day after the window for operational action has closed. Imagery analysed by a technician without adequate training misrepresents the battlefield. Intelligence shared only within a single service rather than across the full spectrum of security actors fails to generate the comprehensive situational awareness that counterinsurgency demands.

In asymmetric conflicts such as counterinsurgency, insurgent groups deliberately exploit the opacity of terrain, forests, deserts, urban warrens, and cross-border hideouts to offset the conventional superiority of state militaries. GEOINT, in principle, penetrates this opacity. Satellite imagery can detect encampments in dense forest. Similarly, persistent surveillance UAVs can map patterns of movement along smuggling corridors. Thermal imaging can identify human presence in areas claimed to be uninhabited. GIS platforms can overlay population data with conflict events to reveal the spatial logic of insurgent activity.

In Nigeria, Boko Haram's exploitation of the Sambisa Forest, a thickly vegetated reserve spanning roughly 60,000 square kilometres in Borno State, demonstrates this dynamic with particular clarity. The forest's canopy cover, combined with the absence of reliable road networks and ground-level cartographic data, rendered it effectively invisible to conventional intelligence collection methods. It was precisely this invisibility that GEOINT technologies were positioned to overcome, though the extent to which they succeeded involves a more complicated assessment than proponents of these technologies typically acknowledge.

In Nigeria, the Sambisa Forest used by Boko Haram and ISWAP as a primary base of operations, logistics hub, and hostage-holding facility exemplifies this challenge. Therefore, traditional cartographic data was fragmentary and outdated, even as the ground-level reconnaissance in the forest's interior was both operationally hazardous and informationally limited. Satellite imagery, combined with UAV surveillance, enabled a process of progressive spatial mapping that transformed the operational understanding of the theatre.

Nigerian military operations in the North-East, particularly under Operation LAFIYA DOLE, benefited from the integration of overhead intelligence into campaign planning. As the war endures, satellite imagery was used by the military to identify probable camp locations, supply routes, and crossing points along the Nigerian borders with Niger, Chad, and Cameroon. UAV reconnaissance provided persistent monitoring of specific areas identified through satellite analysis, generating the time-series data necessary to distinguish between transient and permanent activity patterns.

The interception of Boko Haram supply convoys, documented in several Nigerian military operational reports, illustrates the practical contribution of this evolved approach. UAV surveillance of known supply corridors enabled the identification of convoy movements before they reached their destinations, have provided

ground forces with actionable intercept opportunities. Unfortunately, while GEOINT can identify where Boko Haram commanders shelter; it cannot, by itself, resolve the conditions that generate new recruits to replace those commanders when they are neutralised.

The space programme

Nigeria's entry into the domain of space-based observation came into being with the launch of NigeriaSat-1 in September 2003, a milestone placing Nigeria among the handful of African states with indigenous satellite assets. Built by Surrey Satellite Technology Limited of the United Kingdom and launched aboard a Russian Kosmos-3M rocket from the Plesetsk Cosmodrome, NigeriaSat-1 was a modest but symbolically significant achievement. Operating as part of the international Disaster Monitoring Constellation, it carried an optical payload capable of generating multispectral imagery at 32-metre ground resolution with a wide swath of over 640 kilometres. However, the NigeriaSat-1's resolution was insufficient to support fine-grained tactical intelligence.

A satellite that can resolve features at 32 metres cannot distinguish between a military camp and a farming settlement, nor can it track vehicle movements reliably. Its primary contribution to security was more indirect: the establishment of a geospatial data infrastructure, the training of Nigerian engineers and analysts, and the creation of institutional frameworks, particularly within NASRDA for managing, processing, and archiving spatial data.

The launch of NigComSat-1, Nigeria's communications satellite, aboard a Chinese Long March 3B rocket in May 2007 added a further layer of spatial infrastructure. Though NigComSat-1 suffered an in-orbit failure in November 2008 due to a solar panel malfunction, its replacement NigComSat-1R, was launched in December 2011 and provided C, Ku, Ka, and L-band coverage across Africa, Europe, and parts of Asia. For counterinsurgency purposes, communication satellites constitute an enabling infrastructure for the dissemination of spatially referenced intelligence across dispersed operational commands.

The launch of NigeriaSat-2 and NigeriaSat-X in August 2011 represented a qualitative upgrade in Nigeria's Earth observation capacity. NigeriaSat-2, a SSTL 300-class satellite, carried a 2.5-metre panchromatic and 5-metre multispectral imager, providing imagery resolution an order of magnitude finer than NigeriaSat-1. At 2.5 metres, it became possible in principle to identify vehicles, distinguish between structures, and detect surface activity in ways that earlier Nigerian satellites could not support.

The Geospatial industry is growing

The geospatial industry, spanning commercial and defense sectors, has become the hotbed of rapid innovation and growth. According to economic trend analysis, the industry is projected to grow from \$339 billion in 2018 to \$ 1 trillion in 2027, a 13.8 percent compound annual growth rate. This growth rate even outpaces the industry's growth between 2013 and 2017, which was 11.9%. While the U.S. currently leads the geospatial market, economic analysis reveals that the Asia-Pacific region is the fastest growing.

While the wholesome application of GEOINT is driven by the proliferation of armed groups across the Sahel, operational shortfalls has been attributed to insufficient technology, implicitly recommending more platforms, better sensors, and higher-resolution imagery as the primary remedies. Against this position, researchers argue that institutional and political conditions are the primary determinants of GEOINT's effectiveness. This is not a denial of technology's importance but a reordering of analytical priorities: the question is not whether Nigeria has drones, but whether Nigeria has the institutional architecture to turn drone surveillance data into actionable intelligence.

Few years before the full insurgency, Nigeria acquired Israeli Aerostar tactical UAVs earlier, but their operational integration was limited and their operational lifespan curtailed by maintenance challenges and spare parts availability.⁴⁴ The intensification of the Boko Haram conflict catalysed more systematic investment. The Nigerian Air Force negotiated the procurement of Chinese CH-3, CH-4, and Wing Loong UAVs, platforms with both intelligence-gathering and strike capabilities around 2015 onwards. These systems introduced a genuinely new operational dimension: persistent aerial surveillance over the Sambisa Forest and adjacent borderland areas, real-time video feeds to ground commanders, and the capacity to conduct precision strikes against identified targets.

The period from 2019 to 2025 witnessed a further intensification of Nigeria's investment in unmanned and space-based intelligence platforms in its counter insurgency drive. A landmark acquisition was the Bayraktar TB2 combat drone from Turkey, procured in 2022. Nigeria also acquired the Turkish Songar armed drone, the Aerosonde Mk4.7 for army use, and the Tekever AR3 maritime patrol drone for the Navy, supplemented by AR-500B shipborne UAVs from China. In parallel, the Defence Space Administration moved into indigenous drone development. By 2024, the agency had commenced production of a range of UAV systems including the AYBARS-II surveillance drone, the ADAN 70 assault platform, and the SZK-290 surveillance system. The launch of DELSAT-1, Nigeria's first dedicated defence satellite, further signaled this ambition, underscoring the recognition that sovereign geospatial intelligence capacity requires purpose-built military intelligence systems responsive to the specific requirements of the armed forces.

NigeriaSat-2, having surpassed its original design lifespan, delivered degraded imagery quality. NigComSat-1R approached the end of its operational life, raising the prospect of a communications capability gap before replacement systems could be fielded. The institutional landscape remained complicated: coordination among NASRDA, the DSA, and the operational armed services continued to improve incrementally, but remained insufficient for the demands of a threat environment requiring real-time, integrated responses across multiple domains.

Despite the long counter insurgency war, one of Nigeria's structural constraint is the persistent shortage of trained personnel capable of deriving actionable intelligence from geospatial data streams. Nigeria's investment in satellite and UAV hardware has outpaced its investment in the analytical workforce needed to exploit that hardware. In order to meet the growing demand for GEOINT professionals, we must prepare the next generation of STEM

FCC moves to exit satellite services operations in the upper C-band

America's wireless leadership is back. After years of falling behind other countries, President Trump and Congress restored the FCC's spectrum auction authority in the One Big Beautiful Bill and established an aggressive spectrum pipeline. In doing so, the statute assigned the FCC an unprecedented task, auction a massive swath of mid-band spectrum in record time.

Thanks to the early and close collaboration with the FCC's federal partners across the Trump Administration including the Federal Aviation Administration—we are delivering on time, on budget, and with no surprises. Today's decision to auction 160 megahertz of the Upper C-band is a really good win for the country, according to FCC Chairman Brendan Carr.

FCC decision today sets the stage for the FCC to run an auction of prime, mid-band spectrum next year, exceeding the 100 megahertz minimum established in the law. The Lower C-Band, which the FCC freed up during the previous Trump Administration, brought 5G, fixed wireless, and other innovations to countless Americans, says Brendan Carr. Now, in auctioning the Upper C-Band that sits next door, we will unify the two bands to create an enormous landmass of 440 megahertz of mid-band spectrum. This harmonized Super Band will be the envy of the world. Freeing up this spectrum drives down prices, raises speeds, and enhances competition.

On July 24, 2026, the U.S. Federal Communications Commission (FCC) published the Upper C-band Report and Order that repurposes 160 MHz of Upper C-band spectrum in the contiguous United States for next-generation terrestrial wireless services. The spectrum will be auctioned by no later than July 2027, and satellite operators will be required to clear the spectrum by December 2030.

According to FCC, gross incentive payments of approximately \$5.6 billion will be paid to SES if the spectrum is cleared within the specified transition deadlines. The Report and Order also provides a framework for the reimbursement of reasonable and necessary costs associated with the transition of Upper C-band customers to other spectrum in order to provide them with substantially the same service. SES remains fully committed to working cooperatively with the FCC and all stakeholders to complete the Upper C-band transition in time. SES restates its commitment to disciplined financial allocation of future proceeds received under the FCC's Report and Order.

A pipeline of mid-band spectrum remains critical to keep pace with the escalating demand for mobile capacity, especially as networks evolve towards 6G. Americans consumed a record 132.5 trillion megabytes of wireless data in 2025, and data usage has increased by roughly 35% per year for the past three years.^{7F} The emergence of artificial intelligence and the boom in machine-to-machine communications will require even greater wireless network capacity growth to support critical drivers of our economy.

Since 2020, and the subsequent lapse of our auction authority in 2023, no new bands have been auctioned, leaving the nation ill-prepared to address tomorrow's economic and geopolitical competition. As progress stalled in recent years,

our economic and geopolitical competitors opened up more spectrum for mobile broadband. To get America back on track, the Commission is running an aggressive two-pronged strategy to release more mid-band spectrum through a combination of auctions and secondary market transactions.

The frequency ranges 3 400–4 200 MHz and 4 500–4 800 MHz are in the list of candidate bands that emerged from studies conducted within the ITU Radiocommunication Sector in connection with this conference agenda item. Most existing C-band satellites use the first of these ranges for their downlink transmissions. The band 4 500–4 800 MHz is associated with the downlinks of the fixed-satellite service (FSS) Plan, and is intended to preserve orbit and spectrum resources for future use on an equitable basis by all countries.

Currently, there are some 160 satellites in the geostationary orbit using C-band frequencies for their downlink transmissions. This is the equivalent of more than 3000 satellite transponders with a 36 MHz bandwidth with the potential for transmitting about 180 Gbit/s at any given instant. This infrastructure represents an investment in excess of USD 30 billion in spacecraft and launch costs alone, without taking into account investment in the ground segment made by users and satellite operators.

The deployment of IMT systems in these frequencies have drastically reduce the benefits that these resources have brought to users around the world, because fixed-satellite services and IMT systems cannot share frequencies in the same geographic area.

Critical services delivered via C-band

C-band frequencies are used for downlink satellite transmissions that provide a wide range of services in developed and developing countries, including critical applications such as distance learning, telemedicine and universal access services; backhaul services including telephony, Internet; very small aperture terminal VSAT data links such as bank transactions or corporate networks; distribution of television programmes; mobile-satellite service feeder links, and emergency links, including disaster recovery services and meteorological tracking. These services require the high reliability and broad geographic coverage that can only be delivered in the C-band.

The satellite beams in C-band cover large geographic areas and facilitate intercontinental and global communications. In higher frequencies, such as around 12 GHz (Ku-band) or 20 GHz (Ka-band), beams are more focused towards smaller areas to overcome the more severe signal attenuation due to atmospheric effects. This is illustrated by the downlink footprints of a satellite currently operating at 180°E, for C-band and in Figure 3 for Ku-band.

Due to their broad geographic reach, C-band beams allow for economically viable coverage of smaller markets and regions with low population density. In C-band, region-wide coverage can be provided with high availability, irrespective of rain zones, because rain fade effects are almost negligible in these frequencies. On the other hand, the severe rain fading effects on Ku-band or Ka-band signals require operators to



create smaller beams focused on areas of high demand and population density, in order to maintain the required quality of service in an economically viable manner.

Eutelsat, SES secure \$6.1bn for clearing US satellite spectrum

European satellite operators Eutelsat and SES are set to receive a combined \$6.1 billion for freeing up satellite spectrum in the US. Under a plan approved by the US Federal Communications Commission (FCC), Eutelsat expects to

receive \$504 million in pre-tax payments, while SES is set to receive about \$5.6 billion, respectively. Alongside the payments, both satellite giants will also be reimbursed for eligible costs incurred during the transition. As a result, this will free up 160 megahertz of the C-band spectrum, granting telecom companies more capacity to expand wireless services.

SES CEO Adel Al-Saleh commented on the decision, stating, "We commend Chairman Carr and the FCC staff for their diligence, speed, and hard work." He emphasized that the company remains fully committed

to working cooperatively with the FCC and all stakeholders as the process progresses.

Al-Saleh noted that the incentive payments appropriately recognize the critical role SES will play in repurposing the spectrum. He added that the improved reimbursement process should support timely execution, minimize finance expenses, and help partners move quickly. SES stands ready to support its customers and execute the transition plan.

The structure of the deal ties substantial financial rewards to strict regulatory timelines. The \$5.6 billion in gross incentive payments is not guaranteed upfront but is contingent on

successful spectrum clearing within the 2030 and 2031 deadlines. This creates a direct alignment between SES's operational performance and its financial returns from the transition. Additionally, the reimbursement mechanism for reasonable and necessary costs provides a safety net against unexpected expenditures during the complex repurposing process, potentially stabilizing cash flows during the multi-year transition period.

Sideline content business

NAB again emphasizes that use of the Upper C-band for satellite program contribution and distribution is critical to the broadcast industry and that use has become more intense since the "Lower C-band" auction less than five years ago.

While the Lower C-band transition occurred largely without disrupting incumbent C-band services, that success was possible only because the Commission preserved a substantial portion of C-band for satellite use. NAB believes that further expansion of new services into Upper C-band will be dramatically more complex and expensive than Lower C-band and will result in material degradation and interruption of broadcast services.

"Any expanded use of the Upper C-band spectrum must ensure that continuing incumbent operations remain fully protected from interference to the extent there are any changes made to the Upper C-band; and that the unique capabilities of C-band that incumbent users rely upon are fully preserved to the extent those users may be transitioned to other bands or platforms", NAB said.

As has become commonplace, the wireless industry paints an exaggerated picture of spectrum saturation to justify further spectrum allocation. The association claims that the United States lags behind peer nations in licensed mid-band spectrum by an average of roughly 200 MHz and without additional spectrum, U.S. networks will be unable to meet nearly a quarter of peak traffic demand by 2027.

These claims from the wireless industry, however, of "spectrum crisis," "spectrum shortage," and "spectrum crunch" repeat hyperbolic contentions of the past. And so, to meet that supposed explosion of demand that was just around the corner, spectrum was auctioned for the overhyped yet ill-defined, "5G" technology. As it turns out, the wireless industry's claims that 5G would revolutionize wireless applications never materialized.

For instance, despite its claim that the Lower C-band "has proven crucial in delivering the benefits of 5G to American consumers and enterprises," US leading operator, Verizon has only improved average "5G" download speeds by an anemic 12 percent from mid-2020 until early 2025, even though Verizon won the vast majority of Lower C-band licenses offered during Auction 107.

Verizon now claims that Upper C-band spectrum "will deliver the connectivity and capabilities that American consumers and enterprises need." But like before, there is no

reason to take the wireless industry's claims at face value particularly given how they ignore the reality of how its spectrum is actually being used and posit poor spectrum management policies. While in the past the Commission has played the part of wireless industry cheerleader, the FCC now has ample reason to examine the wireless industry's claims with great skepticism. If it continues to roll out the red carpet as a result of slogans rather than real-world experience and data, the Commission risks reallocating spectrum in a manner that causes material degradation to critical incumbent operations while providing little-to-no benefit to the public by extending spectrum to speculative use cases.

Mobile operators' claim that "China could soon have nearly four times more 5G spectrum than the United States" is both meaningless and irrelevant. It is meaningless because there is no such thing as "5G spectrum" in the United States. Wireless spectrum is allocated on a technology agnostic basis. Unlike broadcasters, U.S. wireless providers are free to upgrade the technology used in their spectrum from 2G to 3G to 4G, to 5G and beyond, all without FCC approval. Their failure to make adequate spectrum available for 5G is not because spectrum is lacking, it is because of their unwillingness to upgrade.

As NAB commented previously, C-band satellites implement hemispheric coverage, which is not typically available in Ku-band satellites but is critical to providing simultaneous cross-continent and intercontinental delivery. A single C-band satellite can simultaneously cover the contiguous United States, its Caribbean territories, and Alaskan rural areas. Indeed, the Commission recognized that the "C-band service is often the only option available to reach remote villages in Alaska" The Commission's conclusion has been echoed by Alaskan telecommunications providers. Achieving that capability at Ku-band may require a lease of transponders on multiple Ku-band satellites or spot-beams, which will be far more expensive if not economically infeasible in rural areas.

In making any decision to expand the use of Upper C-band to new services, the Commission should focus on minimizing disruption to incumbents, not on maximizing revenue from a spectrum auction. As a matter of spectrum policy, the Commission has historically sought to minimize impacts on incumbent users. Before the Commission rushes to clear bands that are currently in heavy use, it should ask whether the operators have exhausted options to leverage technology improvements and network densification to meet capacity needs.

Put simply, the burden should fall on proposed entrants to do all they can to optimize their throughput before calling on the Commission to open more spectrum that runs the risk of causing interference to or significantly constraining incumbent users. Nor should the Commission readily accept forecasts from parties that have an interest in hoarding more spectrum, especially when those projections of wireless demand have proven consistently erroneous in the past. Forecasts seeking to justify reallocation of spectrum, a limited resource, should have a high burden of proof.

Consumers do not want or care about spectrum itself. They want to make phone calls, send text messages, and exchange data. The amount of spectrum needed for those purposes depends equally on the technology employed, the topology of a carrier's network, and its pricing models. Simply put, forecast demand for network throughput is not the same as demand for spectrum.

STARTUP SPOTLIGHT

Near Space Labs speeds accurate property imaging from the stratosphere



Accurate property imagery is one of insurers' most potent tools for underwriting and assessing damage, and Near Space Labs has developed a way of providing high-quality images in a more economical manner. Based in Brooklyn, New York, the startup combines existing technologies and atmospheric knowledge with highly sophisticated robotics and other emerging technologies to provide very high-resolution imagery faster, helping insurers to improve both underwriting and claims outcomes. "We fly autonomous devices to the edge of space, covering very large areas at very high resolution—and cover them very fast," comments Rema Matevosyan, co-founder and CEO, Near

Space Labs, and a former researcher in systems engineering for complex aerospace systems. "We can map large geographic areas in hours rather than days and weeks, making orders-of-magnitude improvement in the speed of claims handling." The most commonly sourced, high-resolution imagery for insurers today is produced using fixed-wing aircraft. While more accurate and cheaper than generally available satellite imagery, fixed-wing captured imagery has drawbacks when it comes to the currency of the images. "Most of the United States is covered once a year, best case," comments Matevosyan.

"It's clear to us that with a shifting risk landscape related to environment changes and high levels of urbanization, that's not adequate." Near Space Labs' founders were previously in the business of satellite imagery tasked with building large satellite clusters for the European Commission's Copernicus Satellite Network. The founders realized that there was a better way to tackle the problem focusing neither on outer space nor the lower atmosphere where winged aircraft fly. Near Space's "sweet spot" which explains the company's name is the stratosphere different directions or same direction at different speeds. It is

into this layer of the atmosphere that Near Space Labs flies its craft, a balloon-based platform. Called "Swiftys," these autonomous devices operate by maneuvering to and exploiting reliable upper-atmosphere wind currents. Through altitude control, the Swiftys can use contrary winds at different altitudes, or go in the same direction at different speeds. Matevosyan describes the stratosphere as a rough environment that more closely resembles the lower atmosphere of Mars than Earth. On Earth, winds close to the surface are unpredictable. "The higher you go, the more stable and predictable they are," she says.

No internal combustion engines, no rockets

"The stratosphere is a sweet spot for remote sensing because it is essentially twice higher than airplanes go, allowing more imagery per device," explains Matevosyan. "If you launch a satellite or plane, in addition to a high operating cost, you have a very limited ability to upgrade or change those platforms whereas we can continuously upgrade our hardware."

The balloon-based approach provides a combined advantage of being able to map large areas from the stratosphere with a resolution that could only be obtained from airplanes in a manner that is unparalleled in terms of flexibility, speed and scalability, according to Matevosyan. Once launched, the fleet navigation software and the fleet of robotic Swiftys work together to make autonomous navigational and maneuvering decisions in the stratosphere.

"We can build our devices within days and ship them wherever needed," Matevosyan observes. "They're miniature they fit in a suitcase and since they don't require an airport, you can deploy them with much greater speed and flexibility." Near Space Labs' greatest advantage is timeliness based on the Swiftys' easy deployment and the fact that they collect ten times as much data per hour as do fixed-wing aircraft.

She notes the difficulties associated triaging personnel on the ground and dealing all the bad actors that seek to take advantage of the situation. Since litigation and other costs pile up over time, insurers need more timely solutions to accurately assess damages, she says.

"If you're waiting for data to come in two weeks that's already too late," Matevosyan notes. "Using our solution, with one single flight and a few hours you could have all of New York City or the San Francisco Bay area, for example, with one single pass. It's a response time of hours against days of collection."

Near Space Labs is building new Swiftys on a weekly basis to scale its overall operation and provide more data and insights for customers, Matevosyan relates. "We've seen clients with property imagery that hasn't been updated for two years," she says. "In post CAT situations carriers sometimes wait for weeks for data to come through which is also unacceptable. For every property in force whether in Centerville, Ill., or south Florida—we can map within hours instead of days, and that's what resonates with our customers."

Near Space Labs secures \$20m in series B funding

Near Space Labs had raised \$20 million in a Series B funding round led by Bold Capital Partners. The company plans to use the funds to scale its operations and expand into new market segments. The round includes participation from strategic investor USAA, alongside Climate Capital, Gaingels, RiverPark Ventures, and existing investors Crosslink Capital, Third Sphere, and Draper Associates. Near Space Labs has now raised more than \$40 million in total funding.

Near Space Labs operates a fleet of small, helium balloon-lifted aircraft called Swift, which capture high-resolution imagery from the stratosphere without the need for engines or pilots. The technology has found traction with commercial customers, particularly in the insurance sector. According to the company, insurers use its imagery to assess damage from large-scale disasters such as wildfires and hurricanes.

The insurance industry has been one of the startup's biggest customer segments to date. One of the company's most important investors, USAA, is a major insurer and financial services provider. Insurance carriers subscribe to Near Space's imagery to track and understand the impact of large-scale disasters like fires and hurricanes, according to Rema Matevosyan, co-founder and CEO.

Near Space Labs says it will be expanding its U.S. coverage, as well as developing customized coverage plans for customers, which it says will be tailored to end users' operations. The startup currently operates over select areas of the U.S. but intends to scale up to cover 80 percent of the population with 7 cm resolution imagery twice per year. Matevosyan says that expansion is feasible without special flight licenses, as the Swift platforms operate passively using wind currents.

Higher accuracy and greater scalability

The company also plans to explore applications in agriculture, where the founders see potential to offer higher accuracy and greater scalability than drones or satellite-based solutions. "The idea of low-cost aerial imagery is valuable for many parties, not just insurance," says Will Borthwick, principal, Bold Capital Partners. "Even when you think about the advent of AI, which requires timely and high-quality data to work properly, it's the moment in time for something like this." The company was founded by Matevosyan, CTO Ignasi Lluch, and chief engineer Albert Caubet, all of whom have backgrounds in space and physics research.

Targeting underwriting blind

When Near Space Labs first introduced its balloon-borne imaging technology, the concept attracted attention for its unusual approach: small aircraft lifted by helium balloons into the stratosphere, navigating with wind currents rather than engines. Today the company is positioning the platform less as an experimental technology and more as a scalable source of imagery data for insurers. Matthew Tucker, Chief Revenue Officer, Near Space Labs, says the insurance industry emerged early as the company's primary commercial focus. "I was brought on to head up the first commercial go-to-market plan," Tucker says. "And we landed on insurance. Of all the industries that geospatial best serves, insurance is where we kind of started." Insurance demand has grown alongside the company's operational expansion. Earlier reporting by Insurance Innovation Reporter noted that Near Space Labs experienced rapid growth over the past year, supported by a \$20 million Series B funding round led by Bold Capital

Partners (Santa Monica, Calif.), with participation from strategic investor USAA (San Antonio, Texas) and several venture investors. The funding followed what CEO Rema Matevosyan described as a "breakthrough" year that included a sixfold increase in revenue and growing traction within the insurance sector.

"That investment allowed us to stand up the operational side of the business," Tucker says, describing the expansion of manufacturing and field operations. "Manufacture the devices... and stand up the operations team to go out and fly the vehicles to deliver that nationwide coverage." "We think there's a 6% to 10% improvement in loss ratios just by having better imagery to support risk assessment in rural areas", Matthew Tucker

The company now has more than 100 Swift platforms in production and is launching imagery coverage across an initial cohort of eight states as the first phase of a nationwide expansion. According to Tucker, Near Space Labs plans to publish imagery from this first group of states and then expand coverage based on customer priorities and market demand. "We have multiple nationwide customers now," he says, adding that the company is listening closely to those customers as it rolls out its coverage plan.

Addressing imagery gaps in rural areas

Near Space Labs' value proposition centers on providing high-resolution imagery in areas where traditional aerial capture is less frequent. Texas illustrates the opportunity. The state has the largest rural population in the United States, and insurers often lack up-to-date imagery for properties in sparsely populated regions.

According to Tucker, conversations with insurers suggest that improved imagery could help carriers better align premium with risk in those areas. "We think there's probably somewhere between a six to ten percent improvement in loss ratios just by having better imagery to support risk assessment in rural areas," Tucker says. Near Space Labs estimates that roughly one million parcels in Texas currently have imagery from other providers, but that imagery may not offer 7-centimeter resolution or twice-yearly capture. The company estimates that about \$2.5 billion in direct written premium may be supported by outdated or incomplete imagery.

Texas has also become a focal point for the company's coverage strategy. "Texas sits at the center of the United States' climate-driven home insurance crisis," says Rema Matevosyan, CEO, Near Space Labs. "It is one of the largest property insurance markets in the country, one of the most disaster-exposed, and one of the fastest-growing populations moving into high-risk areas. Traditional approaches to aerial imaging can no longer keep pace. Near Space Labs' dedicated coverage program is now delivering continuous, 7-centimeter aerial imagery across the state. Our hope is to bring complete clarity to underwriting decisions and expand carriers' visibility into the many communities long-underserved by the aerial imaging industry." Near Space Labs says its platform is designed to provide consistent imagery at 7-centimeter resolution with capture cycles twice per year.

Economics of stratospheric

capture

The company's technology captures imagery using its Swift platforms, which are lifted by helium balloons into the stratosphere. Operating at altitudes comparable to or higher than commercial aircraft, the imaging systems can capture large geographic areas in a single pass. "You compare a single swath of capture from a Near Space Labs Swift compared to an airplane that has to go back and forth," Tucker explains. "Those are the economics which make us viable when it's not viable for aerial in rural areas." Because the platforms do not require pilots, engines, or airports, Near Space Labs can deploy imagery missions using small mobile crews that launch the systems from ordinary locations such as open fields or parking areas. Those lower operating costs allow the company to capture imagery more frequently and in regions where traditional aerial capture may not be economically viable.

"Near space is the atmospheric sweet spot between 20 km and 100 km (12–62 miles) above Earth, just shy of the edge of space. Free from significant weather, it's an ideal zone for geospatial imaging, capturing expansive views of the earth with unmatched clarity," Near Space Labs.

Potential role in catastrophe response

Near Space Labs also sees potential applications in catastrophe response, where insurers often need rapid imagery to assess damage after major events. Because the company's platforms operate above traditional airspace, they may be able to capture imagery even when aircraft flights are restricted following a disaster. The company believes that the same operational model that enables broad underwriting coverage could also allow insurers to obtain post-event imagery more quickly after hurricanes, wildfires, or severe storms.

As insurers increasingly rely on data and analytics to support underwriting and portfolio management, demand for updated imagery continues to grow. Some insurers access imagery through third-party analytics platforms, while others ingest imagery directly into their own internal analytics systems. For Tucker, the company's role is to provide imagery that supports those risk-assessment processes. "If that data is more up to date," he says, "you're only ever going to improve those risk assessments at the time when you need the data."

As natural catastrophe frequency continues to rise quadrupling since the 1980s per capita in the U.S., according to Matevosyan, the need for fast, reliable, high-resolution imagery grows more urgent. Insurers, she believes, are uniquely positioned to drive climate resilience and Near Space Labs intends to be their eyes in the stratosphere. "Insurance is about understanding and transferring risk," she says. "And you can't do that without the right data." "Whether people like it or not, insurance is one of the best tools that we have today to create that resilience," Matevosyan continues. "There's no climate resilience without financial resilience and there's no financial resilience... without insurance."



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Assessing geopolitical drivers of UAE's space program

In February 1976, five years after the founding of the United Arab Emirates, Sheikh Zayed Bin Sultan Al Nahyan, founding father of the UAE, met with the crew of NASA's Apollo 17 mission. The meeting was arranged by an Egyptian-American NASA scientist named Dr. Farouk al Baz who coordinated the presentation of a model of the U.S. Space Shuttle during the meeting.

Sheikh Zayed was also gifted a fragment of lunar rock which had been acquired during the Apollo mission, a present from then President Richard Nixon. This meeting is one of the several exchanges highlighted by current UAE officials in an effort to draw a through line from Sheikh Zayed's enthusiasm for space to the UAE's present-day space endeavors.

Zaki Nusseibeh, the UAE's Minister of State who served as an advisor to Sheikh Zayed throughout the 1970's, "recalls the zeal and commitment UAE's founding father had when it came to exploring the frontiers of science and education to take his country into the future." Dr. Farouk al Baz also recalls the late Sheikh's keen interest in space, recounting a conversation they had regarding the Apollo mission. Sheikh Zayed raised countless questions about the intricacies of the mission: "he wanted to know how the astronauts survived in space, how they did various experiments, how they managed to bend to pick up rocks from the moon surface."

Sheikh Zayed died in 2004, years before the UAE's space endeavors would blast off in earnest, but he had lived to witness the first two successful launches of Emirati-owned communications satellites, Thuraya 1, in the year 2000, and Thuraya-2 in 2003.

Since founding of the first Emirati research center dedicated to space in 2006, the Mohammed bin Rashid Space Centre MBRSC in Dubai the UAE has made rapid strides towards its stated goal of becoming the regional space hub. There are currently fifteen satellites in orbit that are registered under the UAE flag. The founding of its space agency in 2014 corresponded with the announcement of its Mars Hope Mission, which successfully launched in July 2020 and arrived to the Martian surface in February 2021.

Emiratis also take great pride in the flight of the first Emirati to space in October 2019, when Hazaa al Mansouri journeyed to the International Space Station where he stayed for eight days. By opening and funding several local research centers, the UAE has also made progress towards its goal of creating a local base of expertise to sustain space sector R&D in perpetuity, an effort that compliments another Emirati strategic space goal: "Effective local and international partnerships and investments in the space industry." This goal aligns with the UAE's effort to become a knowledge economy, a

necessary step if it is to remain prosperous in a world increasingly shifting away from reliance on hydrocarbons.

Space experts repeatedly praise the UAE's political will in regards to its space program. In their 2020 assessment of UAE space activities, Renata Knittel Kommel, Ashley Peter, Mackenzie Puig-Hall, Luc Riesbeck observed: A unique feature of the UAE is its strong political will for space activities. The UAESA has been given legal, financial, and administrative independence to enable the agency to carry out all actions and acts necessary to achieve the nation's goals and objectives for the space sector. The political support for the UAESA to exercise all powers, actions, and activities necessary has allowed the Agency to direct R&D spending and enable universities and Space Centers to take actions in space more quickly than other nations in the global space community.

This deeply deliberate approach to growing the UAE national space sector has two important implications. First, it explains the early successes of the nation's space activities and suggests this success will only grow in the long run. Second, it implies that the UAE government views space activities as politically beneficial. Even in the context of a monarchy, political will is not easily fabricated, particularly when it is directed at an endeavor as complex as space exploration. It is therefore instructive explore the political rationales of the UAE's space endeavors.

There are two primary motivations for the Emiratis' pursuit of regional space hegemony. The first motivating force, is that a booming space science and technology sector would be a profitable means of diversifying the UAE's economy in order to shield it from the volatility of global oil markets.

In addition to providing future generations of Emiratis with jobs if and when the state's present social stipend system becomes unsustainable, the space sector also offers ample opportunities for local and foreign investment, an opportunity which the UAE government has already begun pursuing by way of easing regulations on foreign investment.

The second motivating force the UAE government's desire to build a sense of nationalism and civic identity among Emiratis, and particularly among the younger generations of Emiratis. The UAE's space policy documents fervently emphasize that space activities are a national effort by and for Emiratis. They also emphasize that this effort reflects Emirati ambition and ingenuity: space exploration is the natural next milestone for a country with a long history of common suffering and mutual dependence.

This powerful cultural narrative is a piece of a grander state-led social engineering effort tailored "to fashion the young into more self-reliant, achievement-oriented adults who will demand less from the state in terms of social welfare, while showing greater willingness to volunteer in their communities and contribute to market-driven economies."

Thus, rationales one and two are mutually reinforcing: the state must diversify its economy in order to remain prosperous in perpetuity, and must have capable, local talent to engage in and sustain this newly diversified economy.

The UAE'S space sector

The first UAE-owned satellites, ThurayaSAT's 1-3, were launched throughout the period of 2000 and 2008 from launchpads in the Pacific Ocean. Thuraya-2 and Thuraya-3 are still in orbit; Thuraya-1 operated successfully for two years but, due to malfunctions in its solar panels, it was retired to the

graveyard orbit. These mobile communication satellites are owned by Thuraya, a telecommunications company owned by the UAE government and a subsidiary of the al Yahsat Satellite company. These satellites provided mobile communications to the Middle East for the first time, revolutionizing the region's communications during a politically turbulent time.

The 1991 Persian Gulf War, which unfolded after Saddam Hussein's invasion of Kuwait, has been called the world's first "space war" as it was the first conflict which illustrated the utility of the satellite-based GPS system, which enabled U.S. troops to navigate the hostile terrain with greater ease than would have been possible in its absence.

Recognizing the importance of localizing these technological capabilities, the next UAE satellite to be launched in 2009, DubaiSAT-1 was built by a South Korean company, Satrec Initiative, and Emiratis made up thirty percent of the team of engineers. Its successor satellite, DubaiSAT-2, was also built by Satrec, with fifty percent of the work being carried out by Emirati engineers. DubaiSAT-1 was retired to the graveyard orbit in 2016 while DubaiSAT-2 still orbits, continuing on its mission which, according to the UAE-owned Mohammed bin Rashid Space Centre which operates the spacecraft, is to provide "remote sensing, high-res electro-optical images for international scientific, sustainable planning, and disaster relief purposes."

Yahsat Satellite Communications Company, also owned by the UAE government, has three satellites in orbit. The first two were launched in 2011 and 2012, while the most recent was launched in 2018. These satellites are categorized as "commercial satellites with military use" because they establish service in a frequency band known as the ka-band, which is the preferred band for military communications. Yahsats 1 and 2 were manufactured by a French company, while Yahsat-3 was manufactured by an American company based in Virginia.

A major space milestone was achieved by the UAE in 2018 with the launch of Khalifasat, the first Emirati satellite to be built entirely by Emiratis. Given its indigenous origin, this satellite has been dubbed a "source of inspiration for young Emiratis." A remote sensing satellite that is more agile than its predecessors, its stated mission is to "assist global governments and private organizations to monitor environmental changes, ensure effective urban management, and aid in disaster relief efforts, amongst other critical services.

There are seven additional satellites currently in orbit registered under the Emirati flag. Meznasat, the first student-built satellite in the UAE, collects data on greenhouse gas concentrations and monitors red tide algae in the Arabian Gulf. Nayif-1, the UAE's first nano-satellite, which was "launched by MBRSC in collaboration with educational institutions as part of the sustainable space science knowledge transfer programme," carries only amateur communications technology as its primary intent was to provide a hands-on learning opportunity for young Emirati students.

The UAE also has a military satellite in orbit: the Falcon Eye 2, which was belatedly launched by an Arianespace Soyuz rocket in December 2020. The Light 1 satellite, launched in March 2022, is another important milestone for the UAE. This collaborative mission between the UAE and Bahrain is the "first scientific mission in the region to monitor and study terrestrial gamma rays emitted by lightning and thunderstorms."

The UAE frequently emphasizes that its space program is an Arab achievement, a framing that aligns with their goal of becoming the regional space hub. Commenting on the mission's successful launch, a representative of the sponsoring Emirati University stated that "This collaborative initiative represents a distinct model of what researchers in the Arab world can achieve." More collaborative Arab missions like Light 1 are likely to follow.

The remaining three Emirati-flagged satellites in orbit are small satellites of different varieties. The MYSAT-2, also known as DhabiSat, is a cubesat developed by students at Khalifa University. Like the Nayif 1, its mission is primarily educational.



The Dewa-Sat 1, which was launched in February 2022, is an experimental nanosatellite owned by the Dubai Electricity and Water Authority. Its mission is "to complement the terrestrial internet of things communication network to increase the efficiency and effectiveness of Dubai Electricity and Water Authority's operations and support the digitisation of our electricity and water networks." DMSat 1, designed by the Dubai Municipality and the MBRSC, is the Emirate's "first nanometric environmental satellite." It gathers data on air pollutants and greenhouse gases that will be used to "find solutions and develop long-term plans to confront the challenges of urban pollution and climate change and explore the future environmental reality in Dubai and the UAE. As such, it is an important example of how the Emiratis leverage space to protect and preserve their country in the long-run.

One of UAE's major spacecraft listed is the Hope Rover, perhaps the greatest pride and joy of the UAE's space efforts to date. Successfully launched in July 2020, the rover successfully arrived at Mars in February 2021. The spacecraft was built at the University of Colorado Boulder in collaboration with UC engineers and MBRSC engineers, and the MBRSC is conducting the remainder of the mission with oversight from the UAE space agency. The Hope mission has been branded as a "celebration of Arab ingenuity and achievement" as it is the Arab world's first interplanetary mission, and its rhetorical value has been immense.

The UAE Space Agency UAESA is another source of great Emirati pride. Founded in 2014, UAESA is "responsible for establishing partnerships, assisting academic programs, advancing national and regional space exploration, and investing in research, development and commercial space

projects." The agency is tasked with the implementation and oversight of the UAE's National Space Strategy, which was published in March 2019. This expansive sixty-page long policy framework outlines six strategic goals, featured in Figure Four, and aligns them with the various programs and initiatives which are being undertaken in pursuit of those goals.

The National Space Strategy is not limited to scientific and technological measures of success alone but also extends to domestic and international economic considerations. Strategic goal two the "development of advanced local capacities in Space technology manufacturing and R&D" has been fiercely pursued via the establishment and funding of four local research centers.

These research centers have partnerships with similar centers abroad in order to achieve the transfer of necessary technical skills. This naturally

contributes to the actualization of strategic goal five, the promotion of "effective local and global partnerships and investments in the space industry." The strategy document itself is the result of thorough consultation and collaboration. Its advisory committee included nine expert members hailing from seven different countries. Space experts often commend the Emiratis' proactive approach to consultation with global industry and government leaders, and the positive influence of this consultation is exemplified by the UAE's many early space successes.

The second portion of goal five, the local and global investments in the UAE space industry was in part realized with the announcement of the UAE's new Space Law. The Chairman of the UAE Space Agency, Dr. Ahmed bin Abdullah al Falasi, commented that "The law will be a key factor in opening the doors for investment in the national space sector to various global companies, due to its legislative and regulatory environment, which provides foreign investors with assurance ahead of starting their



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business and projects in the UAE." This law is tailored to create a regulatory and legislative environment friendly to foreign investments and collaboration, an important step towards ensuring a sustainable space sector.

Economic diversification

The UAE's turn to space is one piece of a broader transition towards establishing a knowledge economy. While the UAE's space sector may still be relatively young, other Emirati knowledge economy sectors have been unfolding for some time and illustrate the state's skill in that regard. From Oil to Knowledge: Transforming the United Arab Emirates into a Knowledge-Based Economy by Allam Ahmed and Ibrahim Alfaki details the UAE's diversification efforts.

Alfaki and Allam also provide useful comparisons to other nations that have been successful in their efforts to establish a knowledge economy, namely, the Republic of Korea and Singapore. Ahmed and Alfaki assert that the gradual rise in growth rates of non-oil GDP until 1990 followed by the steady

increase thereafter "appears to reflect the success of the UAE's diversification strategy of promoting non-hydrocarbon sectors."

In comparing the UAE to its Gulf Cooperation Council counterparts as well as the Republic of Korea and Singapore, the authors conclude that the UAE has made "remarkable improvements towards the knowledge-based economy." They credit this achievement in part to the fact that the "UAE's commitment to transitioning to a Knowledge-Based Economy is receiving the required political backing and is further supported by the availability of significant financial resources and wealth that can play a proactive part in realising the KE vision."

Dubai itself is a success story of Emirati diversification. A hub for local and international travel, Dubai tops most every list as the most open market in the Gulf, and it therefore is the "centre of Gulf commerce, travel, finance, communications, and transport and the one truly global location in the region." Rory Miller credits the success of Dubai's in the tourism sector to its "unparalleled infrastructural

base which ranks very high in terms of global connectedness." This connectedness that has bolstered Dubai's tourist sector has also paid dividends in the UAE's space efforts, as Dubai has been selected as the host location for several pre-eminent space conference and meetings, including the 2021 International Astronautical Congress, the 2021 Space Generations Congress, and several meetings of the United Nations Office for Outer Space Affairs.

Space milestone

A report by Morgan Stanley indicates that the global space industry could "generate revenue of more than \$1 trillion or more in 2040, up from \$350 billion, currently." However, the UAE is joining an increasingly crowded field, as current trends reveal that international governments' space budgets grew by 9.5 percent in the last fiscal year. Private entities, too, are driving the frenzy, as evidenced by SpaceX's several recent milestones, including the first commercial human spaceflight mission, the continued rollout of the company's Starlink satellite constellation, and their successful design and reuse of orbital-class launch vehicles, which helps to keep launch costs down and make

the industry more sustainable.

To date, the Emirati approach to its national space sector exhibits a willingness to address these challenges head on. The final page of the UAE's National Space Strategy Summary 2030 identifies the "success factors" that will be used to measure the success of the agency in enacting the strategy, including active stakeholder involvement and coordination, review and revision of the space policy, and risk management during strategy implementation. The Emiratis proactive approach to overcoming possible challenges is a likely indicator of success.

Two key challenges will likely constitute the largest barriers to a sustainable and successful Emirati space sector. First, the agency is tasked with ensuring collaboration between the various local stakeholders, of which there are many. While this whole-of-government approach is certainly promising, it is unclear if the agency has been able to foster serious collaboration between its various research centers and agencies. Another emphasis is on interaction and collaboration among all members of the R&D sector, a critical pillar of a

sustainable shift towards a knowledge Economy.

The Director of the Hope Project, Omar Sharaf, connected the Hope mission to the legacy of the Islamic Golden Age of the eighteenth century, noting that "We as a region used to generate knowledge. A lot of the technologies that we use today and the science being done today is based on the outcomes of scientists from the region." It was also the first mission launch countdown to be conducted in Arabic. The nationalist value of this mission was not merely rhetorical, though: as previously discussed, the spacecraft was built at the University of Colorado Boulder with a team of young Emiratis involved in order to help "the Emirati scientists and technicians quickly develop expertise in Mars exploration."

Another space milestone of great value from a citizen-building perspective was Hazaa al Mansouri's trip aboard the International Space Station. His trip made considerable news in and beyond the Middle East, and great effort was made to engage the Emirati public in the mission. While on board the International Space Station, Mansouri conducted thirty-two experiments which had been designed by Emirati school children as a part of a competition run by the Mohammed bin Rashid Space Center.

Mansouri also recorded the first tour of the International Space Station in Arabic, which has reached nearly half a million views on the MBRSC's YouTube channel. Upon Mansouri's return to the UAE, the nation burst into communal celebration: His Highness Mohammed bin Rashid al Maktoum posted Mansouri's image on his Instagram feed, commenting that he had "broadened the horizons of our future generations in space"; the world-renowned skyscraper, Burj Khalifa, was lit up with Mansouri's image; and countless signs, statutes, and other public tributes were spread throughout the country. The logo of the mission, which Mansouri wore as a patch on his space suit, reads "the ambition of Zayed" yet another rhetorical means of linking present UAE space endeavors to the prestigious legacy of the founding father of the UAE.

The "Generation Hope" initiative is another prime example of a government-led effort to cultivate desired citizen outcomes by way of its space endeavors. Announced on November 2, 2020, this four-month program is tailored to "inspire a new generation of scientists and engineers who dream of exploring the galaxy." Throughout this period, the MBRSC hosted series of weekly webinars related to the Hope Mars Mission, one in Arabic and one in English. The MBRSC will also host two "awareness camps", one for high school students and another for "distinguished undergraduates" that will lead activities related to Mars and space exploration.

Her Excellency Sarah Bint Yousif al Amiri, the UAE's Minister of State for Advanced Technology and the current Chairwoman of the UAE Space Agency, has also made many instructive comments about space sustainability. Speaking in Davos, Switzerland, she emphasized the need for continued global dialogue on three main issues: continued access to space for new countries, the management of orbital debris, and the access to data for all nations. On the issue of data, Amiri

emphasized data relevant to battling the impact of climate change on Earth, such as the data on maximizing crop yields that will aid sustainable production in the face of rising temperatures. This indicates that the UAE's definition of space sustainability is multifaceted, encapsulating both the stewardship of the space domain itself and also the use of space tools in achieving terrestrial sustainability.

Amiri's comments throughout the panel continuously emphasized the need to protect access to space for all. In her opening comments, she noted that "the dialogue needs to continue with regards to the sustainability of access to space, ensuring that nations around the world have the necessary access."

This sentiment has been echoed by other UAE efforts in space. In October 2021, the Mohammed bin Rashid Space Center MBRSC and UNOOSA announced their signing of a memorandum of understanding on satellite payload hosting. This agreement reportedly provides that "the two parties will provide opportunities in the Payload Hosting Initiative which offers a cost-effective and modular satellite platforms that can host multi-purpose payloads." This payload project falls under UNOOSA's broader Access to Space for All initiative, an effort that aims to bridge the gap in capabilities between space-faring and emerging or non-space-faring nations. With a particular focus on emerging and non-space-faring countries, the aims of this initiative are to connect established and emerging space actors and to support capacity building and technological development.

The UAE is one of five space entities supporting this initiative, joining the European Space Agency, the Japan Aerospace Exploration

Agency, the German Aerospace Center, and the China Manned Space Program.

The Hope Mars Mission exemplifies this duality. In a 2021 interview with the Center for Security and International Studies, Sarah al Amiri noted that a major driver of the Mars Hope Program is the role it will play in achieving not just economic stability, but also social stability.

When asked about the name choice of the mission's title, "Hope," Amiri commented: If we go back to when this program was conceptualized in late 2013, the region was coming on the back of a lot of instability and a lot of it was due to the youth not having a voice, not having opportunities, not having basic access to stability within the region, the Prime Minister was putting together a program that one, empowers youth, who make up a large portion of this region, and two, empowers them on a very risky program. At the time that we started this mission I think we were all thirty and under. It was quite a mark of hope: yes, entrust the youth, yes, provide them with opportunities, and provide them with the tools and see how they rise with science and technology as a mechanism to infuse development. And that was the reason behind the selection of the name.

This goal of empowering and engaging the youth has been omnipresent throughout the UAE's space programming, as evidenced by the many youth-oriented projects.

The UAE's approach to space resource utilization law is also forward-looking. Asteroids and other celestial bodies contain platinum, nickel, and other rare metals that are lucrative both here on Earth and in space, as they could eventually be used to sustain interplanetary missions. In 2019, the UAE Space Agency announced the rollout of a new law regulating space mining activities. Dr.

Mohammed Al Ahabbi, Director General of the UAE Space Agency, commented that "We are setting regulations and laws with the future in mind. This will help inspire investor confidence and allow companies to clearly understand the rights a state could grant them when domiciled in that country."

The "rights" Dr. Al Ahabbi is referencing are the rights of private companies to retain full ownership of their acquisitions from space resource mining. At the time of this law's announcement, this made the UAE the second country with such a right for private companies in space resource mining. The Emirates' preemptive regulation of this activity aims to attract space companies to the country, thereby supporting their goal of achieving a sustainable national space sector.

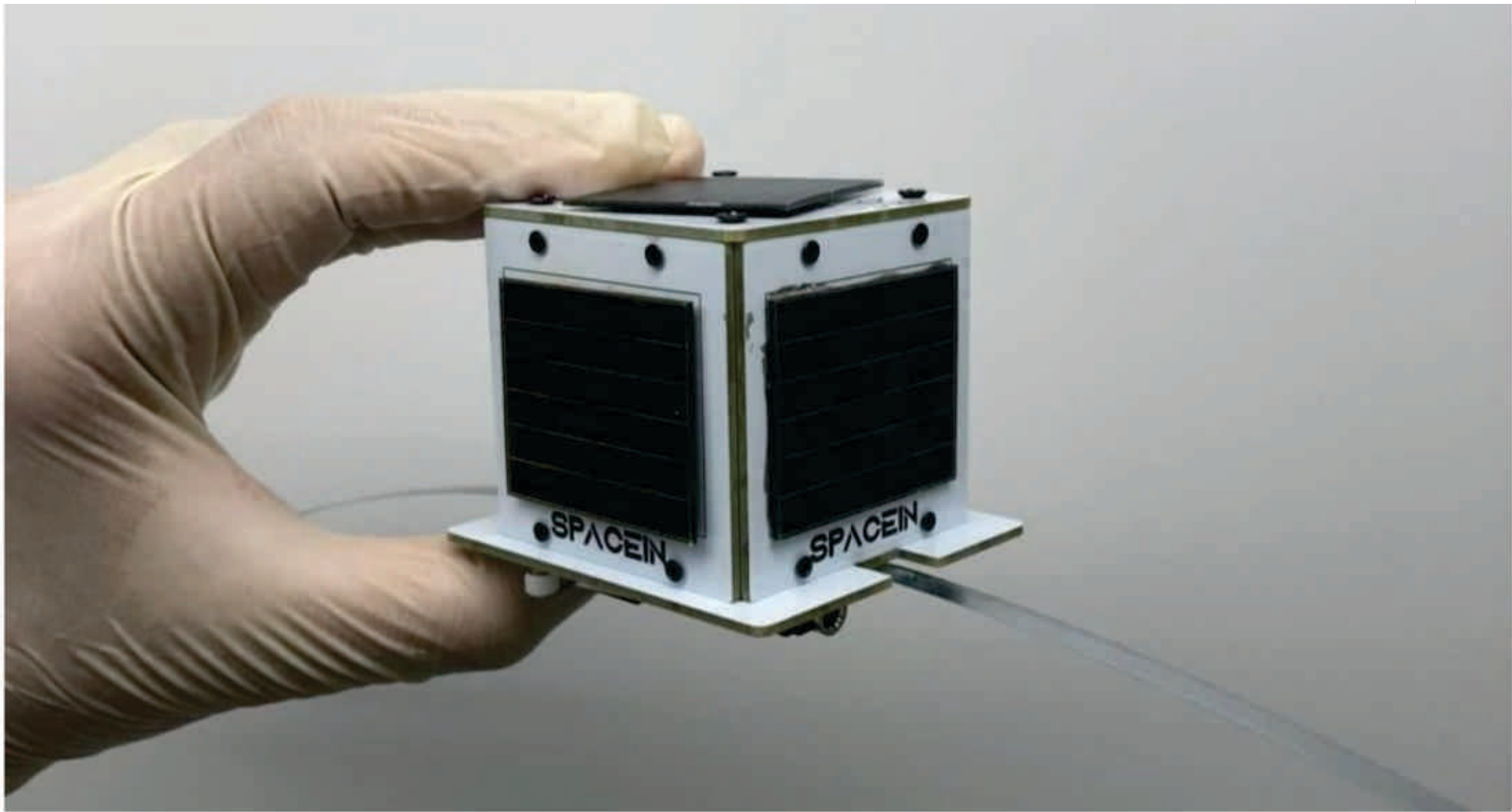
It also aligns the Emirati's interpretation of international space law with that of other countries who have been publicly deliberating on space resource utilization, like the United States and Luxembourg. The UAE's leadership in space resource utilization therefore serves both national and international goals.

Salem Humaid Al Marri, Director General of the MBRSC, also helped kick off the IAC by reading a quote from the country's founding father: "Future generations will be living in a world that is very different from that to which we are accustomed. It is essential that we prepare ourselves and our children for that new world." Al Marri continued to describe al Nahyan's vision and dream for space exploration. He also framed the UAE's pursuit of space exploration as a natural point in the country's evolution from a desert-dwelling people to a modern scientific nation. Emiratis, he noted, have used the moon for navigation for generations, so their lunar landing ambitions align with the nation's heritage.



SPECIAL REPORT

Alba Orbital and its PocketQube missions



PocketQubes are miniature, tiny satellites based on the CubeSat form factor but are even smaller measuring just 5x5x5 centimeters, that provides a cost-effective and accessible means of space exploration and research.

In terms of standard, the PocketQube are of varying size where a single-unit, PocketQube is one eighth the size of a single-unit CubeSat with a side length of 5 cm. Single, 1.5 and 2.5 unit satellites have been developed. PocketQubes are small, and this can present design challenges; but the tips and tricks below should help you out when miniaturizing payload or designing satellite to the PocketQube standard.

In the past decades, advancements in the miniaturization of electronic technologies remained the driving force behind the development of the smartphone, has revolutionized society, empowering the average person to have a wealth of knowledge at

their fingertips, while democratizing access to information on a global scale. This same driving force of technological miniaturization, known as 'Moore's Law', has enabled the development of 'PocketQube', a satellite small enough to fit in your pocket.

Alba Orbital is the world's leading PocketQube company that has launched 19 picosatellites on-orbit to date. Alba is a vertically integrated NewSpace company 'democratising access to space', providing turnkey solutions from advanced picosatellite platforms. Alba has worked with over 30 customers across three continents, including prestigious clients such as Stanford University, Carnegie Mellon University and TU Delft. As Tom Walkinshaw, Founder and CEO of Alba Orbital notes, 'The PocketQube revolution is almost like going from the mainframe era of computers to the age of information with

democratized access to the internet. It's the same thing for space - PocketQubes are democratizing access to space."

PocketQubes are highly miniaturized satellites, one eighth the size of a CubeSat, comprising of one or more cubic units of 5 cm with a maximum mass of 250 g per unit or 'P'. The original concept was proposed in 2009 by professor Bob Twiggs as a solution to further reduce the costs and development time involved with satellite development, widening the doors of space access for small organizations to develop their own space program.

As the PocketQube standard has gained popularity in recent years, there has been a growing interest in developing new technologies that are suitable in these small, low-cost satellites, focusing on making the subsystems required for PocketQubes more compact, efficient, and reliable, in order to maximize the capabilities and mission lifetimes of these satellites.

When we started thinking about building a satellite, we first saw the Cubesat standard and thought that this was the only thing available to small organisations like ours, but this was too expensive - over 100,000 Euros! When we heard about PocketQubes we were really excited because they were cheaper to develop and to put in space. Until now, only major organisations, big companies, and some universities could raise the funds to fly satellites.

In April 14, 2021, Alba Orbital has become the 1st Scottish company to take investment from Y Combinator. YC is famous for being an early investor in Airbnb, Dropbox, Twitch, Stripe, Reddit and many more billion dollar startups and is seen as the top global program for early stage startups on the planet.

On 6 December 2019, Alba Orbital made history as the company broke the world record for most

PocketQube satellites deployed in-orbit. In that year, the Scottish-based PocketQube manufacturer, successfully launched six picosatellites from New Zealand on Rocket Lab's 10th Electron flight, 'Running out of fingers'. Included in this historic launch were Hungary's first picosatellites, SMOG-P and ATL-1, developed by faculty and students at the Budapest University of Technology and Economics the leading technological university in Hungary.

The seven satellites on board were for commercial rideshare customers bringing the total number of small satellites deployed by Rocket Lab to 47, continuing the company's record of 100% mission success for customers. The payload was deployed to a 400 km circular orbit, before the Kick Stage's Curie engine reignited and dropped the stage to a circular 385 km orbit for deployment of Alba Orbital's payloads. According to team leader, Dr Gschwindt, the team had decided to develop picosatellites as the reduced form factor inherent with the PocketQube standard would greatly reduce both development time and economic costs. Dr Gschwindt and his team at Budapest University of Technology and Economics have been active developers of PocketQubes since they started in 2014 and have since developed three PocketQubes code named SMOG-1, SMOG-P and ATL-1.

The economy in the 21st century is unimaginable without the space sector. According to Morgan Stanley's prognosis in 2020, the global sales revenue of the space industry will increase from the current USD 350 billion to over USD 1,100 billion by 2040, hereby it will be one of the world's fastest growing industries in the coming period. According to the European Commission's survey, 10% of all EU policies and sectors are currently being affected by space activities, and this proportion is expected to increase rapidly in the upcoming years.

Despite their size, the capabilities of PocketQubes have proven immense. Their compact form factor has allowed for launches starting from as little as €25k through Alba Orbital's dedicated launch services. This affordability has opened space access to high schools, universities, startups, and research institutions worldwide. Teams have been able to design, build, and fly their own satellites for the first time.

Since the first PocketQube launch in 2013, mission types have ranged from Earth observation and Internet of Things (IoT) experiments to communications and technology demonstrations. The result is an ecosystem of small satellite innovation, proving that impactful space missions can be achieved in the smallest of sizes.

"With the 100th PocketQube reaching orbit, we've fulfilled the revolution to democratize access to space," said Tom Walkinshaw, CEO of Alba Orbital.

The growing popularity of the PocketQube standard has led to rapid innovation. Alba Orbital's own 3P Unicorn-2 satellite remains the world's smallest commercial Earth observation platform, capable of capturing high-resolution

imagery that rivals much larger satellites.

Built by students and lecturers at the Budapest University of Technology and Economics, HUNITY tested a new PocketQube platform while supporting student experiments and hands-on learning, advancing Hungary's educational satellite programs.

According to the European Space Agency's estimates, every euro invested in the space sector shows six times return, as multiplied profits are realised in the economy through the complex supplier system. Besides, NASA calculates eight times return on investment in the US economy. Therefore, the priority areas of the global economy depend on space, such as global telecommunications, internet, as well as crop, water and climate observation built on Earth Observation data, meteorological services, precision agriculture or satellite navigation.

The cluster includes Turkey's first pico-satellite, Grizu-263a which was designed by a team of engineering students from Zonguldak Bülent Ecevit University and named in honor of the 1992 Kozlu coal mine disaster. The Grizu team are joined by other prestigious universities on the Alba Cluster 3 lineup such as TU Delft and Ariel University. ACME AtronOmatic who flew TRSI-1 on Alba Cluster 2, also joins the Alba Cluster 3 roster as Alba Orbital's first returning launch customer. Speaking on why TU Delft signed up to launch with Alba Orbital, Delfi-PQ team member, M. Ş. Mehmet Uludağ said: "Alba Orbital are one of the first and only companies to focus solely on PocketQubes, so it is nice when a company has a focus as you can communicate with them easily and they can really understand your problems. Alba Orbital are also the only company right now who have a qualified PocketQube Deployer and this gives you a certain confidence that your satellite will be deployed without any problems."

AlbaPod

The AlbaPod was developed in the UK by Glasgow-based Alba Orbital when it became clear to the developers of these ultra-small platforms that an adequate PocketQube launch infrastructure did not exist. "It was obvious that client demand required an increase in picosatellite deployers, designed to the specifications of the PocketQube Standard," explains Tom Walkinshaw, CEO of AlbaOrbital. "We knew that this would provide more reliable and frequent launch opportunities."

The AlbaPod which meets the launch environment requirements of most major launch providers does just this, and makes it possible for PocketQubes to be integrated on any launch vehicle as part of a 'rideshare' mission. In December 2019, the AlbaPod was successfully qualified after deploying six PocketQubes in low earth orbit, via an Electron rocket launch from Mahia, New Zealand.

Barnaby Osborne, Technical Officer of the project at ESA says: "The lightweight, unique design can be easily integrated into any launch vehicle. Alba Orbital have made extensive use of 3D printing to lower the cost of the deployer, while still maintaining the demanding quality standards required for space. This is a key requirement for their target customers, who need low-cost reliable access to launch services."

October 27, 2020: Alba Orbital Ltd announced the successful integration of nine PocketQube satellites ahead of their upcoming Alba Cluster 3 mission, 'That time of year', which will be the largest PocketQube launch in history to date. Using the company's AlbaPod v2, the world's only space proven PocketQube deployer, Alba Orbital will take customer satellites to orbit on a SpaceX Falcon 9 launch vehicle in December 2020 as part of a rideshare agreement.

PocketQube satellites from all over the world are getting to space with Alba Orbital for Alba Cluster 3. The PocketQubes confirmed to launch on Alba Cluster 3 are DelfiPQ, a 3p PocketQube developed by TU Delft in Netherlands. DelfiPQ is the start of a iteratively developed line of PocketQubes with the aim to enable new and unforeseen missions with distributed networks of PocketQubes. Delfi-PQ is testing a LOFAR payload and a laser retro reflector.

Grizu-263a, a 1p PocketQube developed by Zonguldak Bülent Ecevit University in Turkey. Grizu-263a carries an inertial measurement sensor and a passive magnetic control subsystem. The TRSI-2 a 1p PocketQube developed by TRSI in Germany.

The HADES and EASAT-2. The twin 1.5p PocketQubes developed by AMSAT-EA in Spain. EASAT-2 was developed in collaboration with the European University of Madrid and its mission is to be a satellite for communication between radio amateurs via a 145/435 MHz transponder. It also carries a basalt from Lanzarote, similar to lunar ones, provided by the CSIC research group on meteorites and planetary geosciences.

HADES is also an FM/FSK voice and data repeater for amateur use and carries a SSTV camera module developed and manufactured in the Department of Radioelectronics of the Brno University of Technology in the Czech Republic.

SATTLA-2, a 2p PocketQube developed by Ariel University (Israel), which will utilize WiFi cards for extreme long-range link applicable to transmit video for over 600 km in LOS conditions.

Unicorn-1, Unicorn-2A and Unicorn-2D: Unicorn-1 is a 2p built in partnership with the European Space Agency. Unicorn-2A and 2D are earth imaging 3p PocketQubes also developed by Alba Orbital UG in Germany.

Alba Orbital Cluster 3, manifested on a SpaceX Falcon 9 launch vehicle and launched in Q2 2021 launch with a target Sun Synchronous Orbit at 500 to 600 km. Speaking on the success of Alba's PocketQube launch business, Founder and CEO, Tom Walkinshaw added: 'This a huge milestone for Alba and the PocketQube community. Demonstrating annual, reliable and affordable flights for the PocketQube standard is what is required for more teams to get involved in PQs. This flight nearly doubles the number of PocketQubes ever flown to orbit, with Alba orbiting 15 of those satellites.'

Following the mission success of Alba Cluster 3 & 4 in the new year, Alba Orbital and

AMSAT-EA in Spain rideshare agreement led to the successful launch of yet another PocketQube satellite ('URESAT-1') on-board Alba Cluster 6 in Q4 2022, a project managed by AMSAT-EA, a non-profit amateur radio association, on behalf of Union de Radioaficionados Espanoles, the Spanish Radio League Association. The mission was flown via SpaceX's Falcon 9 launch vehicle using Alba Orbital's flight-proven AlbaPod to deploy the pico-satellites in Low Earth Orbit (LEO).

PocketQubes in Hungary

Hungarian space research and space activities go back to a history of 75 years, since the famous Lunar Radar experiment of the Hungarian scientist, Zoltán Bay. The abilities of Hungarian research entities, academic institutions, and even economic actors also stand out on a global scale. From the region, Romania, Czech Republic and Poland also increased their budget in the field, and except the Czech Republic, each country has its own space agency, while Hungary, at a dynamic pace, is trying to catch up on its backlog observable on regional level.

Today, services built on satellite data became determining elements of critical infrastructure, without which, the disaster management or the military would not be able to carry out their tasks. The extent of data-based economy and society is well illustrated by the fact that satellite data is used as a precondition for overcoming the most significant problems in the 21st century.

As satellite data became part of everyday life and critical infrastructure, it is highly important in terms of sovereignty and national security that the state obtains data from an actual and authoritative source, through a reliable channel. Through promoting widespread agricultural use of innovative technologies and services built on satellite data, more efficient production can be realised. Therefore, the income-generating capacity of business entities is growing, moreover, the climate protection and environment protection considerations can be better applied.

As the CubeSat segment transforms the space sector, indispensable infrastructures related to it provide a unique breakout opportunity for Hungary. Budapest is poised to establish a CubeSat assembly, integration and test centre that is regionally outstanding, qualified for most carriers, provides complex services, and fulfils the increasing CubeSat capacity requirements in the region.

Nevertheless, interdisciplinary space activities everywhere in the world are implemented through intensive international collaborations. In recent years, significant progress in the field of strengthening Hungary's diplomatic relations, has enabled actors of the Hungarian space sector into signing various Memorandums of Understanding.

International partnerships, international corporate collaborations and emerging bilateral and multilateral diplomatic relations broaden the joining opportunities to the global space industry value chain and bring it closer for the domestic corporate and scientific sphere. Therefore, the Hungarian economic actors, whose presence in the strong international competition was not visible at times, can now strengthen their international visibility and activity in order to open new opportunities for business and industrial relations.

Smartphones on the battlefield

by John M. Mchale

Military planners want warfighters to have the same capability that civilian consumers get from their commercial smartphones and are testing different devices. However, they still have to overcome security hurdles and the short development cycles in the commercial market before full-scale deployment can happen.

The typical civilian smartphone whether it is an iPhone 5, Samsung Galaxy III, or even a Blackberry is easier to use and has more processing capability than any handheld device that soldiers, Marines, sailors, or airmen use in combat environments today. Modern cell phones have amazing technology, but are not seen as rugged or secure enough for military use on the battlefield. That is until recently. Different programs are in development in the Services to leverage commercial smartphones for battlefield use. One Army initiative the Nett Warrior program, run by PEO Soldier expects field these devices as early as 2014.

"No defense company in the world can beat the reliability and performance these small devices deliver," says Jason Regnier, Acting Program Manager for the Nett Warrior program at Ft. Belvoir, VA. "It is money well spent. What is enabling their use in part from a policy was a relaxing of the requirements about the environments they would be used in. For example, they don't have to survive a nuclear blast anymore. We are still looking at more ruggedized devices for underwater use and the like, but right now we are focused on commercial devices due to the tremendous cost savings and they are meeting all of our objectives so far."

"Smartphone development within the DoD is a testing environment," says Brett Kitchens, Senior Director, DoD Strategic Programs, U.S. Federal Government Markets at Motorola. "PEO Soldier wants a smartphone device at the edge running secret-level security, but it is not a program of record yet today. I think the efforts will move quickly. Some brigades are already testing different smartphone equipment and software. Eventually there will most likely be a pool of devices for the services to choose from based on their mission needs and user preference."

Nett Warrior

Right now Nett Warrior, an integrated, dismounted situational awareness and mission command system is in the operational testing phase and begins fielding in 2014, Regnier says. However, the Army is in a hurry to get this technology out earlier and is fielding Motorola Atrix Android-enabled smartphones with certain brigades this year to improve situational awareness. They are still secure with strong encryption,

but not certified by NSA for secret data. It is not under a program of record, but is more of an experimental requirement.

The Nett Warrior program is currently using Rifleman Radios from General Dynamics C4 Systems during demonstrations to interface with various smartphone devices running the Android operating system, Regnier says. The Rifleman Radio is an interim solution until the Army finishes developing the Nett Warrior tactical radio, he says. General Dynamics C4 Systems also is developing the Nett Warrior radio, which will weigh less than 2 lbs., communicate using the Soldier Radio Waveform (SRW), and enable access to the U.S. government's classified networks at the secret or sensitive but unclassified levels, according to a General Dynamics release. The Low Rate Initial Production order is for 2,052 radios, scheduled to begin delivery early in 2013.

"For the smartphones, we are looking at commercial devices that have a dual or quad processor design, are low power, are unlocked so we can remove their software and install the government code, and have a bright, easily readable display," Regnier says. "The WiFi and Bluetooth functions are turned off on these phones and only connect through the tactical radio. Each device functions essentially as a mini computer with a dual- or quad-core processor.

"One common frustration with using these commercial devices is that just when you have one modified and the proper software added, the company stops selling them," Regnier continues. "An example of this was a Samsung Note device we looked at that had a large, bright screen that the warfighters liked, but we were too late as Samsung has already stopped selling them and moved on to the next one.

The commercial development cycle goes even faster than we thought it would. For Nett Warrior to make it through each year, I will have to look at what the next smartphone will be to keep up with what the commercial cell phone guys are doing. For example, many cell phone companies are moving to Organic Light Emitting Diode (OLED) displays, which will be brighter but easily detectable at night. We need to make it dark so the enemy can't detect it and make the displays compatible with night vision goggles.

"The key will be to eventually have software that will work across multiple platforms even if the physical devices go obsolete," Regnier continues. "If you do it right and follow the coding it will work. But for us there are only certain phones that will work because the manufacturers do not unlock all the phones in the same way. We need the devices unlocked so we can remove their code and upload our certified software. The reason is we have to have secret capability in the end user device."

Securing smartphone communications

"The first hurdle for smartphone acceptance in the military is the security aspect, and industry and the government have got to prove it. But we think we have [gotten] it solved," Kitchens says. "We anchor the data at rest, which then goes through the chip as encrypted packet and users will have the keys to secure. Also if you pull the data out without the key, you kill it. The NSA is looking at certifying the security solutions and there will be different paths to agency certification of devices. They will also need criteria for mobility. It will be up to the authorities to take the risk, and right now 256 encryption looks good enough as it has not been broken, and 256 B is even tougher." Motorola secure smartphones include their AME 1000, which is based on the ES400 device for enterprise applications.

"Warfighters see the value of what you can do with a smartphone, but before it gets into the field en masse, the devices really need to be secured," says Tim Skutt, MILS Solution Architect at Wind River. "Right now smartphone use is kind of in a middle ground, going through limited experiments, not in widespread deployment yet. Wind River's secure Android offering has a holistic approach that supports integration of security enhancements tailored to the use case, as well as unique commercial Android capabilities, into security enhanced devices.

We have five pillars that we are implementing when developing Android solutions attack detection and prevention; device integrity; isolation; infrastructure security; data protection and system protection, which includes the ability to sanitize remotely."

Trusted handheld platform

"Enabling top-secret security in a COTS phone is a difficult challenge," says Gordon Jones, INTEGRITY Secure Virtualization at Green Hills Software. "Certifying a COTS phone for use can be done, but by the time the phone is certified, it may be obsolete before you can deploy it to the troops. What is needed is a way to keep the security portable across architectures that also meets the commercial release process."

Green Hills is participating in a Marine Corps effort called the Trusted Handheld Platform that is looking to advance the development of commercial mobile device technology for the DoD by enabling a capability to access multiple security domains, Jones says.

The program has four requirements, with the first seeking an isolation technology such as a separation kernel or security kernel, he continues. This will isolate the software components, control the intra-domain access, and also isolate the other resources on the devices. Second, it must be multipersonality, so the devices support multiple personalities on a

single handset. Another requirement is that it use commercial standards and not be a custom government design. The fourth requirement is that it have a common product line architecture across multiple platforms, Jones says.

"Green Hills engineers are applying their separation kernel – INTEGRITY, and running multiple versions of Android on top of it and controlling the device," Jones says. "This guarantees separation time and space for the applications on top and also runs a complete virtual machine monitor. There will be applications running inside of Android, and since Android is a large and complex piece of code, the level of assurance for any code running inside of Android is low so isolation is required. What we do is isolate Android from the rest of the system. For instance, one Android could be connected to the Secure Internet Protocol Router (SIPR) network and one will be connected to the Non-secure Internet Protocol Router network, but they will be isolated from one another on top of the INTEGRITY kernel."

This dual domain phone would have an IT persona and a private persona – both isolated from each other on top of a trusted environment that would have an NSA-certified separation kernel like INTEGRITY, Jones says. A dual domain smartphone for the warfighter could operate in a classified and unclassified network as well as separate personal and work data. Having only one physical device also enables the warfighter to save on size, weight, and power, he adds.

"For protection of data at rest when implementing the INTEGRITY kernel on a device with Android as a guest, we insert a virtual self-encrypting drive that guarantees that every piece of data written to memory is encrypted by INTEGRITY in a trusted partition before being written to memory in the phone," Jones says. Therefore, as data moves in and out of Android unknown to Android, it is encrypted by the architecture when in motion or at rest and cannot be compromised.

Secure networks and tactical app stores

Engineers at Lockheed Martin are enabling the use of commercial tablets and smartphones by developing a secure 4G tactical cellular network they call MONAX, says David Weber, Business Development Manager, C4ISR Systems at Lockheed Martin Information Systems and Global Solutions in Philadelphia. The network can be set up in places where there are no cell towers and, within hours, a private, secure cellular network is operational. No matter the smartphone or tablet device used for voice, video, and data transmission, users will still be able to access the network if they have the proper clearance, Weber says. Once connected, their device accesses a VPN tunnel that is encrypted, he adds.

"Once you get into the network, there are multiple layers of security via the Mobile Device Management (MDM) feature, which enables users to set secure access policies," Weber says. "The system can also be Common Access Card (CAC) enabled. For data at



rest protection, the system can be remotely zeroed out through the MDM feature. Tactical radio users also can access MONAX by just entering the VPN tunnel, he adds.

"We have a MONAX application store that is very minimal because we don't build apps, but we will have the capability to download apps or purchase them from other vendors," Weber says. "Five apps that come with the MONAX solution are VOIP, tactical app, chat, map app, and an NSA app. The apps are developed for or rehosted on a smartphone, then approved and made available to warfighters in the app store. You can download popular apps, but we recommend you turn that capability off. If the customer wants to, we can enable it, but it can be risky as it opens up to the 'dirty' Internet."

The system consists of a portable MONAX Lynx sleeve that connects touch-screen smartphones and tablets to a MONAX XG Base Station

infrastructure located on the ground or on airborne platforms, according to a Lockheed Martin MONAX brochure. Currently the Marine Corps uses MONAX in military exercises and it is also used for humanitarian disaster relief, Weber says. The Coast Guard is using MONAX with iPads in all their medical clinics across the U.S., he adds.

Ruggedizing the smartphone

While commercial smartphones have state-of-the-art processing capability, they are not what the military would traditionally call "rugged," but have features and interfaces with which warfighters are comfortable.

The Army did run a program for rugged handheld development called the Joint Battle Command-Platform (JBCP) Handheld System, which has since been moved under Nett Warrior. It is no longer an active program, but the Army is still

looking at the ruggedization developments.

DRS Tactical Systems' first rugged handheld offering came out of that program and was called the SCORPION H1. "Although we met the initial requirement, it became clear it didn't meet with user expectations," says Bill Guyan, VP at DRS Tactical Systems.

"Warfighters have the same expectations in terms of ease of use that they get from their personal smartphone: lightweight, small enough to fit in a pocket, and an efficient touch screen with good visibility and graphics. So for the next version – the H2, we went a bit outside the box. We ruggedized a commercial handheld instead of building it from the ground up."

The H2's appeal is its modularity that enables warfighters to customize it for their mission. Its sled mating system mates through a connector that allows for expansion sleds for extended

battery life, USB hub, SAASM GPS, information assurance, RFID, IR camera, dead reckoning, a cold weather module chemical/biological detection, or a combination based on customer specifics. If the phone is damaged or a newer model is available, it also can be easily swapped in and out of the housing. The 3G/4G-ready H2 features the Google Android 2.3.5 preinstalled and is Android 4.0 (Ice Cream Sandwich) ready. It uses a Qualcomm Snapdragon S3 Processor and has 1 GB of RAM. It weighs 8 ounces and has about 8 hours of battery life and can be charged while interacting with tactical radios.

The General Dynamics Itronix GD300 rugged smartphone also came out of the JBCP, says a General Dynamics spokesperson. The device meets MIL-STD-810G and is resistant to dust, rain, shock and vibration, and humidity. It has GPS capability, can be worn on the arm or chest, and weighs less than 10 ounces. The GD300 also can interface to a tactical radio network for secure communications.



From one satellite to constellations: Loft's first 5 years in space

In June 2021, Loft launched its first satellite to space, the first step in our mission to make space fast, simple, and reliable. We were setting out to test an idea to make space capabilities as easy as deploying a new application on the cloud. Just five years later, we are now deploying full constellations and AI agents, including the first reported vision language model for near real-time Earth observation analysis. What began as a bold idea is now an on-orbit AI platform, built by an international company, with a heritage of missions that would have seemed ambitious at the outset.

Loft Orbital is the leading provider of space infrastructure as a service. It is a Series A startup having raised \$20 million+ and has 60+ employees in the USA and France. Its mission is to take some of the complexity out of space; technological advances are making space and satellite missions easier and more affordable. Loft Orbital flies and operates customer payloads on its microsatellites as a service. Companies turn to Loft Orbital when they want to focus on their area of expertise and trust Loft Orbital to operate their satellites using its mission agnostic, flexible operating system and interfacing technology.

Loft Orbital combines satellite buses with their Payload Hub which can be used to house any type of sensor and for any type of mission, from IoT to imagery. Their Payload Hub capacity ranges from 1 g to 70 kg, or even just software loaded onto the onboard edge computer.

Loft Orbital simplifies everything for their clients by integrating the payload into the Payload Hub, contract for the launch provider, and actually operate the spacecraft. Loft Orbital has developed a platform called Cockpit which makes operating payloads easy for their customers. They are providing space infrastructure as a service, including everything from mission design, instrument development, satellite integration and testing and launches. Loft Orbital aims to remove the complexity of satellite development and operations.

Loft mission is to be the fastest, simplest, and most reliable path to orbit for any payload. The company flies customer payloads onboard quarterly scheduled satellite missions, and handles the entire mission as a service. Loft customers can thus focus on what matters most to them: their payload and the data it collects. To make it possible, Loft Orbital has developed the software and hardware products that make Loft satellite missions truly plug and play, eliminating years of complex design and engineering. With qualified, commodity satellite buses procured in advance and available off-the-shelf, Loft delivers payloads to orbit in months not years.

Loft was founded to challenge the traditional, slow-paced space industry in a new way. The goal was to eliminate the complexity of space missions by building hardware and software abstraction layers that allow customers to focus on their core mission. The YAM-3 program was the first to prove that mission, but it hasn't just been a proof of concept. It's a commercial rideshare mission flying three customer payloads and hosting two on-orbit AI software missions, and it continues to operate today. Not only was this Loft's first satellite in space, it still serves as proof that Loft's hardware and software stack can reduce schedule and technical risk so customers can focus on their objectives.

One of the most significant milestones in Loft's story is the opening of Orbitworks, and what is now a proven model for enabling partners and nations to build their own sovereign space capabilities leveraging Loft's infrastructure and expertise. Orbitworks is a joint venture with Marlan Space, and the first satellite production facility in the Middle East. It represents a maturation of everything Loft has learned in five years and an answer to a common question from our government customers: how do we build a space capability that we actually own and control, without starting from scratch?

Joint ventures like Orbitworks allow customers to gain access to Loft's platform, expertise, and on-orbit infrastructure while retaining the security, autonomy, and sovereign capacity that matters to them. Today, Orbitworks is supporting three contracts for the French government to develop Earth observation and AI-driven intelligence missions. The team is also working closely with other customers to deploy novel capabilities like in space quantum encryption. This year Orbitworks will be launching Altair, the first fully AI-enabled, multi-sensing constellation with edge compute and always-on connectivity for near real-time intelligence.

If YAM-3 proved the satellite rideshare model, YAM-6 pushed the boundary of what's possible by creating a novel platform for deploying AI and advanced software.

In 2023, Loft launched YAM-6 as a new type of high-performance compute platform to simplify access to space for developers. YAM-3 was already running software missions for other customers, but now the developer community had access to a dedicated open platform for running AI applications on orbit without having to own the hardware. Instead of designing, building, and launching a physical payload, customers could test and deploy their applications directly onto Loft's on-orbit computing infrastructure.

To date, Loft has supported more than 13 AI and software missions for customers like NASA, Microsoft, Helsing, Little Place Labs, and Wallaroo.AI. This includes collaborating with NASA's Jet Propulsion Laboratory to deploy the first on-orbit visual language model for near real-time Earth observation and object detection. These applications are diverse, ranging from the global tracking of vessel movements to detecting radar jamming. Loft has become the open platform for leading AI companies to meet evolving global challenges in new ways. We are no longer operating like the cloud as a metaphor. Loft is the cloud infrastructure in space supporting rapid, reliable insights.

Expanding globally: the diverse team that built the platform

As its launch manifest grew with new flight programs, so did Loft's facilities and international footprint. Soon after the company was founded, Loft built its European headquarters in Toulouse, France, a hub of aerospace innovation and talent. In 2024, we expanded our production capabilities with a new 13,000 square foot facility in Golden, Colorado, featuring ISO-8 cleanrooms and test equipment for full in-house integration and testing. Today, we are building out a new facility in Arvada, Colorado to support US government customers and their classified missions. Loft has also developed a joint venture in Abu Dhabi to bring new space capabilities to the region. Building a global team has been core to our company culture and key growth driver of Loft's diverse customer base.

Constellations as a Service: EarthDaily and multi-satellite launches

Launching customer payloads on dedicated and rideshare platforms became so routine for Loft, that supporting constellations was the natural next step. We're integrating, launching, and operating 10 satellites for the EarthDaily Constellation, a system purpose-built to deliver daily, globally consistent measurement of planetary change.

As of today, Loft has launched seven satellites on behalf of the company, with another slated to just next week. To support the customer's timeline, this also led Loft to challenge itself to integrate six satellites on a single launch, and find new ways to automate commissioning operations to stay ahead of schedule. This work with EarthDaily has demonstrated Loft's ability to deliver not just missions, but scalable systems, with much more to come.

5 years in and just getting started

In some respects, we have surprised ourselves with how far we have come. YAM-3 validated our new operating model. AI-enabled platforms like YAM-6 expanded the mission profiles. The EarthDaily constellation is proving we can deliver at scale. And Orbitworks has become a blueprint for a future where any nation or organization can have rapid and secure sovereign access to space.

Fast, simple, and reliable has been the standard we've held ourselves to as a mission and an operating philosophy, and it'll carry the company forward the next 5 years into AI infrastructure and constellations as a service. None of this would have been possible without our incredible team of global experts working together to build something new.

Loft Orbital offers a true end-to-end service enabling customers to rapidly deploy and operate their payloads on reliable high-performance satellites at an unprecedented simplicity and affordability. Loft Orbital has also contracted Airbus to modify the Arrow platform to make it suitable for a wider range of longer lifetime missions and applications.

Loft Orbital has offices both in the USA and France, being based in the heart of Silicon Valley in San Francisco, and in the European space capital Toulouse, and intends to continue rapidly growing its French presence following this contract relationship with Airbus. Airbus previously benefitted from public support to develop the Arrow platform and OneWeb pilot line in Toulouse.

Bruno Le Maire, French minister for the Economy, Finances and the Recovery, said: "This groundbreaking contract between start up Loft Orbital and global space leader Airbus is a very good news. It demonstrates the uptake of New Space companies in France and the synergy across the space ecosystem for developing industry wide innovation."

It also testifies the speed at which the French space ecosystem is growing, with start-ups, SMEs, and large groups working together to provide world-class solutions, and fully validates the ongoing government strategy and initiatives to develop a vibrant and growing next space innovation ecosystem. I am very pleased that the project presented by Loft with the support of Airbus relies on French suppliers, more than 60% of the value being created in France."

Jean-Marc Nasr, Head of Airbus Space Systems said: "This sale of our small LEO platform Arrow to Loft Orbital is a ringing endorsement of our strategy to develop mass manufacturing for the next space era. Our reliable platform is already proving its worth in orbit for OneWeb who have more than 60% of their fleet in orbit. We look forward to working with Loft



Orbital to provide them with the best space technology possible – combining industrially-proven know-how with disruptive innovations – to serve their customers."

Pierre-Damien Vaujour, CEO of Loft Orbital said: "We are beyond excited about this procurement agreement with Airbus that is an industry first. Leveraging Airbus engineering experience and Airbus OneWeb Satellites production capabilities is enabling us to truly bring Loft's vision to life. While we are using this initial procurement to deliver to our customers who have ordered services based on a few tens of satellites, we see this as an opportunity to offer much larger constellation services to governments and companies worldwide. In

addition, the level of support we have received in France, and the quality of the engineering talent, is simply unmatched and we are looking forward to growing the company here in Toulouse."

The improvements to the Arrow platform, including all the engineering, qualification, test, and production of the first few spacecraft will be performed by Airbus in Toulouse. The production at scale of the remaining Arrow-derived platforms will be performed by Airbus OneWeb Satellites. Airbus Space's strategy of Next Space will seek further engagement with new players in the space ecosystem to ensure that sustainability and reliability in the LEO space environment is guaranteed for the future.

Loft Orbital to be Enhanced with IDRS™ Always-On technology

Loft Orbital has partnered with LEO communication specialist Addvalue to offer rapid, secure and simplified access to space, enhanced by always available end-user access. As part of this partnership, Loft Orbital has procured multiple Inter-satellite Data Relay Systems. The first Loft Orbital program to feature IDRS is YAM-6, which was launched in Q4 2023. Loft Orbital makes space simple by flying customer missions as a service onboard its own standardized satellite platforms. By combining mass-manufactured commodity satellite buses from active production

lines with its Hub, a universal interface for payload accommodation and operations, Loft Orbital provides customers with rapid and turnkey mission deployments.

Co-founder and COO of Loft Orbital Alex Greenberg explains, "multiple Inter-satellite Data Relay Systems expands our service offering by enabling constant access to our satellite infrastructure. Combined with our edge compute capabilities, in which we provide an onboard environment for flying our customers' software applications, IDRS enables our platform to address a wide range of tactical and real-time uses cases for satellite data. In line with our strategy of bulk procuring hardware and holding it in inventory to enable truly off-the-shelf access to space, we have procured multiple IDRS flight models."



APPOINTMENTS

EnduroSat Names Brandon Tripp as Chief Commercial Officer

EnduroSat, a space infrastructure builder, announced the appointment of Brandon Tripp as Chief Commercial Officer. In this role, he will lead the scaling of EnduroSat's commercial operations and accelerate global growth.

Tripp brings more than 15 years of commercial space, defense, and national leadership experience. Most recently, he led global growth initiatives at Bluestaq, scaling the company's presence across international defense and commercial markets. Prior to that, he led capture strategy for Palantir's Space business, supporting enterprise and government programs across the space and national security sectors. He has also held leadership roles at AMERGINT Technologies (now CACI) and TMC Design. A former U.S. Army Special Forces Green Beret, Tripp brings a disciplined, mission-driven approach to building teams and scaling organizations.

"EnduroSat has established itself as one of the most innovative and fastest-growing companies in the space sector," said Tripp. "The company's ability to combine engineering excellence with a highly scalable business model really impressed me. EnduroSat is not just building satellites—we're building the infrastructure that will power the next generation of space missions. The combination of fixed pricing, end-to-end service, and serial production helps customers move faster, reduce risk, and accelerate mission success."

ICEYE appoints Christos Kolimenakis as Chief Executive Officer of ICEYE UAE

ICEYE, the world leader in sovereign intelligence from space, announced the appointment of Christos Kolimenakis as Chief Executive Officer of ICEYE UAE. The appointment reflects ICEYE's long-term commitment to the UAE and reinforces the growing strategic partnership between the European Union and the UAE in space, defence and advanced technologies. By establishing dedicated local leadership, ICEYE is expanding its long-standing presence in the country to deepen collaboration with government, industry and national champions, while supporting the UAE's ambition to become a leading global space hub.

Kolimenakis joins ICEYE after a 15-year career at JPMorgan, most recently serving as a Managing Director in the firm's UAE office. During his tenure, he led JPMorgan's

Innovation Economy coverage across EMEA, building long-standing relationships across the technology ecosystem and advising many of the region's most innovative companies throughout their growth journeys. Having spent a significant part of his career in the Middle East, particularly in the UAE, he brings extensive leadership experience and a strong understanding of the region's rapidly evolving technology and innovation landscape.

As UAE CEO, Kolimenakis will lead ICEYE's operations in the country, strengthen strategic partnerships and support the company's long-term growth in the UAE. He will also work closely with customers and stakeholders to help develop sovereign space capabilities and contribute to the long-term growth of the UAE's space ecosystem.

Bernard Beya appointed as CEO of Liquid Intelligent Technologies DRC

Liquid Intelligent Technologies, a business of Cassava Technologies, a global technology leader, announce the appointment of Bernard Beya as Chief Executive Officer of its operations in the Democratic Republic of Congo (DRC), effective 1 April 2026.

"The DRC represents one of the most exciting growth opportunities in our region, and Bernard's appointment comes at an important moment in our journey. His deep understanding of the local market, combined with his commitment to customer success and operational excellence, will help accelerate our ambitions to expand digital infrastructure and enable greater economic growth across the country," said Sutha Siva, EVP: Group Chief Operating Officer at Cassava Technologies.

Bernard brings over 20 years of leadership experience in telecommunications, including deep expertise in the DRC market. He joined Liquid in September 2022 as Chief Financial Officer and was appointed Acting CEO in November 2025, overseeing the organisation's strategic, operational and commercial direction. His proven track record of delivering results and building stakeholder trust highlights his capability to lead Liquid DRC effectively.

"I am honoured to lead Liquid DRC's next phase of growth. Our priority is to build on the strong operational and financial foundation we have established to deliver greater value for our customers and partners. As a business of Cassava Technologies, we can expand access to reliable connectivity, cloud, cyber security, colocation and compute AI for our customers. We can play a meaningful role in

accelerating digital transformation for the country's enterprises, government, and communities," said Bernard.

Mavenir Appoints Jitin Bhandari as Executive Vice President, NeoCloud Platform and Forward Deployment Engineering

Mavenir announced the appointment of Jitin Bhandari as Executive Vice President, NeoCloud Platform and Forward Deployment Engineering. In this role, Bhandari will lead Mavenir's expansion into the rapidly growing NeoCloud market while building a Forward Deployment Engineering practice that will work across Mavenir's communications service provider and NeoCloud customer base.

Building on its recently announced AI-Integrated Platform and AI Service Assurance framework for communications service providers, Mavenir is extending its AI platform, tools and cloud-native expertise to NeoCloud providers. This represents a significant new market opportunity that is additive to Mavenir's established global base of mobile network operators, communications service providers and hyperscalers.

Bhandari brings nearly three decades of experience in telecommunications, software-native technologies, product innovation and business leadership. He joins Mavenir from Nokia, where he most recently served as Chief Technology Officer for Cloud and Network Services, with responsibility for technology strategy and innovation across cloud-native and AI-powered networking solutions.

During his tenure at Nokia, Bhandari held several executive leadership positions, including Chief Product Officer for Core Network Applications and Vice President and General Manager of Digital Networks, where he led large-scale software portfolios and next-generation communications platforms. Earlier in his career, he held leadership roles at Oracle, Acme Packet and Alcatel-Lucent, helping drive the industry's transition to cloud-native architectures, network virtualization, software-defined networking and real-time communications services.

Cognitive Space Appoints Dan Hunter as Chief Growth Officer

Cognitive Space announce the appointment of Dan Hunter, a space & intelligence industry veteran executive, as its first Chief Growth Officer to lead market growth and mission success for the US Government and Allies, and the commercial space markets.

Dan Hunter served as Senior Director of Strategy for Peraton's National Security Space Sector, Chief Technologist for Jacobs Engineering (now Amentum's) National Security Sector as well as held prior roles with SAIC, Cisco and General Dynamics covering the most sensitive Title 10 and

Title 50 missions. Based in Northern Virginia, Hunter brings essential skills and knowledge to the Cognitive Space team and represents its investment in an enduring presence in the critical National Capital Region.

"After an extensive search campaign, I am beyond thrilled to have Dan join us to help not only accelerate but shape the future of space orchestration as we transition into the next phase of growth for the company, deploying our systems for critical national security infrastructure. Dan is a seasoned and well-respected professional in the industry and brings a great depth of knowledge and expertise, with an intimate understanding of the challenges and customer missions we are addressing" said Guy de Carufel, Founder and CEO of Cognitive Space.

"With the massive expansion of commercial space, increasing complexity of proliferated architectures for Government missions and demand for automation and adoption of commercial technology, Cognitive Space sits at that nexus and I'm very excited to be asked by Guy and the leadership team to join the company" said Hunter.

Elizabeth Seward Becomes SuperSharp CEO

Elizabeth Seward has taken over as full-time CEO of thermal imaging pioneer SuperSharp, having worked as Deputy CEO alongside co-founder Marco Gomez-Jenkins since joining the business in November 2025.

With the company focussed on delivering novel datasets for customers, she will now lead SuperSharp as it grows its team, productionises manufacturing and bring its next-generation instruments to market. Elizabeth has over 20 years of experience in the Space and Defence domains, starting out as thermal engineer before transitioning through future programme design to business development and strategy. She held senior positions at Airbus Defence and Space and BAE Systems, where, as Head of Space Strategy, Elizabeth led the strategic planning and business development activities including for the campaign for the multi-sensor Azalea programme.

In addition to her corporate roles, Elizabeth is also active in the space / technology start-up community as an angel investor and, previously, a board advisor to Seraphim VC. Under Marco's leadership, SuperSharp successfully grew from three co-founders to a team of 40 employees, achieving substantial revenue growth and securing contracts with partners including the UK Space Agency (UKSA), the European Space Agency (ESA) and the UK Ministry of Defence (MOD).

Notable achievements during this period include winning the Technology Pioneer Award at the Deloitte Gravity Challenge (2021) and ESA Business Incubator's 'Pitch to Fly' Competition (2023). SuperSharp joined the Satlantis Group in 2023.

Stoke Space Names Kevin Weil to Board of Directors

Stoke Space announced that technology executive Kevin Weil has joined its board of directors. Weil brings deep product leadership experience as the company continues developing Nova, its fully reusable, medium-lift launch vehicle.

Weil has spent more than two decades building category-defining technology companies and products. He has held senior leadership roles at OpenAI, Planet Labs, Facebook, Instagram, and Twitter, helping shape product strategy and development for platforms used by billions of people worldwide. He was part of the management teams that took Twitter and Planet public and helped scale products including Instagram and ChatGPT into global platforms. Most recently, he served as vice president of science at OpenAI, where he focused on applying artificial intelligence to accelerate scientific discovery.

"Kevin has built and scaled some of the world's most important technology companies through periods of extraordinary innovation and growth," said Andy Lapsa, co-founder and CEO of Stoke Space. "He understands how to transform breakthrough technologies into enduring businesses, build organizations that scale, and guide companies through pivotal moments of growth. As Stoke moves toward commercial operations, his experience will be invaluable as we advance our vision for fully and rapidly reusable space transportation."

"The next era of space transportation will be defined not only by technical breakthroughs, but also by the ability to make access to space dramatically more reliable, affordable, and routine," said Weil. "Stoke has assembled one of the strongest engineering teams in aerospace and is pursuing a bold vision for full reusability. I'm excited to join the board and help the company scale its technology, operations, and business."

Weil earned a bachelor's degree in physics and mathematics from Harvard University, graduating summa cum laude, and a master's degree in physics from Stanford University. He also serves on the boards of Cisco and The Nature Conservancy and is a term member of the Council on Foreign Relations.

Axiom Space Appoints Chief of International Operations for New Switzerland Entity

Axiom Space, a leader in human spaceflight services and developer of era-defining space infrastructure, appoints Dr. Renato Krpoun as Chief of International Operations – Europe, Middle East and Africa (EMEA), to lead the new Axiom Space, Switzerland subsidiary, based in Lucerne, Switzerland.

Dr. Krpoun brings more than 15 years of



experience as a space policy and business leader. Previously, he served as chair of the European Space Agency (ESA) Council at delegate level and spent the past decade as Head of the Swiss Space Office (SSO) at Switzerland's State Secretariat for Education, Research, and Innovation (SERI). At SERI, he directed the federal government's national and international space policy, strategy, and law including Switzerland's investments into space research and development.

"We're excited to have Renato's proven expertise, providing on-the-ground leadership as we expand our broader vision for the EMEA regions to advance the global space ecosystem," said Dr. Jonathan Cirtain, CEO and President of Axiom Space. "Since the establishment of Axiom Space, Switzerland, and now with Renato joining the team, we're doubling our efforts to carry international partnerships forward, enabling research opportunities and direct access to low-Earth orbit (LEO) for institutions, agencies, and governments across multiple regions."

He will lead operational execution in international markets for the EMEA regions, develop strategies for market engagement, regulatory compliance, and manage government/institutional relations in the target regions. He will also serve as a senior liaison between Axiom Space and governments, agencies including ESA, industry partners, and customers.

Axiom Space Builds Out

Executive Team for Commercial Space Station

Axiom Space, a leader in commercial human space exploration, appoints Zach Gitomer as Chief Financial Officer and Erick Wegerer as Chief Information Officer.

"We are pleased to welcome these exceptional leaders to the Axiom Space team," said Dr. Jonathan Cirtain, CEO and President of Axiom Space. "Their strong record of helping complex organizations advance their strategic priorities will strengthen our executive team to further advance our core business objectives."

Gitomer brings more than 15 years of global experience across corporate finance, capital markets, mergers and acquisitions, and strategic advisory. Throughout his career, Gitomer has advised on approximately 100 strategic and financing transactions representing nearly \$100 billion in aggregate transaction value.

Prior to Axiom Space, Gitomer advised innovative growth companies across private and public markets, helping management teams and boards of directors navigate critical strategic, financial, and capital allocation decisions throughout their lifecycle. He served in senior investment banking and capital markets roles at Bank of America, Merrill

Lynch, and Citi, supporting many of the world's leading technology and growth companies.

Gitomer holds a bachelor of science in Finance and Accounting from the New York University Stern School of Business. Wegerer brings deep expertise in leading technology strategy and building collaborative and high-performing teams. Previously, Wegerer served as chief information officer at Insitu, a Boeing company, where he worked on cloud infrastructure, enterprise resource planning, and cybersecurity initiatives while leading a large IT and Security team. He also served in leadership roles at GBW Railcar Services and Sage.

Vast Names Former CEO of Slingshot Aerospace and U.S. Air Force Veteran Melanie Stricklan to Lead New Special Programs Division

Vast, the company building next-generation space infrastructure, announced the appointment of Melanie Stricklan, co-founder and former CEO of Slingshot Aerospace and a 21-year U.S. Air Force veteran, as Senior Vice President of Special Programs. The new division will deliver space-based capabilities for the U.S. national security

enterprise, including the defense and intelligence communities.

"Melanie brings to Vast more than two decades of experience at the intersection of advanced technology, national security, and commercial space," said Max Haot, CEO of Vast. "She is joining Vast at a pivotal moment as we develop in-house, high-performance technologies with direct applications for the U.S. defense and intelligence communities."

Stricklan co-founded and led Slingshot Aerospace, a global leader in space intelligence and autonomy. Prior to Slingshot, she served 21 years in the U.S. Air Force spanning advanced space systems development and testing, acquisitions, operations and national security leadership. Most recently, she led innovation and strategic growth at Space Foundation, where she built Space Workforce for Tomorrow (SWFT) into a national space industry coalition.

"The pace of technological innovation is accelerating, and America's leadership in space will depend on its ability to develop and deploy new capabilities faster than ever before," said Stricklan. "Vast combines proven spaceflight expertise, advanced manufacturing, and a mission-first mindset to support the United States' most critical national security missions in low Earth orbit and beyond."

STARTUP SPOTLIGHT

SuperSharp, a University of Cambridge spinout developing innovative EO telescopes



SuperSharp Space Systems Ltd, a University of Cambridge spinout, has received a £5 million award from the UK Space Agency. The funds will enable an in-orbit demonstration of SuperSharp's unfolding thermal infrared space telescope for climate change mitigation applications. In addition, the company has delivered the first prototype of its ultra-high resolution telescope, Hibiscus, which is scheduled to begin space operations in Q4 2026.

The development of this prototype was support by the Centre for Earth Observation Instrumentation and the UK Space Agency. Taken together, these milestones confirm the young start-up's place as a leader in the

developing field of climate-change mitigation using space imagery. SuperSharp develops innovative space telescopes that capture ultra high-resolution images of earth's surface and that transform the economics of earth-observation imagery. With small satellites that unfold in space into large telescopes, these devices achieve up to 10x better resolution per unit cost than the current standard.

With the ability to resolve single buildings and the wide field of view to capture entire cities in a single pass, SuperSharp's mission is to enable climate change-mitigation applications, moving them from

the drawing board to in-orbit deployment. Specific applications include detecting heat stress in agriculture and monitoring urban heat loss at the individual building level. The £5 million award comes from the UK Space Agency's National Space Innovation Programme, designed to invest in high-potential technologies, drive innovation and unlock growth across the UK. SuperSharp joins seven leading innovators from the UK's space industry, receiving £24 million in total.

Speaking when the funding was first announced, Dr Paul Bate, CEO of the UK

Space Agency, said: "These new projects will help kickstart growth, create more high-quality jobs, protect our planet and preserve the space environment for future generations. They go to the heart of what we want to achieve as a national space agency that supports cutting-edge innovation, spreads opportunity across the UK and delivers the benefits of space back to citizens on earth."

Using thermal infrared imagery for sustainability applications has been spoken of for many years but has failed to make the leap into real-world deployment. The promise remains rich, including

urban energy monitoring, identifying where roof insulation is missing, and early detection of heat stress in crops, to direct efficient resource use and boost yields, but a 'Goldilocks Problem' has proved difficult to overcome: Existing space imaging technology cannot provide detailed thermal images at the frequency that's required. Some large, expensive satellites in low-earth orbit can capture high-resolution images infrequently, while small, low-cost satellites capture frequent but low-resolution images. While space-derived data has been used to assess the thermal efficiency of large buildings, this has not translated to smaller buildings.

SuperSharp's approach is different, with smaller payloads that unfold in space to become large telescopes. As a result, SuperSharp can match the current state-of-the-art for imaging resolution, while at the same time maximising the field of view: scanning an area that can cover entire urban conurbations or large-scale agriculture. The result is much greater resolution per unit cost, enabling these new climate change mitigation applications.

The UK space industry is in a period of rapid growth, fuelled by government initiatives, private investment, and a thriving ecosystem of innovative startups. As the sector expands, new ventures are not only pushing the boundaries of space technology but also creating exciting career opportunities across a range of disciplines. From satellite design to space sustainability, UK startups are leading the way in developing the space economy of the future.

Last month SuperSharp announced it had selected Kongsberg NanoAvionics' MP42 microsatellite platform as its launch platform, in anticipation of launching in late 2026, onboard SpaceX's Transporter rideshare service.

Marco Gomez-Jenkins, CEO of SuperSharp, said: "These are two critical milestones in SuperSharp's history, and in the coming age of space observation for climate change mitigation. We're proud of the vote of confidence that the UK Space Agency funding represents, and the delivery of the first prototype of our Hibiscus telescope. Our objective has always been to rewrite the economics of space imaging, through innovative technology and a user-centered approach, and we're on our way."

SuperSharp has reached a major development milestone with its cutting-edge compact thermal imaging solution, Casper, now fully operational and already delivering its first test images. The announcement marks a critical step forward as the technology moves closer to its planned launch into orbit in 2027.

Designed for CubeSat, microsat and small satellite platforms, Casper integrates seamlessly into both solo and multi-payload configurations. It features an advanced extreme telephoto telescope design, enabling high-resolution thermal imaging capabilities that make it particularly well-

suited for Earth observation applications such as wildfire detection and monitoring of the urban heat island effect. The Casper camera will be integrated into one of Satlantis' missions. This upcoming mission will be a multi-modal data collection effort, capturing imagery across visible and thermal infrared bands. This flight will provide critical in-orbit validation of the system's performance and will officially establish Casper's flight heritage, an important milestone in the satellite imaging industry. This mission serves a range of applications and has been developed primarily for Earth Observation. A secondary goal is to build on the capabilities of legacy missions. The Casper instrument will be primarily utilised for point-and-stare earth observation operations.

With global interest growing in responsive Earth observation technologies, Casper positions SuperSharp as a key player in delivering compact, high-performance imaging solutions for environmental monitoring, disaster response, and climate research.

The company will continue system testing and environmental qualification over the next year to prepare for Casper's integration into a suite of optical instruments which will subsequently be mounted onto Satlantis' satellite platform, built and manufactured by Kongsberg Nano Avionics.

SuperSharp is a SATLANTIS company

In May 2023 the two companies announced that SATLANTIS had acquired a controlling interest in SuperSharp. The agreement ensured that SuperSharp has the financial and industrial resources required to reach the first in-orbit demonstration. This deal created a global leader in high-resolution electro-optical payloads for small satellites, with a presence in Spain, France, the United States through SATLANTIS LLC, and now the United Kingdom.

SATLANTIS is a leading Space technology company delivering cutting-edge solutions for Earth Observation and Universe Exploration. At the core of its innovation is the Integrated Standard Imager for Microsatellites, a high and very high-resolution optical payload designed for Small Satellites.

SuperSharp develops unfolding space telescopes to capture high-resolution thermal infrared images of the Earth. The company's unique technology allows it to fit a large telescope in a small satellite, making low-cost, high-resolution, and frequent Earth-imaging possible. This makes powerful thermal infrared space telescopes much more affordable while achieving 4x greater resolution per unit cost than the current state-of-the-art solutions. The images captured by SuperSharp's space telescopes can be used for applications such as tackling climate change, crop monitoring, and maintaining global security.

SATLANTIS' Earth Observation (EO)

technology provides simultaneous coverage across different spectral ranges, as well as thermal infrared capabilities with SuperSharp, video, and polarimetry. This advanced data blend ensures exceptional terrestrial precision and ultra-high resolution, with features like simultaneous visible and infrared and short wave and infrared spectral capture and the ability to continuously acquire imagery of non-linear ground structures.

SATLANTIS delivers full satellite solutions that address critical challenges across multiple sectors, including environmental monitoring particularly methane emissions detection, security coastal, maritime, and border surveillance, and energy infrastructure monitoring of plants and pipelines. With a 100% success rate across seven Space missions and more launches in the pipeline, SATLANTIS continues to grow, expanding its impact in the Space technology sector.

Headquartered in Spain at the University Science Park of Leioa-Bilbao, SATLANTIS also operates in the USA at the Gainesville, Florida Innovation Hub, in France at Bidart, focusing on image processing and with the UK company SuperSharp located in Cambridge, specialized in thermal infrared payloads.

SuperSharp has successfully completed their Innovate UK grant project. This project marks an incredible milestone for the team, as they continue to push the boundaries of innovation. This telescope is named after one of the Cambridge pubs, The Punter.

The technology in use is unfolding, self-aligning, light-weight telescopes. The optics must be positioned with respect to each other with an accuracy of a fraction of a wavelength and kept there at all times.

These unfolding telescopes can be launched as very small and light payloads and become large powerful telescopes once in orbit. The bigger the telescope is, the better the definition it can deliver. Their unique deployable optics technology dramatically reduces the launch size for any space optical system hence drastically improving capability for a given cost. Furthermore, to achieve high revisit rates many satellites are needed. As such with a considerable cost reduction per satellite, SuperSharp's technology also enables extremely high refresh rates with large satellite constellations.

Other research groups are working on unfolding mechanisms and using the telescope images to determine what corrections need to be made to tune the system to give perfect images. During the past few months, the company has focused on completing the Environmental campaign utilising their own in-house testing facility. They have successfully tested the deployment and retraction sequence for the unfolding mirrors.

This accomplishment wouldn't have been possible without the dedication, expertise, and hard work of the SuperSharp team. However, the project would have also not reached completion without the immense support given by Innovate UK and the UK Space Agency.

SuperSharp is keen to keep developing their telescopes and to constantly evolve and include

the latest technological advancements in their hardware.

SuperSharp has ignition

SuperSharp Space Systems Ltd., has secured more than £2 million in projects to develop innovative space telescopes, to capture ultra-high resolution images of earth's surface. With the ability to resolve individual buildings and the wide field of view to capture entire cities in a single pass, SuperSharp's thermal infrared satellite payloads rewrite the economics of earth-observation imagery, and can unlock several climate change-mitigating applications, moving them from speculative to real-world deployment. These include detecting heat stress in agriculture and monitoring urban heat loss at the individual building level.

These projects secured by SuperSharp include development programmes with the UK Space Agency, the European Space Agency, Innovate UK, and other influential players in the space industry. Together they represent a massive vote of confidence in the young start-up's earth-imaging technology, marking SuperSharp's arrival as a significant industry mover, and once more proving the UK's leadership in the space industries.

The company's unique technology allows it to fit a large telescope in a small satellite, making low-cost, high-resolution, frequent imaging possible. With 4x greater resolution per unit cost than the current state-of-the-art imaging, SuperSharp opens new possibilities for earth imagery. Working from its base in Cambridge, UK, the company has already begun developing these space telescopes ahead of in-orbit launches, beginning in 2026.

There has long been an ambition to use TIR imagery in sustainability applications. This includes in urban energy monitoring, identifying where roof insulation is missing, and early detection of heat stress in crops, to direct efficient resource use and boost yields. The problem has been that today's space imaging technology cannot provide detailed thermal images at the frequency that's required. Some large, expensive satellites in low-earth orbit can capture high-resolution images infrequently, while small, low-cost satellites capture frequent but low-resolution images. While space-derived data has been used to assess the thermal efficiency of large buildings, this has not translated to smaller buildings. A new approach is needed.

By designing smaller payloads that unfold to become large telescopes, SuperSharp can match the current state-of-the-art for imaging resolution, while at the same time maximising the field of view: scanning an area that can cover whole cities. The result is much greater resolution per unit cost, which in turn enables new climate-change mitigation applications.

Existing buildings are thought to represent at least one quarter of global energy-related carbon emissions. High energy efficiency in new homes and retrofitted to existing homes provides an opportunity to make progress towards climate targets.



STARTUP SPOTLIGHT

With a detailed understanding of thermal performance at the level of individual homes, monitoring heat loss could become the 'killer app' for thermal satellite imagery. Data could be integrated into building management systems, local authorities could use this data to understand which properties require proper insulation, individual property owners could use it to reduce their electricity consumption, and at a macro level, governments could use the data both to assess the impact of their own initiatives while verifying the CO2 emission data presented by other countries.

Focus on 'InCubed-2'

SuperSharp recently won an 18-month project within ESA's 'InCubed-2' programme, which was funded by the UK Space Agency and benefits from ESA's in-house technical expertise. This project will see SuperSharp develop a large aperture, TIR imaging payload with extreme-telephoto, wide-field optics, and a multi-sensor array. By matching the current state-of-the-art in thermal image resolution, and combining that with a much larger field of view, the telescope captures what amounts to a panoramic view, enabling detailed thermal imaging covering entire cities.

Marco Gomez-Jenkins, CEO of SuperSharp, said: "The last 12 months have been transformative for SuperSharp. The innovative solutions that we're developing will enable ultra-high resolution thermal mapping from space to tackle some of the world's most pressing challenges, from decarbonisation of cities to global security. Having secured several new projects with world-leading space agencies and others we're now hard at work developing multiple space telescopes, as we move towards an in-orbit demonstration beginning in 2026."

Harshbir Sangha, Missions and Capabilities Delivery Director at the UK Space Agency, said: "SuperSharp's thermal imaging technology could help provide a clearer picture of heat patterns in cities, informing important decisions about the steps needed to reduce our impact on environmental temperatures. This work is a brilliant example of how investment in space technology can help us improve life on earth and mitigate climate challenges."

"SuperSharp is the best company to enlarge the camera spectrum and embark hard infrared eyes into our missions. Furthermore, the UK and other international markets will benefit from these unique capacities" said SATLANTIS co-founder and Chief Executive Officer Juan Tomas Hernani. Professor Ian Parry, co-founder and Chief Scientific Officer of SuperSharp, commented: "SATLANTIS are a highly successful company and our exciting new alliance will create a strong optical team and let us deploy our unfolding space telescope in orbit very soon."

Jean-Jacques Dordain, Chairman of the Satlantis group, added: "We have found the right partner in the UK with SuperSharp. We share our respective innovative technologies and a common culture of competitive solutions to better respond to more customers."

UK University spin out companies

The UK university sector is a world-leader with four of its institutions ranked in the world's top ten universities. UK universities are also globally competitive on research commercialisation with Cambridge, Oxford, and Imperial College the second, third and fourth respectively in the world in terms of the number of deals in their spin-outs. There has been a five-fold increase in UK university spin-out investment from £960. There is, however, room for improvement, including the number of deals reached and value of investments raised to close the gap with the US.

Based on a recent report, University spin-outs are critical to the UK innovation ecosystem and have an important role to play in delivering the government's ambitions for the UK to become a science superpower capable of nurturing the world's next Silicon Valley.

In particular, the University of Cambridge is a global leader in research and translating that research to create economic and social impact. The University has focussed on technology transfer and ecosystem development over many decades. It was Trinity College, Cambridge that developed the UK's first Science Park in 1970. This decision was critical in Cambridge becoming a leading global innovation ecosystem with over 5,000 research intensive companies active in the ecosystem.

The University of Cambridge has a pro-entrepreneurship culture focused on maximising impact, not commercial returns. Our IP policy is structured to encourage innovation across our research community and provides flexibility to inventors. The University of Cambridge is recognised for having a low equity model for spinouts. In addition, the majority of returns from commercialisation income are distributed back to inventors, Departments and Schools. This creates a positive feedback loop. A recent economic impact study, by London Economics, found that the University of Cambridge attributes annually £23.1bn of the £29.8bn economic impact to the University's research and knowledge exchange activities including commercial companies spun out from, or closely associated with, the University.

Cambridge Enterprise, which leads the University's innovation activities, was established in 2006. It provides a range of supports to the University from patenting, proof of concept investment, licensing, venture investment, consultancy, accelerators, co-working space and ecosystem development.

Cambridge Enterprise is proactive in developing spinouts from venture building to company acceleration, through to providing investment capital and providing space for them to grow. We have created over 150 spinouts that have raised >£3bn in venture funding over the last decade.

Across UK, Universities are increasingly offering PhD students access to training to develop commercial skills. This is an important step in establishing an entrepreneurial mindset and the necessary commercial skills in the future generation of academic researchers. Developing such a pipeline is something we encourage more of, but not at the cost of the PhD student developing, first and foremost, skills in their

subject matter and completing their studies, according to UK report.

The UK government has set an ambitious target to capture 10% of the global space market by 2030. Backed by significant investments in infrastructure, research, and innovation, this goal is driving the creation of new spaceports, funding for startups, and international partnerships.

With key initiatives like the UK Space Agency's Space Growth Partnership and the establishment of spaceports in Cornwall and Scotland, the UK is positioning itself as a leader in the global space race. This surge in activity has encouraged the rise of innovative startups tackling challenges in satellite technology, space exploration, and sustainability.

Today, investment into university spin-outs has increased from £1.11 billion in the academic year 2015/16, to £5.29 billion in 2022. This reflects a maturing UK equity investment ecosystem and funding environment which has developed over the past decade, with support from government institutions such as the British Business Bank. The latest data suggests that spin-out investment fell during 2022 and the first half of 2023. However, the share of investment received by spin-outs remained in line with 2021 at 11.5% and has increased slightly in 2023 12.5%. The fall in investment is also in line with the wider market slowdown since the middle of 2022, which has continued into 2023.

Increasingly, UK universities are beginning to establish affiliated university investment funds to invest in spin-outs. These are private investment funds, separate from any internal seed funds the university may operate. However, the university usually has a role in establishing them, has seats on the board and may have an agreement with them providing favourable access to spin-outs to help de-risk the investor proposition.

Disrupting Thermal InfraRed imaging satellite

UK based SuperSharp, part of the Satlantis group, has selected Kongsberg NanoAvionics's MP42 microsatellite platform for a first-of-its-kind Thermal InfraRed mission called Blue Moon. The mission will embark SuperSharp's flagship instrument HIBISCUS, an 80kg payload, onboard NanoAvionics' flight-proven MP42 satellite bus. The launch is scheduled for the second half of 2026 onboard a SpaceX's Transporter rideshare service.

The capabilities of Blue Moon will extend beyond that of conventional Earth observation (EO) satellites since the instrument is designed to acquire images day and night.

The disruption of SuperSharps' innovation, however, lies in its proprietary unfolding payload technology, capable of delivering 4x higher resolution per unit cost.

HIBISCUS can capture Long-Wave InfraRed imagery at a spatial resolution of three metres. The data generated by this category-defining satellite will support applications in the field of climate resilience, such as urban heat monitoring, as well as those in the domain of

national security. It aims also to enable new applications in these fields.

In parallel to this agreement, NanoAvionics will also supply an additional two MP42 microsatellite platforms to Satlantis for its new generation of sub-meter resolution Earth Observation satellites. Powered by a team of more than 30 engineers SuperSharp is a University of Cambridge spinout founded in 2017 and part of the Satlantis group since 2023. The company specialises in the design and manufacture of very high-resolution Thermal InfraRed (TIR) imaging satellites. The company's first satellite mission will be carried out in partnership with small satellite manufacturer NanoAvionics, subsidiary of the Kongsberg group.

Marco Gomez-Jenkins, co-founder and CEO of SuperSharp, said: "We are delighted to partner with NanoAvionics on this mission to unlock the value of ultra-high resolution thermal imaging from space. The combination of our HIBISCUS telescope and their MP42 satellite platform will enable new applications in this domain, from climate change mitigation to security and defence. "This mission would not be possible without the ongoing support of institutional actors, in particular the UK Space Agency."

Atle Wølle, CEO of Kongsberg NanoAvionics, said: "Satlantis has been one of our earliest commercial Earth observation customers, and we're excited to build on the legacy of the first three nanosatellites we launched with them. These three new missions highlight how NanoAvionics evolves alongside our customers and their growing needs. By helping SuperSharp and Satlantis deliver industry-leading 3-meter thermal imaging and submeter visible to near-infrared capabilities, we're setting a new benchmark for our standard MP42 microsatellite platform, supporting larger, more advanced payloads than ever before."

Juan Tomas Hernani, co-founder and CEO of Satlantis, said: "The race to space is more and more about partnerships. The breakthrough offered by SuperSharp with its 3 m resolution in TIR in a joint mission with NanoAvionics makes us very proud to lead the global strategy for this. It also gives us an opportunity to fuse TIR as an extended channel into our next missions".

EO pitch award

SuperSharp has been honoured with the Pitch Presentation Award for Earth Observation at Paris Space Week, a recognition that highlights both the innovation behind its advanced imaging technology and the strength of its mission. The award reflects the jury's confidence in SuperSharp's potential to significantly enhance real-time Earth observation, an increasingly vital capability for environmental monitoring, security, and global connectivity.

This milestone took place during Paris Space Week, one of the world's leading gatherings for the global space industry. Hosted at the Espace Champerret in Paris, the event brings together agencies, manufacturers, startups, research institutions, and investors from across the international space ecosystem. Known for fostering high-value partnerships and showcasing breakthrough technologies, it has become a



premier venue for innovation and collaboration.

SuperSharp participated in the event's Innovation Challenge, where cutting-edge companies present their solutions to a jury of industry leaders and decision-makers. Elizabeth Seward delivered a compelling pitch focused on the company's advanced Earth observation capabilities: technology designed to transform how satellite-based imaging is captured, processed, and applied across sectors.

The recognition reinforces the company's growing presence in the European and global space landscape. As satellites and ground-segment technologies evolve rapidly, the company's work aligns closely with the strategic priorities highlighted throughout the event, particularly the need for more efficient, sustainable, and high-resolution observation tools.

Beyond the competition, SuperSharp engaged in productive meetings through the event's structured B2B matchmaking platform, connecting with potential partners, clients, and

collaborators from across the EU, UK, and beyond. These interactions strengthened the company's commitment to building strong relationships within the space community and accelerating the deployment of its technology. SuperSharp's success at Paris Space Week marks an exciting step forward as it continues to push the boundaries of satellite imaging and contribute to the future of Earth observation.

Leadership transition

In the space industry, creating a successful spin-out requires a confluence of technical and commercial skills, as well as other legal, negotiation, and problem-solving skills, especially in a spin-out's early phases. For instance, academic founders tend to be experts on subject matter and technical aspects with little or no formal commercial training, meaning that they often do not have the necessary non-technical skills to create a spin-out on their own, and sometimes may not have the skills or the desire to be a CEO.

Recently, the spin-off announced that Elizabeth Seward has taken over as full-time CEO of

thermal imaging pioneer SuperSharp, having worked as Deputy CEO alongside co-founder Marco Gomez-Jenkins since joining the business in November 2025.

With the company focused on delivering novel datasets for customers, she will now lead SuperSharp as it grows its team, productionises manufacturing and bring its next-generation instruments to market.

Elizabeth has over 20 years of experience in the Space and Defence domains, starting out as thermal engineer before transitioning through future programme design to business development and strategy. She held senior positions at Airbus Defence and Space and BAE Systems, where, as Head of Space Strategy, Elizabeth led the strategic planning and business development activities including for the campaign for the multi-sensor Azalea programme.

In addition to her corporate roles, Elizabeth is also active in the space and technology start-up community as an angel investor and,

previously, a board advisor to Seraphim VC. Under Marco's leadership, SuperSharp successfully grew from three co-founders to a team of 40 employees, achieving substantial revenue growth and securing contracts with partners including the UK Space Agency (UKSA), the European Space Agency ESA and the UK Ministry of Defence.

Notable achievements during this period include winning the Technology Pioneer Award at the Deloitte Gravity Challenge 2021 and ESA Business Incubator's 'Pitch to Fly' Competition 2023.

SuperSharp joined the Satlantis Group in 2023. The company has three class-leading thermal imaging instruments in the final stages of development, each tailored to the technical and budgetary requirements of customers in defence, industry and the civil sector. Flight models of the small form-factor camera CASPER, and SuperSharp's flagship unfolding telescope, Hibiscus, are now in production, while a mid-range camera, SPIRIT, will be launched on a high-altitude balloon next year.

Can AfSA expands national space legislation across Africa?

By Tinetairo Blessing Mushoriwa

Africa's journey into outer space, once characterized by a passive but critical role, has evolved into a dynamic engagement across a wide spectrum of space activities. This transformation is driven by a profound recognition that developing space capabilities are vital instruments for addressing the continent's most pressing developmental challenges, from enhancing agricultural productivity to bridging the digital divide. As more African nations establish space agencies and pursue national programs, a critical need has emerged for a coordinated and unified approach to the complex legal and regulatory issues inherent in this domain. The African Space Agency (AfSA), formally inaugurated by the African Union Commission in 2025 with its headquarters in Egypt, is positioned to play a pivotal role in meeting this need, serving as a central catalyst for legal harmonization.

The Current African Space Governance

The current African space ecosystem reveals three distinct governance models. The first model includes agencies like Kenya Space Agency which fall under the Ministry of Defense, arguably prioritizing security, which creates legal friction when attempting to promote commercial growth that demands transparent licensing and data access.

Meanwhile agencies such as the South African National Space Agency and the Nigerian National Space Research and Development Agency are anchored in ministries dedicated to science and technology, prioritizing research & development and capacity building. This model often separates the promotional function from the hard-law regulatory authority such as licensing, and liability management, arguably leading to functional legal fragmentation.

The third governance model brings to light the Egyptian Space Agency which model establishes its agency as a public economic authority affiliated directly with the President. This arguably grants maximum political leverage for major national projects but concentrates accountability heavily within the executive sphere.

The resulting heterogeneity matters profoundly because it challenges the consistent application of international obligations, specifically the state's binding duty under Article VI of the Outer Space Treaty to authorize and continuously supervise all national space activities. The deep variance in institutional culture and legal mandate across the continent's major space actors presents the single greatest structural impediment to realizing the unified, continent-wide regulatory framework envisioned by AfSA. Achieving coordination requires harmonizing not merely policies, but the fundamental

legal and institutional functions of state responsibility.

The Mandate for Continental Coordination

The genesis of Africa's continental approach to space activities can be traced to the adoption of the African Space Policy Framework and African Space Strategy by the African Union in January 2016. This foundational document was a direct response to the vision articulated in Agenda 2063, a strategic framework aimed at realizing an integrated, prosperous, and peaceful Africa. The policy outlines six core principles, including a focus on addressing user needs, fostering the regional market, and coordinating the African space arena. These principles reflect a strategic shift toward a practical, development-oriented approach, viewing space as a crucial enabler for achieving long-term continental goals.

The formal establishment of AfSA in 2025 was the most significant step in translating this policy into action. The agency's primary mandate is to promote and coordinate the implementation of the African Space Policy and Strategy, according to Articles 2 and 4 of the Statute of the African Space Agency, and to conduct activities that harness space technologies for sustainable development. AfSA is envisioned as the central point of contact for Africa's cooperation with international partners and a key facilitator of collaboration among member states, aiming to eliminate duplication of effort and maximize the efficiency of space activities across the continent.

A crucial, though often understated, aspect of AfSA's role is its mandate to foster a harmonized legal and regulatory environment. The agency is explicitly tasked with working directly with national space agencies and other relevant institutions to coordinate a continent-wide regulatory framework for space activities on the continent. This specific mandate, as articulated in the foundational African Space Agency Act, clarifies the scope of AfSA's power. It suggests an objective focused on harmonization i.e. developing best practices and coordinating disparate national systems rather than outright uniform regulation which would imply a compulsory, singular legal standard across all member states. By engaging in this coordination, AfSA ensures consistency in areas like licensing and liability, aiming to eliminate duplication and bureaucratic inefficiencies while respecting the unique national governance structures of its members.

More so, AfSA stands as a bridge to smoothen and create common ground where inconsistencies arise regarding cross-border space activities between jurisdictions with different approaches and views. It is critical to note that whilst, it seems that there are conflicting positions on the mandate of AfSA, whether it is to harmonize or to create uniform regulation; one thing is clear – Articles 4 and 5 of the Statute of the African Space Agency assigns both mandates to AfSA. Noteworthy; the assignment of this dual mandate does not seek to create friction or confusion, rather it aims to create an all canvassing and encompassing regional legislation which nations can naturalize.

By promoting the adoption of common standards and best practices, AfSA seeks to create a more predictable and enabling environment for both public and private sector involvement in the African space sector.

This push for legal harmonization is not merely an administrative goal but a strategic necessity for the sustainable growth of the continent's space industry. A patchwork of disparate national laws could create significant legal uncertainty, hinder cross-border cooperation on complex space projects, and deter both domestic and foreign investment. A harmonized legal environment, however, provides the predictability needed to foster a vibrant indigenous space industry, facilitating collaborative projects and ensuring that African space activities are conducted responsibly and in accordance with international space law.

Translating Policy into Practice: The Role of National Legislation

To fully realize the benefits of their space activities, African states are translating the obligations and principles of international space law into robust domestic legal frameworks. These national space laws are essential for regulating activities, ensuring compliance, and fostering the growth of a competitive space industry.

Case studies from several African countries illustrate this trend. South Africa, with a mature legal framework governed by the Space Affairs Act of 1993 and the South African National Space Agency (SANSA) Act of 2008, offers a model of a well-established regulatory regime. The country is actively reviewing its legislation to incorporate emerging trends, with a focus on sustainability. Similarly, Nigeria's National Space Research and Development Agency (NASRDA) Act of 2010

provides a legal framework that mandates capacity building, satellite technology development, and a licensing authority for space activities. In Kenya, the establishment of the Kenya Space Agency (KSA) in 2017 has been followed by a draft bill, the Kenya Space Bill 2024, which aims to formalize KSA's role and regulate activities such as satellite launches and remote sensing. These national efforts, while crucial, highlight the need for a continental body like AfSA to act as a coordinating force, ensuring that these frameworks are not only effective domestically but also compatible with a broader African strategy.

Enforcement Challenges and the Need for a Unified Front

National entities responsible for space activities operate under two distinct umbrellas namely; the Promotional Role which is focused on executing R&D, operating national space assets, and building industrial capacity; and the regulatory role which is focused more on enforcing compliance. National space agencies are the primary governmental entities responsible for translating international space law and policy into practical implementation within their jurisdictions.

Their functions, however, vary widely in scope. Licensing and continuous supervision serve as the critical mechanisms for the State to control non-governmental activities and ensure adherence to safety standards, environmental regulations, and core international obligations, such as the duty to authorize and continuously supervise activities under Article VI of the Outer Space Treaty.

Some African states adopt a consolidated model, where the national space agency is mandated to both promote and regulate. For instance, the Kenya Space Agency (KSA) is explicitly tasked with promoting, coordinating, and regulating space activities within the country. Conversely, states may adopt a bifurcated model to prevent conflicts of interest between promotion and enforcement.

In South Africa, the South African National Space Agency (SANSA) focuses on science, promotion, and R&D, while the licensing and regulatory duties are placed under a separate statutory body, the South African Council for Space Affairs (SACSA), which advises the Minister of Trade, Industry & Competition under the Space Affairs Act. This distinction whether the agency is primarily an actor, a regulator, or both; profoundly affects the legal clarity of the domestic space regime.

However, many African agencies face significant challenges in effectively enforcing space law and policy.

Limited financial resources, a lack of technical expertise, and the nascent stage of their space sectors can have constrained their enforcement capabilities. This is where AfSA's coordinating role becomes indispensable, as it can facilitate international cooperation and capacity-building initiatives to strengthen the enforcement capabilities of national agencies across the continent.

Navigating contemporary legal and policy frontiers

Beyond the foundational issues of regulation and enforcement, a harmonized African legal and policy framework is essential for navigating the complex contemporary legal issues shaping the global space arena. The foundational treaties of space law, largely formulated during the Cold War, are increasingly strained by the complexities of the modern space era, driven by factors like the massive proliferation of mega-constellations and geopolitical rivalry.

A unified African voice, institutionalized through AfSA, is crucial for addressing these new realities by actively defining global norms for responsible conduct. This coordinated front contributes to a framework for responsible conduct that fosters a secure and stable space environment for all by providing diplomatic and regulatory leverage.

This is achieved by Africa's collective voice demanding that major space actors fulfil their, arguably, customary responsibility in space debris mitigation and pushes for the institutionalization of Long-Term Sustainability (LTS) Guidelines across the continent. This regulatory discipline compels global commercial operators to adhere to high, standardized benchmarks as a condition of market access across the continent.

The continent acts as a cohesive, non-aligned bloc, providing strong support for the Prevention of an Arms Race in Outer Space and the development of Transparency and Confidence-Building Measures. This collective stance aims to protect critical African civilian and dual-use satellite infrastructure from potential conflict spill over driven by external geopolitical blocs.

Africa asserts the core principle that the exploration and use of outer space must be carried out for the benefit and in the interests of all countries. Arguably this unified position ensures that commercial activities, such as Space Resource Utilization, are



governed by principles that guarantee technology transfer and data sovereignty, thereby achieving substantive equality for developing nations.

One such issue is Space Security. The increasing congestion of orbits and the potential for the weaponization of outer space pose significant risks to African space assets. By actively participating in international discussions and shaping norms of responsible behavior, a coordinated African front can contribute to a framework for responsible conduct that fosters a secure and stable space environment for all.

Another critical issue is Space Traffic Management (STM) and Orbital Debris. The proliferation of satellites and space debris has created significant challenges for the long-term sustainability of outer space. The current international legal framework for STM is nascent and relies heavily on voluntary guidelines. AfSA could play a coordinating role in developing common standards and best practices for debris mitigation across the continent, encouraging

member states to incorporate specific provisions into their national laws.

The contentious issue of Space Resource Utilization also demands a unified African response. While Article II of the Outer Space Treaty prohibits national appropriation of celestial bodies, it is silent on the extraction of resources from them. This ambiguity has led to national legislation in some countries that grants property rights to extracted resources, a move that lacks international consensus.

For Africa, this issue presents both opportunities and risks, raising concerns about equitable access and the potential for a "space grab" by more technologically advanced nations. Active participation in international dialogue is crucial for African nations to shape a future legal regime that ensures fair access, promotes benefit-sharing, and prevents the emergence of new forms of inequality in space.

Africa's evolving legal and policy framework represents a direct and necessary response to the complexities of the 21st-century space

environment. The establishment of AfSA and the development of national space legislation provide the foundational structure for a coordinated, effective, and sustainable African presence in space.

By leveraging international partnerships, investing in capacity building, and proactively engaging in global discussions, African nations can not only safeguard their own interests but also play a vital role in shaping a more equitable and peaceful future for all in outer space.

The amplification of African voices in international space law is not merely a matter of fairness and representation; it is essential for ensuring the legitimacy and effectiveness of the global space governance framework as a whole.

AfSA's success in its legal harmonization mandate will be a critical determinant of Africa's ability to harness the full potential of space for its sustainable development and its aspirations for a prosperous and integrated future.



MIDDLE EAST REPORT

Behind the scene of US-Israel strikes and Iranian retaliations



Last year, Israel successfully launch a synchronized opening strike combining fighter jets, traveling some 1,000 miles, and on-the-ground intelligence assets hitting senior military commanders and nuclear scientists all within minutes. Israeli warplanes flying uncontested over the skies of Tehran and then refueling freely above Syria before returning to base. Drones loitering for hours, hunting Iranian missile launchers, eliminating hundreds of them more than half of Iran's arsenal in less than two weeks. All this might have seemed unthinkable just a year prior, the distance too far, Iran's defenses too advanced, the threat of retaliation by its proxies too grave, its nuclear facilities too deeply buried, Israel's arsenal too small for success. Yet, Israel did it, pulling off an operational masterpiece.

Once the jets launched, what unfolded was the most ambitious and effective Israeli air campaign

in the Jewish state's history, the history of any military with unprecedented scale, precision, and tempo against a nation 75 times larger in geographical size. Within minutes of the campaign's opening, Israel had removed multiple senior military leaders, throwing the regime's command and control into disarray and demonstrating the strategic value of airpower and decapitation strikes.

Over twelve days, the Israel Air Force neutralized Iran's integrated air defenses; struck critical military and scientific leadership, and nuclear targets; and preserved freedom of action for follow-on operations all without losing a single manned aircraft. The multiple strikes demonstrate Israel's operational skill, technological edge, and strategic resolve to independently execute a long-range campaign that solidified its position as the dominant military power in the region and advanced not just its own national security but that of the United States as well. The IDF,

meanwhile, said it dropped more than 18,000 bombs in Iran amid the war, in over 1,000 waves of strikes on more than 4,000 targets, including air defense systems, ballistic missile launchers, weapon production sites, nuclear facilities, various headquarters and military commanders and leaders. According to the Israeli military, forces destroyed or disabled around 60% of Iran's estimated 470 ballistic missile launchers. Around 200 of the launchers were destroyed in strikes, while another 80 were not considered to be operational after the IAF struck tunnel entrances to subterranean facilities where they are stored, according to the IDF.

In the background of last year's Iranian rocket attack on the American-manned Ain al-Assad airbase in Iraq, an intricate game took place, the main arena of which turned out to be the space domain. As the circumstances of the case disclosed on an ongoing

basis suggest, both sides referred to the possibilities offered by satellite technologies and orbital infrastructure, in terms of planning the attack and countering it.

The Iranians were to reach, inter alia, commercial satellite imagery supporting the attack on the base in question, while the Americans carefully monitored the interest of the Iranian side in this regard. Above all, however, US forces took advantage of the opportunities offered by their satellite ballistic early warning system,

During the war, the effects of the shelling could be much more serious for the American contingent, if not for the effective early warning system for incoming missiles, the Space Based Infrared System (SBIRS). Based on a constellation of high-precision infrared observing satellites, it is an important resource tool for

the US Space Force. The key components of the missile warning satellites were built by Lockheed Martin using infrared sensors provided by Northrop Grumman.

According to report, the constellation includes four satellites placed in a geosynchronous orbit and two additional payloads operating on external satellites, operating in extended, highly elliptical orbits for global coverage. Geosynchronous satellites have two types of sensors, continuous imaging equipment and a segmented imaging system.

In the case of systems operating on High Elliptical Orbit, the satellites carry only the general view sensor. Sensors of this type detect electromagnetic waves from the infrared band generated during the launch of ballistic missiles, hence American operators are able to potentially perceive every missile launch from anywhere in the world.

Syria's weak defense capabilities

With Syria's air defense capabilities either unmanned or destroyed in the wave of Israeli airstrikes following the removal of the Assad regime, interim authorities can do little but stand by as Israel and Iran use Syrian airspace for their own ends. The country's weak air defense is due in part to Israel's military campaign in Syria immediately after the fall of Assad and the interim authorities' struggle to organize a new army. Starting in December 2024, Israel instigated an unprecedented and unprovoked aerial campaign targeting military equipment and sites across Syria in an effort to demilitarize the country. These attacks all but destroyed the majority of Syria's air defense infrastructure.

As a result, Syria is unable to defend its own airspace, allowing for major powers to use Syria yet again as a battlefield for their own wars and ambitions. On the ground, interim authorities are still in the painstaking process of integrating armed groups and forming a new army. So far, divisions operating under the interim Ministry of Defense exist largely on paper, with a unified, professionalized command-and-control structure still something that exists more in theory than in practice.

Syria is already feeling the effects of the Israel-Iran war. So far, the war has also displaced nearly 1,000 residents of Quneitra, with more than 100 Iranian missiles and drones intercepted and downed in Daraa and Quneitra since the conflict began. Media outlets report that one woman was killed when a downed Iranian drone crashed into her home in the Tartous countryside.

In the immediate aftermath of the regime's collapse, the Israeli army effectively occupied the UNDOF-monitored demilitarized border strip between the occupied Golan and Syrian-controlled Quneitra in violation of Syria's sovereignty. Perpetuating instability in the south, Israel has been conducting regular incursions, raids and aerial attacks in Quneitra and Daraa since then.

Israel's expansion in south Syria, a footnote now amid the unfolding conflict between Israel and Iran, has been rejected by residents. Israeli military attempts at outreach, including the establishment

of an Israeli field hospital and aid distribution, have been rejected by communities in Quneitra, who have faced destruction of their homes and farmlands, casualties, displacement, arbitrary arrests and curfews amid unchecked Israeli military operations. In late March, Israeli forces advancing in Koya, south-west Daraa, were met with resistance from local fighters, in clashes that displaced at least 3,000 civilians. A subsequent Israeli drone strike on the area killed several individuals.

There are already signs that the latest conflict in region is hardening Israel's occupation in the south: in recent days, Israeli forces have destroyed civilian housing, swathes of agricultural land and forests to improve reconnaissance deep into Syrian territory.

The Israeli army told media that it had completed the main part of its aggressive military campaign against Syria since the fall of the Bashar Al-Assad regime, targeting the military capabilities of the Syrian state. The occupation army claimed that it had destroyed between 70 and 80 per cent of these capabilities.

The campaign in Syria is called Operation Bashan Arrow by the occupation regime. This is a reference to a Biblical kingdom which was part of the land of Canaan, and is believed to have been located in southern Syria and eastern Jordan. The word "Bashan" in Hebrew means "flat or paved land".

The area was named after Mount Bashan, known today as Jabal Al-Arab or Jabal Al-Druze in southern Syria. That's where Israeli vehicles infiltrated and occupied the buffer zone demilitarised under the 1974 disengagement agreement with Syria.

According to the Israeli army, over the past few days it has attacked more than 320 targets in Syria with 350 fighter jets flying 359 sorties against "strategic military capabilities". It claims that this aims to "prevent the access to strategic weapons for hostile parties."

Chief of Staff Herzi Halevi approved the operational plans last Saturday during his visit to the occupied Syrian Golan Heights. On the same night, the Israeli Air Force began launching raids targeting various parts of Syria, from Damascus to Tartus. The targets destroyed included dozens of combat aircraft and helicopters, in addition to radar systems, anti-aircraft missile batteries, ships, surface-to-surface missile systems, rockets, naval missiles and weapons production facilities.

The Israeli attacks also targeted weapons and ammunition depots in Syria, Scud missiles, guided cruise missiles, naval ballistic missiles, drone warehouses and other military capabilities of the Syrian state.

The occupation army revealed that the operation on the ground is continuing, as ground forces are in the buffer zones to secure control of the area, destroy weapons

and dismantle Syrian military infrastructure in the area, under the pretext of "ensuring that they do not reach unwanted parties".

Satellite images show Iran rapidly rebuilding sites hit by US and Israeli strikes

Iran has managed to rebuild a significant amount of infrastructure destroyed during its war with the US and Israel in recent months, ranging from bridges to missile bases, according to latest media report. The report, based on a review of satellite imagery, suggested that the speed at which Tehran is restoring its damaged capabilities is the reason why it is continuing to hold its own against the US after hostilities renewed earlier this month over disputes relating to the Strait of Hormuz.

The extent of damage to some of Iran's military and nuclear sites has been revealed for the first time after more than a quarter of a million previously restricted high-resolution satellite images were released. A leading satellite imagery provider, Planet Labs, restored access to images from nearly 800 locations in Iran which they had chosen to restrict following a request from the US government.

The images show a variety of targets hit from ammunition storage areas to ballistic missile infrastructure, nuclear and surface-to-air missile sites, and naval bases, according to military intelligence company Janes. Verified videos have previously shown these locations were subject to US-Israeli strikes but these newly available images provide an insight into the specific targets of the attacks and the extent of the damage.

Images of the province of Esfahan, which is home to two nuclear facilities - in the city of Esfahan and Natanz - reveal the extent of damage to military infrastructure.

At military bases in the region, damage to buildings are clearly visible. Buildings - identified by Janes as an ammunition storage area for an airbase - have been damaged at the strategically important Shekari 8 Iranian airbase.

Military buildings and government facilities including aircraft hangars, ammunition storage, dockyards, piers, and missile launch sites have been visibly damaged, according to Janes, with the affected sites belonging to both the Iranian government and the Islamic Revolutionary Guard Corps (IRGC).

Many buildings have caved-in roofs and some appear completely flattened. Other images show destroyed aircraft and sunken ships. Craters can also be seen on multiple runways, including at Bushehr International Airport - some of which have since been repaired.

In some areas - designated as "military" on online maps like OpenStreetMaps - nearly every single building has been destroyed. The damage seen "correlates with the US

and Israeli reports of a wide-ranging strike campaign, not only designed to engage standing forces, but degrade the infrastructure behind them", Janes Middle East defence specialist Jeremy Binnie said. Construction and repair sheds at a naval dockyard have also been damaged, according to Janes analysis.

More than 60 structures have been severely damaged or destroyed at a military base in the south of the city. Another dozen were hit at another base further south in the region, near the town of Baharestan. The controversial decision to restrict access to images has limited how journalists, humanitarian groups and analysts assess the impact of the US-Israel war with Iran, including damage to military targets and civilian infrastructure.

Restrictions still remain in place for Planet's imagery across most of the Middle East including Iraq, Lebanon, Israel and Gaza. The California-based company said that a "delay remains in place over other parts of the region and we will continue with managed distribution for those areas in accordance with ongoing national security and personnel safety concerns".

Fresh evidence reveals that Iran is hard at work on the deeply buried nuclear site near Natanz called Pickaxe Mountain, openly defying what remains of the fragile U.S.-Iran memorandum of understanding. This blatant violation demands a clear American response: Eliminate Iran's ability to use Pickaxe Mountain, ideally for good.

Already, a senior regime adviser has called Pickaxe "the most fortified nuclear facility in the world," while openly threatening to turn the entire region into hell if it is struck. Dug as deep as 100 meters under a mountain, the facility was engineered to survive even America's Massive Ordnance Penetrator bunker-busters. Yet, that does not place it beyond the reach of U.S. military capabilities

Trump warned about this threat months ago. In March, he revealed that even after U.S. strikes obliterated key Iranian nuclear facilities in June 2025, the regime was already shifting operations to a new, granite-protected site buried deeper underground. "They wanted to go a lot deeper," Trump said, highlighting Iran's relentless drive for a nuclear weapon.

As usual, Iranian leaders insist their activities are innocent. They claim Pickaxe is merely building a centrifuge assembly plant begun in 2020. Western intelligence assesses it could house an undeclared uranium enrichment facility, even deeper than the Fordow enrichment site the United States disabled and may have already moved centrifuges and other critical equipment inside.

Satellite imagery from the Institute for Science and International Security confirms ongoing vehicle activity, tunnel work, and entrance hardening as recently as late June, despite the terms of the June 17 MOU, in which Tehran promised to "maintain the current status quo" of its nuclear program. "Status quo" does not mean pouring concrete for a hardened nuclear bunker.

SPECIAL REPORT

How China's commercial space companies develop world-class industry



Galaxy Power is a commercial aerospace rocket company invested by Yuanhang Capital's Angel Wheel. Although it was established late, it has developed rapidly. In 2017, Yuanhang Capital entered the field of commercial aerospace investment. The founding team has a deep Beihang gene. With a professional perspective, the team successively invested in commercial aerospace companies such as Galaxy Power, Micro Nano Star Sky, and Aerospace Yuxing in the earliest rounds. Speaking of Yuanhang Capital's investment experience in commercial aerospace, especially in the field of rockets, the founding partner Mr. Chen Dong was quite touched. Commercial rocket market "supply exceeds demand", cautious, high-risk, long-term As the saying goes, "Don't buy porcelain without diamonds."

The field of commercial aerospace is a hard bone, with extremely high industry barriers and sophisticated technology, which make players "extremely cold". Although it also belongs to the category of hard technology, my country's commercial aerospace started relatively late, resulting in fewer investment institutions and entrepreneurial projects in the commercial aerospace field. The previous aerospace projects were all national projects.

Faced with the launching demand of tens of thousands of satellites in the low-orbit constellation worldwide and thousands of domestic satellites in recent years, it is far from sufficient to rely solely on the launch capacity of government-led

rockets. The huge supply gap urgently needs new commercial space capacity to fill.

In 2015, China's commercial aerospace market entered the fast lane, and the demand for commercial rockets once reached the market status of "rockets such as satellites". As an early investor in commercial aerospace, Mr. Chen Dong is optimistic about the current domestic commercial rocket market. In his opinion, although the United States promulgated various policies and regulations to encourage the development of commercial aerospace as early as the 1980s, the first private rocket company Orbital Science Company was born in 1982, and

SpaceX, which is now in full swing, was born in 2002. However, the development of domestic commercial rockets has a late-comer advantage, and the pace of technological catch-up has gradually accelerated in the past five years.

At the same time, the country attaches great importance to the construction of the low-orbit Internet constellation, and has clearly included the low-orbit Internet constellation into the category of "new infrastructure" and upgraded it as a national strategy. The trend of policy and the shortage of resources have enabled the capital market to see the trend and commercial value of commercial rockets.

At the beginning of 2017, Yuanhang Capital

began to pay attention to the commercial rocket startup team. At that time, it inspected a number of rocket startup companies through direct and indirect methods. It was not until the beginning of 2018 that they met their favorite commercial rocket startup company-Galaxy Power. The angel investor who wrote the first check.

Now, Galaxy Power has completed the research and development of the small solid rocket, and will launch the solid rocket into orbit in September this year. "If it succeeds, Galaxy Power will become China's second private rocket company with the ability to enter orbit, and it will also be the world's private rocket company with the shortest time from company establishment to orbit."

For commercial rockets, there are only two states, success and failure, which is a high-risk undertaking. Mr. Chen Dong emphasized: "In choosing a rocket startup team, investors must focus on the rationality of its technical route, especially whether it has low-risk characteristics." It is meaningless for start-ups to talk about innovation and feelings. "Surviving" is the basis for talking about feelings.

At present, Yuanhang Capital has invested in the entire industrial chain of commercial aerospace in rockets, satellites, measurement and control, and downstream applications. After experiencing the era of domestic commercial rocket development, Mr. Chen Dong has his own unique vision of investment in this field.

Chen Dong said: "Commercial rockets are a typical hard technology project, and certainly not a short-term project. However, professional investors negotiate with the company to formulate a step-by-step reasonable technical route, which can also enable the company to obtain phased results in a short period of time, quickly obtain valuable cash flow and the company's high growth".

Judging from the product research and development practice of domestic private rocket companies, private rocket companies with strong technical strength can generally complete the research and development of small solid rockets within two to three years. At present, no private rocket company has completed the research and development of liquid rockets. It is estimated that the research and development of liquid rocket engines and liquid rockets will be completed within 5 years. After investing in early rounds of funds to raise seedling companies, they can also withdraw in due course and hand over the baton to the big funds in later rounds.

Start-up companies primarily depend on acquiring venture funding, either from private or public VC funds, as they are generally unable to access bank loans. The largest of these companies have over \$100 million in Venture Capital funding; the smallest are still shell companies with little funding. These companies are primarily owned by their founders and other important employees. Examples include companies such as MinoSpace, LandSpace, OneSpace, and iSpace.

Many founders of Chinese space companies spent their careers developing technologies at state owned enterprises, China Academy of

Science institutes, and universities. Starting their own companies gave them a chance to commercialize their technologies and technical knowledge. Prior to founding MinoSpace and LandSpace, Wu Shufan had been an aerospace professor at several universities in China and Europe and a researcher at the European Space Agency.

Prior to becoming the chairman of LandSpace, Wang Jian Meng, worked at Xichang launch center, the Beijing Launch and Control Center, then as Executive Vice President of APT Mobile Satcom Limited, a geosynchronous Earth orbit (GEO) communications satellite company. Peng Xiaobo, founder of iSpace, was the director of CALT's R&D center, Jilin University Zhuhai College 2016. He was also the head of CASC's First Academy R&D department.

Some company founders, like OneSpace founder Shu Chang, worked in the CASC space investment fund and as a vice president in strategic investment at Legend Capital prior to starting a space company.

Following the 2014 policy change, Chang decided to found OneSpace after being unable to identify any space companies he thought would be strong investments. Another motivating factor for company founders has been the opportunity to develop their technology free from bureaucratic oversight at state owned enterprises and government institutions. In public talks, several CEOs and company founders cited the ability to develop the technology they had spent their career working on in the manner they saw as best. Starting their own company allowed them to be more innovative with technologies and push boundaries.

The Chinese startups have large chunk of customer base across diverse sectors, including Chinese government agencies or state owned enterprises, foreign government agencies, and domestic and foreign universities and educational institutions. However, most companies initially have a domestic customer base. For instance, launch companies such as LandSpace are targeting about 30 domestic small satellite companies.

Interestingly, many startups do not have websites, and WeChat seems to be the primary mode by which companies communicate with suppliers and potential customers, implying that these are domestic. Most companies would like to grow to a point where they have a foreign presence, but they do not believe they will be able to do so in the near future, unless perhaps in developing countries. They are hampered in entering markets in developed countries because of restrictions imposed by the U.S. or European governments on the use by Chinese companies or Western components, or by prohibitions on exports by the Chinese government.

Leadership

Many founders of Chinese space companies spent their careers developing technologies at state owned enterprises, China Academy of Science institutes, and universities. Starting their own companies gave them a chance to commercialize their technologies and technical knowledge. Prior to founding

MinoSpace and LandSpace, Wu Shufan had been an aerospace professor at several universities in China and Europe and a researcher at the European Space Agency.

Prior to becoming the chairman of LandSpace, Wang Jian Meng, worked at Xichang launch center, the Beijing Launch and Control Center, then as Executive Vice President of APT Mobile Satcom Limited, a geosynchronous Earth orbit (GEO) communications satellite company. Peng Xiaobo, founder of iSpace, was the director of CALT's R&D center, Jilin University Zhuhai College 2016. He was also the head of CASC's First Academy R&D department.

Some company founders, like OneSpace founder Shu Chang, worked in the CASC space investment fund and as a vice president in strategic investment at Legend Capital prior to starting a space company.

Following policy change, Chang decided to found OneSpace after being unable to identify any space companies he thought would be strong investments. Another motivating factor for company founders has been the opportunity to develop their technology free from bureaucratic oversight at state owned enterprises and government institutions. In public talks, several CEOs and company founders cited the ability to develop the technology they had spent their career working on in the manner they saw as best. Starting their own company allowed them to be more innovative with technologies and push boundaries.

Chinese startups have large chunk of customer base across diverse sectors, including Chinese government agencies or state owned enterprises, foreign government agencies, and domestic and foreign universities and educational institutions. However, most companies initially have a domestic customer base. For instance, launch companies such as LandSpace are targeting about 30 domestic small satellite companies.

Interestingly, many startups do not have websites, and WeChat seems to be the primary mode by which companies communicate with suppliers and potential customers, implying that these are domestic. Most companies would like to grow to a point where they have a foreign presence, but they do not believe they will be able to do so in the near future, unless perhaps in developing countries. They are hampered in entering markets in developed countries because of restrictions imposed by the U.S. or European governments on the use by Chinese companies or Western components, or by prohibitions on exports by the Chinese government.

Employees

In the last ten years, Chinese space startups have had a large turnover of employees compared to western counterparts. For instance, some general, companies had employees ranging in size from 10 to over 200 employees; several older or more established companies have 400 to more than 1,000 employees. In interviews, younger companies that have recently entered the market stated that 70 percent or more of their employees are engaged in R&D, the majority

of which had either master's or doctoral degrees, often in engineering or materials sciences.

Most of these companies' employees were domestically educated, and worked at state owned enterprises and China Academy Science prior to joining the company. Examining hiring websites listings for space companies shows that many are looking for employees with advanced degrees and work experience in aerospace engineering and also that these companies are expanding rapidly.

Several companies noted that during the hiring process they primarily look for potential employees that have 5 years of experience at state owned enterprises or government institutions. In interviews with news organizations, company executives said they advertised that their core technical teams have worked on well-known space projects to tout the company's technical prowess. For instance, S-motor, a rocket engine manufacture, advertised the core team's heritage working on Long March 11, Kuaizhou 1, and military systems.

Yuan Si, a former general manager at CGWIC, left the state owned enterprise to join the multinational Gilat Satellite Networks. The reason for the departure is unclear. Perhaps most important is that his salary would be higher. In September 2018, a viral post on Chinese social media highlighted the case of an engineer from the Xi'an Aerospace Propulsion Institute that had left the institute to work at LandSpace for 10 times his previous salary.

In some instances, employees move to commercial companies because they are able to be more innovative with a technology on which they have worked for years. In a short documentary on OneSpace, an engineer stated that he went to work for OneSpace because he was allowed to implement his ideas on how to improve flight computers, dramatically reducing their weight.

Being a second mover

Many of the Chinese companies that have been established in the last several years base their business models on those of companies in the United States or Europe that have been successful.

By emulating first movers in the West, Chinese companies may be able to reduce the overall level of risk they take. By deliberately choosing to follow rather than lead, these companies may be able to focus on making secondary innovations that ultimately may make them more successful than their Western counterparts, a strategy that has worked to China's advantage in many sectors such as IT, manufacturing, and high-speed railroad equipment.

As an employee of one company noted, once China sees the tide, "China is able to help push the tide in a certain direction and we're able to make great headway in a short amount of time." Another company noted that once China sees that an indus

The numbers have grown over the years. In 2017, Space Angels reported that Chinese space companies raised \$230 million, whereas the Aerospace Engineering Technology Research Institute found that the Chinese commercial space sector raised 2.1 billion RMB, approximately \$310 million, for 17 space companies in 2017. Space Angels notes that the vast majority of the investments in Chinese space companies were made between 2016 and 2018.

Angel investor Niu Wen, who has invested in LandSpace and MinoSpace, among other companies, is quoted to have estimated around 6-7 billion RMB approximately \$870 million to \$1 billion USD, representing the upper range of our estimate in total investment in Chinese commercial space. During this time period, Chinese investment has represented a growing share of global investment in space companies. Space Angels estimated that between 2009 and 2018, investments in Chinese space companies comprised 5 percent of global investments in space.

One of the major motivations for the Chinese government to open commercial space to private activity was to leverage private capital. Venture Capital firms investing in Chinese start-up space companies include Matrix Partners China, Shunwei Capital, K2VC, and Legend Capital. Some Chinese VC firms, such as Tencent Holdings, have invested in foreign space companies, like Satellogic, Planetary Resources, and Moon Express as well.

Start-up companies primarily depend on acquiring venture funding, either from private or public VC funds, as they are generally unable to access bank loans. The largest of these companies have over \$100 million in Venture Capital funding; the smallest are still shell companies with little funding. These companies are primarily owned by their founders and other important employees. Examples include companies such as MinoSpace, LandSpace, OneSpace, and iSpace.

In efforts to spur development and attract high technology jobs, many Chinese provinces and cities operate government-owned VC firms. Some of these firms have taken minority stakes in space companies. For example, Beijing E-town, the VC firm of the city of Beijing, has invested in several of the commercial space companies that have established their headquarters in that city. Other provinces, such as Jilin, have also used state-owned VC firms to support local high technology industries.

Another prominent investment group is Chinese Academy of Sciences, its institutes, and Chinese universities. Investments in space companies from these groups are limited to companies that emerge from their own institute or university. One of the earliest and largest investors in Chang Guang Satellite is the Chinese Academy of Sciences' Changchun Institute of Optics, Fine Mechanics, and Physics. As of March 2019, Spacety's largest shareholder has been the Chinese Academy of Sciences Center for Space Applications on Engineering and Technology through a

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improvements on this to meet our market needs or to improve its overall performance or services. We can see what works and then can improve upon it and mass market."

Interviewees from several companies noted that they are waiting for U.S. commercial space companies to figure out and understand the needs of the market: who the potential customers are, what downstream applications are feasible, and which business models can be successful. Chinese commercial space companies are reducing risk by carefully watching the advances and missteps of American companies.

Trend in funding

Space Angels, a U.S. VC firm that invests in the space industry and tracks global space investments, has estimated that total Chinese investment in commercial space was \$336 million in 2018. The Future Aerospace Research Institute found Chinese space companies raised 2.1 billion RMB, approximately \$310 million in investments during 2018 across 34 rounds from seed to Series C capital for non-listed companies. Future Aerospace notes that two older space

companies listed on Chinese stock exchanges sought further funding, raising another 1.4 billion RMB, approximately \$206 million together, resulting in over \$500 million raised in 2018.

Although state owned enterprises often do not directly invest in private companies, they have provided support through other means. For example, Chinese CASIC "supports more than 6,000 private innovative, entrepreneurial programs that have attracted more than 1.7 billion yuan

series of holding companies. There are five Chinese Academy of Sciences-backed investment funds that have invested in several commercial space companies.

Several universities or university-affiliated groups have also invested in space companies. The Harbin Institute of Technology Robot Group has invested in OneSpace and S-motor; Tsinghua University is a minority investor in TYSpace, Laserfleet, and UCAS through a series of holding companies. Several Chinese commercial space companies

offer stocks on public markets, including Zhuhai Orbita and APT Sat. In July 2019, PIESAT, a Beijing-based Earth observations and satellite navigation software developer, conducted its initial public offering (IPO) on the Shanghai Stock Exchange Sci-Tech Innovation Board.

Huzhou City reportedly provided LandSpace 200 million RMB of funds dedicated to civil military integration, which are likely related to LandSpace building its production facility in Huzhou, although the purpose of these funds has not been publicly stated. The Chongqing government provided subsidies to OneSpace for its facilities in the Chongqing Liangjiang New District in exchange for OneSpace establishing a subsidiary in Chongqing. It tied its financing plan to the development of OneSpace.

A few publicly traded or private companies have invested in space. Huaxun Fangzhou, a communication technology company, owns a stake in ZeroG Lab, a satellite manufacturer. It plans to use this manufacturer to build a remote sensing satellite constellation consisting of 378 satellites, which Huaxun Fangzhou plans to

finance and operate. Other listed companies, such as Tatwah Smartech, have acquired space companies to enter space markets. In 2017 and 2018, Tatwah Smartech acquired a 49 percent ownership stake in Sri Lanka's SupremeSat and Malaysia's ASN Satellites. At least two start-up space companies have invested in other startups: Spacety holds minority shares in both LaserFleet and AerospaceMaker; LandSpace has indirect minority investments in both MinoSpace and Space Wisdom through an investment partnership with several other technology companies and several CAS VC funds.

In September 2018, at a commercial space conference in Wuhan, many presenters mentioned "winter of capital," referring to the inability of many space companies to attract Venture Capital, in an apparent sharp departure from preceding years. In interviews conducted in March 2019, when asked about this trend, company representatives stated that during the first half of 2018, Venture Capital firms had been hesitant to invest, but since that time companies with strong business plans have been able to

attract Venture Capital. Chinese venture capitalists and reports on Venture Capital in China have noted that funding has begun to concentrate around a few categories such as launch. This suggests that although Venture Capital may have initially saturated the market when private investment in space was first allowed, Venture Capital firms have since become more cautious when investing in space companies, and are conducting more due diligence on companies' market prospects.

Chinese launch vehicle providers

Before 2014, launch services in China were the sole domain of state owned enterprises, particularly Chinese Aerospace Corporation's CALT and SAST. During this period, Chinese Aerospace Corporation conducted some commercial launch activities including, selling launch capacity on Long March rockets to foreign buyers through China Great Wall Industries Corporation; however, most launches were in support of government and state owned enterprises missions. Chinese Aerospace Corporations continues to dominate the launch market in China: it conducted 37 of China's 39 orbital launch attempts in 2018.

Despite the dominance of CASC in China's launch market, a number of commercial launch services and launch vehicle system and component manufacturers have been established in recent years. Over 15 companies with plans to sell launch services using their own launch vehicle, including two backed by state owned enterprises.

As of July 2019, LandSpace, OneSpace, and iSpace, the three largest private launch companies have all attempted orbital launches; iSpace is the only one of the three to successfully reach orbit. LandSpace currently has the most ambitious plans, as it has successfully demonstrated medium-lift launch vehicles to sun synchronous orbit (SSO) as well as low Earth orbit LEO and GEO. Expace, a commercial launch company backed by CASIC, has

conducted two commercial launches since it was spun-off of CASIC in 2016; ChinaRocket, a commercial company backed by Chinese Aerospace Companies, launched its first rocket in August 2019. ChinaRocket28 was founded in 2016 to make CASC's launch vehicle offerings more competitive commercially. Four of these companies including Expace, iSpace, LandSpace, and OneSpace have received significant financial support from China's Venture Capital community.

Another notable early entrant to the launch sector, LinkSpace, which has recently demonstrated retro-propulsive hovering capabilities on a large suborbital hopper vehicle. Since 2017, there has been a second wave of commercial launch services and system suppliers companies that have been founded. Many have conducted engine tests and, in a few cases, suborbital flight tests. Companies in this category have raised significantly less money than launch companies in the first wave, although funding levels vary among second wave companies. Several of these companies, such as S-motor, Space Transportation, and TWR-

Engine, have developed unique engine technologies or rocket designs. Other launch companies include Galactic Energy, SpaceTrek, Enter Space, Deep Blue Space, and Jiuzhou Yunjian. Galactic Energy appears to be the most advanced of these companies, as it is the only one of these companies that has successfully conducted a target launch with its Ceres launch vehicle.

Several Chinese commercial launch providers with the exception of Expace, ChinaRocket, and iSpace, were still in the phases of conducting R&D and demonstrating their suborbital and orbital launch vehicles, although several have domestic and foreign launch contracts.

Since the beginning of space travel, the multistage expendable launch vehicle has been the predominate approach for boosting payloads to orbit. Although this has been a reliable approach, the high cost of launch has limited civil, commercial and military endeavors in space. The recent proliferation of commercial launch providers, coupled with the highly competitive nature of this market, has stirred a renewed interest in identifying alternative means of recovering launch vehicle assets to reduce the cost of access to space.

In general, these companies have initially focused on small launch vehicles up to several hundred kilograms to LEO. Several companies have also announced plans for medium lift vehicles. Many of these companies are pursuing reusable launch vehicles through a variety of technologies, including retropropulsive landings and parachute return of an upper-stage glider. Investigations into the reuse of launch vehicles can be traced back to the early years of the space age. In public presentations, companies have touted their goal to provide rapid response launch times of under 6 months. In a presentation at the Fourth China International Commercial Aerospace Forum in Wuhan, China, Expace president Zha Xiongquan stated that their quickest turnaround was several days from signing a contract with a customer to launch.

As of August 2019, only five companies had conducted orbital launches. These are Expace, ChinaRocket, LandSpace, OneSpace, and iSpace. LinkSpace, another early launch company, conducted a vertical take-off and vertical landing hover test of its 8.1-meter tall rocket, reaching an altitude of 20 meters in March 2019.

With the exception of LinkSpace, each of these companies' rockets has been solid-fueled. Although companies are targeting orbital launch markets, several, including iSpace, OneSpace, SpaceTrek, and EnterSpace, plan to also sell suborbital vehicles to companies as a platform to verify space technologies.

In December 2018, LandSpace opened its own launch vehicle production facility in Huzhou, Zhejiang province, making it the first private launch company to own a full production facility. In its new facilities, LandSpace hopes to achieve a production rate of 15 launch vehicles a year by 2022. Other launch companies may produce subsystems in their own facilities, but integrate their rockets in facilities owned by the large

SOEs. For example, both LandSpace and OneSpace have released images of their rockets in a CASC facility in Xi'an.

As Chinese launch companies receive orders, they are likely to build their own production facilities. OneSpace has reported that it is currently constructing manufacturing and testing facilities in Chongqing, Sichuan, with an annual production capacity of 30 small orbital launch vehicles and 20 suborbital launch vehicles. EnterSpace, a launch company founded in late 2018, plans to build a factory with a production capacity of 35 launch vehicles a year.

Since July 2019, all private launches have conducted private launches at the Jiuquan Satellite Launch Center or the Wenchang Spacecraft Launch Site. Media reports suggest that the Chinese government plans to make Jiuquan the permanent location for commercial launches.

Chinese media reports suggest that launch companies will continue to use government facilities for launch, but may construct their own launch pads at launch centers to avoid schedule conflicts with CASC rockets.

In public presentations, launch companies report that the government has been supportive of launch companies' needs for launch, even if the government does not allow companies to choose where they will launch. For instance, during the Wuhan China International Commercial Aerospace Forum in September 2018, Shu Chang, CEO of OneSpace, stated that OneSpace had hoped to take a video of the launch from space using a satellite. However, the satellite malfunctioned.

Currently, most launch companies have not disclosed their cost per rocket or cost per kilogram to launch. OneSpace has reported that its suborbital OS-X cost less than 500 million RMB (\$78 million) to design and build, as that is approximately how much capital they had raised to that point. In September 2018, the general manager of Expace, Cha Xiongquan, noted that Expace's new launch vehicle, the Kuaizhou 11, would cost approximately \$10,000 per kilogram, but they expect the cost to fall to \$5,000 per kilogram over time.

Private commercial companies hope to beat Expace on price. Galactic Energy, for example, is targeting a launch price of \$2,000 per kilogram. It is unclear if these companies will be able to meet these ambitious prices.

According to reports, Chinese commercial launch companies are primarily targeting domestic small satellite companies as their customer base. As of April 2019, most payloads launched aboard commercial launch vehicles were those of commercial satellite companies. For example, Expace has launched satellites for Chuang Guang Satellite, Centispace, and several universities. OneSpace's commercial customers include ZeroG Lab and Spacety, whereas iSpace has sold payload capacity on its suborbital vehicles to ADA Space and ZeroG Lab. Most commercial launch companies that have demonstrated a suborbital vehicle have publicly claimed that they have signed contracts with many commercial satellite companies, but have not revealed details, including the identities of their customers. At the 2018 China International Commercial Aerospace Forum, Expace reported it had 15 signed contracts with customers.

While the limited number of commercial launches

have occurred through April 2019, sponsored by state owned enterprises or government organizations, the trend is chaging.

For example, LandSpace's first orbital launch attempt in October 2018 carried a small satellite for China Central Television manufactured by MinoSpace; OneSpace's first suborbital vehicle carried a technology demonstration for the Aviation Industry Corporation of China; iSpace's July 2019 orbital vehicle carried two satellites for CASIC and Beijing Institute of Technology, a public university as well as a classified military research payload.

Currently, only LandSpace has pursued customers outside China. In 2017, LandSpace and GOMspace, a Danish CubeSat manufacturer, signed a launch agreement. In April 2019, LandSpace signed launch agreements with the United Kingdom's Open Cosmos and Italy's D-Orbit valued at about \$15 million. In a public interview, LandSpace CEO Zhang Changwu has said that LandSpace is planning on directly competing with foreign launch companies, such as SpaceX and Blue Origin, for global small satellite launches.

LandSpace may be an exception to launch companies solely targeting domestic markets, as discussions with representatives of another launch service provider revealed they were unsure if they would be able to sell to many foreign companies due to other countries' controls on foreign trade with China. In the long run, several launch companies have discussed targeting developing markets, but plan to focus on domestic sales for the immediate future.

Competition within this sector will be fierce due to the number of launch providers and uncertain demand for satellite services in China. In public presentations, many launch companies have stated that they hope to work with other launch companies to grow the market, rather than fight over sales, which would reduce margins. Commercial launch vehicle company executives cite the growing demand for small satellites in China and globally as evidence of a sufficient market for several launch companies, although some launch company executives, such as iSpace's vice president Hu Jia, believe that there may only be room for one or two commercial launch companies that ultimately survive beyond the next 5 to 10 years.

Within the small satellite launch market, both CASC and CASIC own companies and sell launch vehicles that service the same market as private launch companies' launch vehicles. Despite this, private launch companies have said that they are not currently competing with state owned enterprises, although they have tacitly acknowledged that one day they will. In a public talk, iSpace President Peng Xiaobo stated that commercial rockets are not competing with launch vehicles that serve national missions, but rather supplementing and filling gaps in China's launch capabilities.

LandSpace CEO Zhang Changwu stated that he did not believe that private launch companies would be competing with SOEs for at least a decade. This is because although state owned





enterprises currently launch over 30 vehicles a year, the demand for launches is closer to 50 a year, meaning there is room for private companies. In particular, Zhang Changwu noted that demand for launches from commercial satellite companies is not being filled by state owned enterprises, as they focus on national missions.

As the government and state owned enterprises are the major sources of demand for satellite services in China, if government organizations continue to procure launches from CASC, the market for commercial launch companies will be constrained, limiting the number of launch companies the Chinese space industry can support. However, it is currently unclear whether private launch service providers will be able to launch military or civil space payloads one day, especially heavier payloads. The government may also choose to continue launching its small payloads on CASC rockets.

Notably, however, one of the payloads on iSpace's July 2019 launch was from CASIC, suggesting the

government may purchase launch from commercial providers. Despite this uncertainty in whether the Chinese government and state owned enterprises, the major source of demand for launching large satellites will purchase from the private sector, companies such as LandSpace are pursuing medium-lift launch vehicles, indicating that at least some companies may try to sell their services to the government once their technologies have been demonstrated.

The demand for many satellite services pursued by commercial satellite operators in China is uncertain. Because the demand for launch is derived from the demand for satellite based services, if these satellite companies are unable to find a market, many Chinese commercial launch operators will not survive.

Foreign satellite companies may supplement the demand for Chinese launch capacity. However, as many foreign companies and governments

are wary of China and its space industry especially Western countries, which have the highest foreign demand for small satellite launches the willingness of Chinese companies and governments to purchase launch capacity from private Chinese launch services is unclear.

Due to barriers to entry, Chinese launch companies' ability to pursue foreign customers is unclear. As of July 2019, only LandSpace had announced contracts with foreign companies. As noted above, executives at the most prominent Chinese commercial launch companies expect the Chinese space market to support anywhere from several launch companies to only one. From interviews with industry watchers, it appears the general consensus is that Expace, LandSpace, and iSpace are the most likely companies to survive long-term.

Satellite manufacturing
China is one of the largest manufacturing countries in the world of consumer electronics,

telecommunications equipment, solar panels, and high-speed railcars and locomotives, among other items. It has a thriving, internationally competitive, and innovative especially on cost high technology manufacturing sector. It is home to a large number of skilled manufacturers that can meet a variety of price points.

Therefore, China has a robust, technologically advanced satellite manufacturing sector. Since the late 1960s, when China built its first satellite, DFH-1, China Academy of Space Technologies CAST has manufactured almost all government satellites. China Academy of Space Technologies has many subsidiaries, with each subsidiary specializes in manufacturing specific satellite sizes to avoid competition.

According to experts on China's space sector, starting in the late 1990s, the Chinese government authorized Shanghai Academy of Spaceflight Technology to manufacture satellites in order to introduce competition with China Academy of Space

Technologies. Currently, China Academy of Space Technologies and Shanghai Academy of Spaceflight Technology remain the dominant satellite manufacturers, providing satellite buses and payloads for all national space activities. Some subsidiaries within the two state owned enterprises started to focus on the commercial market in the early 2010s, endeavoring to lower costs, increase efficiency, and attract nongovernment customers.

These large state-owned satellite manufacturers have trained an experienced workforce in satellite manufacturing. Most founders of commercial space start-ups come from China Academy of Space Technologies; many commercial companies actively seek to hire engineers from China Academy of Space Technologies and Shanghai Academy of Spaceflight Technology.

Many of the prominent commercial satellite companies are actually spin-offs from these Chinese Academy of Science institutions. They have since expanded their space activities beyond component manufacturing. Examples include Chang Guang Satellite Technology and SpaceOK. Satellite component manufacturing is one of the oldest commercial market segments in China's space sector. Several private companies established themselves as satellite component suppliers for the government in the early 2000s. In recent times, few of these established private component suppliers have expanded their space activities, manufacturing entire satellites.

While the technological capabilities of these commercial companies are still limited, many satellite start-ups have built a CubeSat within a few months of their founding. According to reports, no commercial start-up has built a satellite larger than 30 kg, but in 2019 two companies are attempting to build 100 kg satellites.

In addition to leveraging state owned enterprises supply chains and capabilities, the emerging Chinese space sector can leverage the broader Chinese manufacturing sector, which is able to move quickly to scale production while remaining cost competitive. In a short documentary on OneSpace, company representatives noted that they were able to source components from the civil aviation manufacturing industry, as opposed to traditional space technology suppliers, due to that industry's ability to meet their needs at lower cost.

Many start-ups also manufacture satellite components as a way to generate revenues and offset costs for more capital-intensive activities. For instance, MinoSpace sold ground station equipment in its first few months to generate revenues, even though it currently focuses on manufacturing full satellite systems.

In essence, building and deploying LEO constellations requires substantial time and capital. Most companies that plan to build such a constellation generally do not expect profits for their first 3 years. Many of these companies currently plan to manufacture components or small satellites for others until their own constellations become profitable.

These new start-ups tend to build at least one CubeSat as a test satellite in order to verify and validate their technological competencies, even if they do not plan on becoming a manufacturing company. Many of these start-ups have indicated that they may outsource their manufacturing to build their

large constellations. Manufacturing is thus a steppingstone for many start-ups to enter the commercial space industry, as companies must verify their technologies to attract investors. As the industry matures, the number of companies that engage in satellite manufacturing may decrease.

Some commercial start-ups plan to remain in the manufacturing industry. A few are focused on selling entire satellite buses and payloads, especially MinoSpace. Industry players such as Spacety and Zero Gravity Labs are offering end-to-end turn-key solutions where they manufacture, launch, and operate satellites for customers.

These companies expect to win contracts from new commercial operators to build satellites for large constellations in LEO, because they can manufacture satellites at lower cost and faster timelines compared to traditional SOE satellite manufacturers. Based on reports, Chinese commercial manufacturers have significantly lowered their costs by taking larger risks and sourcing cheaper components from non-traditional suppliers rather than using state-of-the-art space components like the traditional SOE satellite manufacturers do.

Future market potential

Despite the multiplicity of startups in the sector, Chinese industry players are of the opinion that the commercial space industry will possibly only support two to three commercial satellite manufacturers, and that companies will have to become specialized component manufacturers to stay viable. The current competition among small satellite manufacturers is already intense; one industry insider described it as a "battle to the death."

Another stated that the CubeSat market has become so oversaturated and competitive that companies are manufacturing CubeSats at a loss right now. In order to remain competitive and differentiate themselves from other commercial companies, startups have to build larger satellites, which may bring them into competition with China Academy of Space Technologies and Shanghai Academy of Spaceflight Technology.

A major limiting factor for the commercial satellite manufacturing industry is that all government contracts for satellites are currently given to China Academy of Space Technologies. This makes the domestic customer base very small for commercial manufacturers. Most major satellite contracts with foreign governments and customers are also given to China Academy of Space Technologies, as China Great Wall Industry Corporation negotiates most of these foreign contracts.

According to insiders, many commercial start-ups are unable to leverage China Great Wall Industry Corporation's network, and must market their products and find customers on their own. A few commercial manufacturers are negotiating with potential customers from Europe, Africa, South America, and Southeast Asia and may have signed Memorandum of Understandings with them. However, commercial start-ups are currently only able to

sign small contracts with clients who have limited means to purchase satellites, like universities and other start-ups. This may change if commercial companies are able to build larger satellites competitive with those manufactured by China Academy of Space Technologies.

Satellite broadband internet

Satellite communications is one of the most established commercial space sectors in the world, a result of the profitability of long distance telecommunications earlier on and the current profitability of direct-to-home satellite television broadcasting services.

Prior to the late 2010s, China did not have any fully private satellite communications companies as the country heavily regulates its telecommunications industry. The GEO satellite communications market in China is dominated by state owned enterprises backed commercial companies, primarily China Satcom and its subsidiary APT Satellite, and Asiasat, which is partially owned by CITIC Limited. According to Euroconsult, the two largest sources of demand for capacity are television signal distribution and network backhaul, with enterprise networks following third due to regulations restricting their size. Unlike in foreign markets, direct-to-home television broadcasting in China is a free-to-air service meant for rural markets. As such, it does not generate large revenue streams in China. Chinese LEO market led by startups are growing to provide broadband internet services globally.

On March 13 2025, China successfully launched the fifth batch of low Earth orbit satellites for its first commercial satellite constellation from a seaside spacecraft launch site in south China's Hainan Province.

The accomplishment has solidified the constellation's progress toward its goal of global connectivity, Lu Ben, senior vice president of Shanghai Spacesail Technologies Co., Ltd, developer of the satellite constellation, Spacesail, told the media recently.

Noting that the latest launch marks the inaugural mission from the No. 1 launch pad at the Hainan commercial spacecraft launch site, Lu said that the development and operationalization of the launch site have enhanced China's capacity for space launches. "The use of commercial launch facilities will significantly support the speed and quantity of our low Earth orbit satellite constellation development, facilitating a faster establishment of this constellation," Lu stated. The Spacesail Constellation is China's first mega-constellation to enter the formal networking phase.

According to Lu, the project aims to

deploy over 15,000 satellites in three phases. The first phase focuses on 648 satellites that are designed to achieve regional coverage. The second phase expands this network to 1,296 satellites, which allows for global coverage, while the third phase envisions a comprehensive network that offers diversified services.

The latest launch, which deployed 18 satellites in a single mission, underscores China's mastery of the "one rocket, multiple satellites" technology, said Lu. This innovative approach involves stacking flat-panel satellites, significantly optimizing the use of rocket space and enabling high-frequency launches.

Internationally, Spacesail has been actively promoting the constellation's commercial applications. In November 2024, the company signed a memorandum of understanding with Brazil's state-owned telecommunications company, TELEBRAS, to provide satellite internet services in remote areas across Brazil, according to Lu.

China's commercial satellite constellation Spacesail is providing satellite communication services to Brazil and broadband internet access to the country's remote and underserved regions. The services are being carried out through the partnership between the constellation's developer Shanghai Spacesail Technologies Co., Ltd. and Telebras, a Brazilian telecommunications enterprise, according to a memorandum of cooperation signed by the two companies.

The memorandum noted that the commercial services to Brazil will officially kick off in 2026. The cooperation marks the official launch of the Chinese company's overseas business. Spacesail is a low Earth orbit megaconstellation with full frequency bands and a multi-layer and multi-orbit design. Its commercial network construction was officially launched on Aug. 6, 2024. At present, the constellation has 36 operational satellites in orbit. They have completed relevant service tests and have proven to be capable of providing broadband communication services.

Chinese LEO constellation leader, Shanghai Spacesail Technologies Co Ltd has finalized partnership with Airbus marking another step in expanding the global operational scope of China's commercial satellites, exemplified by Spacesail's Qianfan Constellation.

According to the market cooperation agreement between the two sides, Spacesail will integrate its Qianfan Constellation into Airbus' HBCplus in-flight connectivity solution. The move aims to provide airlines with high-speed, low-latency broadband services, improving the in-flight experience for passengers. Qianfan is China's first giant low-orbit commercial satellite constellation to enter the formal networking phase. Since the launch of its first batch of 18 networking satellites in August 2024, the constellation has grown to 108 satellites in orbit after five more batches were launched with the latest in October this year.

Tim Sommer, vice-president of Airbus, said that

the partnership reinforces Airbus' strategy to build a robust, diversified satellite ecosystem, adding that integrating Spacesail's large low-Earth orbit constellation will offer customers greater flexibility to meet growing demand for high-quality global connectivity.

Galaxy Space, has also announced plans to sell broadband satellite communications, emulating OneWeb's business model. Another, LaserFleet, plans to build a LEO constellation that will employ laser communications to provide broadband services. Both of these companies are in the early stages of development. However, neither had launched a satellite of its own. Most start-ups are focused on narrowband satellite communications, pursuing internet of things IoT communications markets.

The Chinese startups including Hongyan, Xingyun, and Swarm constellations are planning to sell broadband global internet access and 5G mobile data, targeting rural, aviation, and maritime markets. China Aerospace Science and Technology Corporation has also announced plans for Hongyan to engage in narrowband activities. Xingyun, which is managed by China Aerospace Science and Industry Corporation subsidiary LEOBIT, will focus on narrowband activities, and will target IoT devices.

All of these companies are still in the early stages of development. None of them have launched any satellites for their proposed constellations yet, with the exception of SpaceOK, which launched Jiading-01 in late 2018, and the first satellite for China Aerospace Science and Technology Corporation Hongyan constellation. Xingyun launched a test satellite in 2017, and Commsat has also launched a few test satellites, but none of these satellites will be used for their communications constellation.

However, the narrowband startups are currently targeting the IoT market. Some manufacture and sell IoT receivers to generate revenues as they wait for their constellations to be completed. They are currently marketing space-based IoT to industries in remote areas, such as the agricultural, oil, and shipping industries. However, most companies have not yet developed full business models for their IoT constellations; they are still developing applications for space-based IoT. Some established private Chinese companies, such as Tatwah Smartech and Huaxun Fangzhou, are entering the GEO satellite communications market in other countries. Both of these companies have been around for much longer than the majority of Chinese commercial space companies, but have only recently entered the space industry. From an international perspective, a

subject matter expert noted that first movers in global constellations will be able to reserve the best bands for satellite communications. While Western companies have engaged in launching large LEO constellations operations lately, Chinese companies believe that they are at a major disadvantage as second comers. And in China, companies who are latecomers will have to use the more expensive high frequency bands, otherwise they may not obtain access to spectrum at all.

Equally, Chinese companies believe most of the opportunities in the burgeoning commercial space industry are in the communications sector. The market potential of any space-based service depends on whether it can be sold directly to consumers in China, expanding the customer base beyond the government and other businesses. Chinese space experts said that communications is the only space application that new Chinese space companies will be able to sell directly to consumers, because the average citizen uses telecommunications daily.

When asked why the communications sector is seen as the most promising sector in the commercial space industry, one industry insider responded that most space companies that have completed an IPO in the world are communications companies. At the moment, no launch companies have completed an IPO yet, very few companies in remote sensing have either. Iridium, Globalstar, and Orbcomm were mentioned frequently as companies that have shown promise in the satellite communications sector. The success of these Western companies and their upcoming mega-constellations have generated lots of excitement in the satellite communications sector in China, making it easier for startups to obtain funding for similar mega-constellation projects.

Satellite remote sensing industry

All eyes have been on China's successful smallsat business with hundreds of small satellites launch into orbit in the last few years. The spacecraft and the rocket that launched it, like most of the technology for China's national space missions, was made by China Aerospace Science and Technology Corporation, the state-owned enterprise that holds the main contracts for China's space program. But, in recent years, new opportunities have emerged in China's private space sector.

The commercial space sector is one of the most promising and rapidly growing, so it is no wonder the sector has caught the eye of venture capitalists around the globe. Its main products are launch systems and vehicles as well as satellites, and though natural customers are governments and their space and

defense arms, non-government customers such as telecommunications companies are also involved.

Currently, Morgan Stanley has the global space sector valued at around \$350 billion, but by 2040 they expect that to more than triple to \$1.1 trillion. The opportunities space provides are as expansive as it is, from space travel to asteroid mining to global broadband and certainly military use.

China's space industry is hampered by U.S. and other western countries' export controls, which prohibit cutting edge technologies from the West from being used in China.

The U.S. government has strict regulations around the export to China of technologies used to build, launch, and operate satellites, amounting to a "complete embargo," according to Kevin Wolf, who led the export controls program at the Commerce Department's Bureau of Industry and Security during the Obama administration.

The U.S. bans these exports because there's a "significant risk of diversion" of satellite technology for military uses, even if an export is intended for commercial use. However, according to a report, the lack of access to foreign technology has also spurred China to advance its domestic space technologies, in contrast to some other high-tech industries, such as chipmaking, where its domestic capabilities are further behind.

The four most prominent commercial remote sensing companies are Twenty-First Aerospace Technology 21AT, Chang Guang Satellite Technology, Space View, and Zhuhai Orbita. These companies all have several remote sensing satellites operating in orbit; they all provide remote sensing imagery and services for their customers.

They also all plan to launch a constellation of LEO remote sensing small satellites. The constellations are likely to consist of approximately 30 satellites, although the full constellation for Chang Guang is to consist of 138 satellites. All the satellites are LEO small satellites: the highest altitude for any of the satellites is 650 kilometers and the heaviest satellite is 450 kg. The satellites either capture multispectral images, hyperspectral images, and video.

Chang Guang Satellite Technology Co., Ltd. CGSTL, founded in December 1st, 2014, it is the first commercial remote sensing satellite company in China. With the total registered capital of 1.97 billion yuan, the company is composed of CIOMP, Jilin provincial government, and social capital.

Jilin-1 satellite constellation is the core project under construction by CGSTL.

The phase I of the project consists of 138 high-performance optical remote sensing satellites covering video, high resolution, wide band, infrared, multispectral and other series. At present, CGSTL has sent 79 Jilin-1 satellite constellation networking remote sensing satellites into the designated orbit through 20 launches. Currently the number of remote sensing satellites in orbit is 72.

Up to now, CGSTL has built the world's largest sub meter commercial remote sensing satellite constellation, occupying a dominant position in remote sensing information services, it has gradually become an important global source of space remote sensing information.

According to the calculation of the existing satellites in orbit, the Jilin-1 satellite constellation can visit anywhere in the world 23 to 25 times a day, with the ability to photograph a global twice a year and a national six times a year. It provides high-quality remote sensing information and product services for land security, geographic mapping, land planning, agricultural and forestry production, ecological environmental protection, smart cities and other fields, which is of great significance to the construction of digital China.

However, due to long-standing U.S. restrictions on access to space technologies, China's space industry has been forced to develop its own technologies and capabilities. Consequently, China's commercial space sector may not suffer the same vulnerabilities to foreign restrictions going forward as other high-technology sectors.

Industry players across China indicated that China's space industry would possibly not be as strong or as independent if it relied more on foreign space technologies. One industry expert noted that "U.S. International Traffic in Arms Regulations ITAR restrictions helped China in the end because it forced us to develop our own capabilities and technologies. If there weren't ITAR restrictions, China probably would not be so far advanced in its own capabilities and technologies."

In the field of commercial space, CGSTL is the first commercial remote sensing satellite company in the whole industry chain, which integrates satellite research, development, operation management and remote sensing information services. Relying on the Jilin-1 remote sensing satellite data, CGSTL can provide customers with high time resolution, high spatial resolution, high spectral resolution, fast wide area coverage of satellite remote sensing data and comprehensive application services of spatial information based on satellite remote sensing data.

At the same time, with its core technology accumulation in satellite platforms and space optical payloads, CGSTL is able to provide customers with customized satellite manufacturing and related services, including satellite whole and part components, test and test services, on-board services, and naming services.

As the first "unicorn" enterprise in Northeast China, Chang Guang Satellite Technology Co., Ltd. has always adhered to the "innovation-driven development" strategy, with a cumulative R&D investment of over 1.3 billion yuan. With the continuous iteration of satellite R&D technology, the company has currently built several mass production lines, including the satellite AIT pulse production line, with an annual production capacity of 200 remote sensing satellites.

Jia Hongguang, Secretary of the Party Committee of Chang Guang Satellite, revealed that after four technological advancements in satellite integrated design and manufacturing technology, the Jilin-1 satellite has decreased from the initial 400kg level to the 20kg level while ensuring that satellite performance indicators only increase. The manufacturing cost has also been reduced to one-twentieth of the original, laying a solid foundation for the rapid networking construction of "Jilin-1".

Founded in 2016, Spacety is a fast-growing company providing satellite-based services globally, with its international headquarters in Luxembourg in 2019. A world leader in cubesats and smallsats, it has developed, launched, and operates 30 satellites for science and technology demonstration missions. As a leading provider of satellite-based services, it provides fast, frequent, flexible, and low-cost space missions with its advanced and reliable small satellite fleet.

These space missions support science experiments or observation, and in-orbit demonstrations and/or validations of space technologies and products, or space systems. Those quick turnaround and end-to-end services have enabled world class space research and helped innovative space technologies to gain space heritage.

Spacety is building and deploying a microwave-based Synthetic Aperture Radar satellite Earth Observation constellation to provide the world with global coverage and real-time imagery data as a service DaaS.

This C-band SAR constellation monitors and observes the Earth, day and night, rain or shine, and make SAR imagery of every point on Earth accessible and affordable to users. The SAR data will be distributed worldwide and will enable innovative solutions to manage our changing world and make it better

On January 26, 2023, the U.S. Department of the Treasury added Spacety Co., Ltd. (Changsha) into the Specially Designated Nationals List. Spacety Luxembourg S.A., as the holding subsidiary of Spacety Co., Ltd. (Changsha), was implicatively added into the SDN List.

As one of the pioneers in the global commercialization of miniaturized SAR remote sensing satellite, the company said it have been consistently adhering to the mission of "Making Space Accessible", committing to developing miniaturized SAR satellite with extremely cost-effective, constructing SAR constellation and providing one-stop service of SAR overall data solutions.

The company said: "It has never had any commercial relationship, or made any deal, or signed any agreements with the Russian entity accused by the United States and we have stopped all the commercial relationships or business with other Russian entities since the Russo-Ukrainian War started, and we have never and ever participated in any form of military activities in support of the Russo-Ukrainian War and the Wagner Group".

In December 9, 2023, Satellite Honghu and Satellite TY-33, designed and produced by Changsha Spacety Co., Ltd., Spacety in short, were sent up by Zhuque-2 Telemetry-3 Carrier Rocket at Jiuquan Satellite Launch Center. With the successful orbit injection, satellites worked normally in good condition.

Satellite Honghu is a 50kg-class space science experiment satellite independently designed and produced by Spacety. It carries the integrated electronic payload, xenon gas Hall effect thruster payload and krypton gas Hall effect thruster payload developed by Shanghai Lanjian Hongqin Science and Technology Co., Ltd., and will complete the missions including Hall effect thruster orbit control function and performance verification, integrated electronic payload device and power-on/power-off lifetime verification.

This marks the first attempt in China to achieve cumulative 100-kilometer-level orbit control experiments employing xenon and krypton permanent magnet electric thruster systems, in addition to accomplishing approximately 3,000 hours of inorbit ignition experiments and 10,000 times of power-on/power-off lifetime verification of the Hall electric effect thruster system.

The Honghu satellite also carries the "Xingcheng II" argon gas ion thruster developed by Xingcheng Huiyu (Beijing) Technology Co., Ltd. This type of thruster utilizes argon as the propellant, which significantly lowers the costs compared to xenon and krypton gases. Based on ion propulsion technology, it separates ionization from acceleration, achieving an impulse of up to 1500 seconds with a wide thrust adjustment range. In addition,



its integrated and centralized layout design facilitates satellite installation and control. This thruster boasts high reliability and costeffectiveness, making it suitable for various orbital control actions such as orbit injection, networking attitude adjustments, and decommissioning of small satellites. It significantly reduces the deployment cost of satellite constellations.

This flight marks the second in-orbit verification of "Xingcheng II" argon gas ion thruster, mainly conducting electric propulsion telemetry and control, ignition, operation, switch-off procedures, and in-orbit experiments under prolonged working conditions to provide technical support for subsequent product development and applications.

Satellite TY-33 is a 50kg-class space science experiment satellite jointly developed by the Spacety and Hunan University of Science and Technology. It carries the remote sensing camera modules and multiple novel technology payloads, utilizing several platform technologies independently developed by Spacety for the first time, provides more reliable temperature control, thermal protection and energy guarantees for the routine in-orbit operation of payloads.

In particular, Satellite TY-33 adopts newly developed thermal control technology to achieve precise temperature control for satellites in space-constrained space, with a design value of temperature control accuracy better than 0.5°C, and with an expected reduction of temperature control energy consumption by more than 50%, which provides reliable environmental protection for highly temperature-sensitive scientific research payloads. In addition, the multi-layer of TY-33 Satellite utilizes high-performance composites, further enhancing the it's radiation protection capability.

In terms of power supply, Satellite TY-33 for the first time adopts the high power consumption and long duration power supply technology independently developed by Spacety, which enables the satellite to maintain power-on status under normalized high current payload, that meets the demand for uninterrupted in-orbit experiments of payloads.

Satellite TY-33 also carries a scientific research payload independently developed by Beijing University of Posts and Telecommunications utilizing the open-source real-time dual-kernel operating system RROS as the fundamental architecture and the Rust programming language. This payload will accomplish the general missions represented by tensor flow/k8s and real-time missions represented by real-time file system and real-time network transmission on the satellite, as well as guarantee the normal execution of upper-layer applications and scientific research missions, such as inter-satellite and ground latency measurement, live video broadcasting, on-board web chatting service, pseudo-ssh experiments, etc. This marks the world's first dual-kernel operating system written by Rust on the satellite operation.

The successful launch of Satellite Honghu and Satellite TY-33 signifies that Spacety has further consolidated its designing and producing capability of the 50kg-class satellite platform, showcased the cutting-edge technological proficiency of Spacety in the realm of scientific research satellites development, as well as denotes that Spacety's scientific research satellite business is making steady progress, deepening exploration its development, and achieving mutually beneficial development.

This is the launch 18th mission of Spacety. By this stage, Spacety has accomplished the

successful deployment of 30 satellites. Spacety offers customers unparalleled cost-effective and integrated services, persistently takes the lead in China's private spaceflight field in terms of satellite launch quantities and service capabilities.

China's first commercial high-resolution Earth observation satellite network has begun to operate, its developer said. China Aerospace Science and Technology Corp, the country's major space contractor, recently released several images taken by SuperView 1A and 1B, the first two satellites of the SuperView system. The images show the Potala Palace and a local convention center in Lhasa, capital of the Tibet autonomous region, as well as the Hong Kong Convention and Exhibition Center.

The SuperView 1A and 1B were lifted atop a Long March 2D carrier rocket on Dec 28 from the Taiyuan Satellite Launch Center in Shanxi province. They entered preset orbits on about Tuesday and have sent more than 1,200 ground images back to the control center, according to the State-owned CASC.

The two are operating at an altitude of 500 kilometers above the Earth, with a panchromatic resolution of 0.5 meters and multispectral resolution of 2 meters, said Zhang Xiaomin, a senior researcher at the company's China Academy of Space Technology, who oversees the system's development. Zhang said that compared with foreign commercial Earth observation satellites, SuperView satellites have better resolution, accuracy and coverage. China now operates the Gaofen network that has four satellites in service, but the system mainly serves government departments and the public sector rather than businesses, said Yang Yike, director of high-resolution satellite projects at CASC.

The two identical satellites are part of the SuperView network of at least 24 Earth observation satellites, which CASC expects to become one of the world's largest commercial providers of space imagery and geospatial data, Yang said. He added that the whole



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CHANG GUANG SATELLITE





system will be built by 2022. Once the network is completed, it will consist of 16 optical satellites like the SuperView 1A and 1B, four optical satellites that are more advanced, four radar satellites and several mini-satellites, according to Yang.

The Earth Eye Co., Ltd. is another Chinese startup dedicated to advancing the export of China's commercial space industry. Since its establishment in 2021, it has focused deeply on markets along the Belt and Road Initiative, working closely with private aerospace companies such as Changguang Satellite, ADASpace, CAS Space, Galactic Energy, Tianwei Technology, Magiccube Satellite, Spacetube, and Rongweitech. Through these partnerships, we have achieved revenue exceeding 100 million RMB without any external financing.

The company's TEE-01B satellite was successfully launched into orbit on June 6, 2024, from the Jiuquan Satellite Launch Center. This milestone marks the company's transformation from a remote sensing data trader to an integrated enterprise combining satellite operations with data sales.

The TEE constellation consists of 1 optical remote sensing satellite with 1-meter resolution, 10 with 0.75-meter resolution, and 2 with 0.5-meter resolution. As

of November 2024, one 0.5-meter resolution optical remote sensing satellite is already in orbit. Once fully deployed, the TEE constellation will enable a rapid emergency response time of just 1.2 hours. Additionally, the company has access to 18 commercial ground station partners worldwide, significantly accelerating our data transmission capabilities and allowing us to deliver high-precision, high-efficiency remote sensing imaging services to global clients.

The TEE remote sensing constellation consists of three low-Earth optical satellites, offering panchromatic imaging with sub-meter resolution and multispectral imaging services. The constellation covers the entire globe with daily revisit capabilities, and is designed for applications in agriculture, ocean monitoring, emergency management, natural resource supervision, and municipal transportation.

TEE-01B, the first satellite of the TEE constellation, was deployed at an orbital altitude of 545 km. It carries a panchromatic/multispectral optical remote sensing camera, capable of achieving 0.53-meter panchromatic and 2.12-meter multispectral resolution. Its applications include crop census, island surveillance, early disaster detection, topographic mapping, and infrastructure inspection.

Among the Chinese commercial space companies that have actual products on the market as well as tangible services for sale, few had customers outside of China. Companies indicated that they aspire to expand beyond China, but because China's commercial space sector is nascent, they are prioritizing finding their footing in the domestic market first.

Some companies also stated that when they eventually expand to foreign markets, they will prioritize developing countries that participate in Belt and Road Initiative rather than Western markets because they are likely to be at a competitive disadvantage compared to more mature Western companies in Western markets.

Furthermore, they are more likely to encounter protectionist policies to shield domestic space companies from foreign competition in Western countries. Western countries are also likely to be more susceptible to the United States' geopolitical influence over its allies in their stances towards products from China's commercial space industry.

China's state-owned space industry has already increased its presence and sales in Africa and Latin

America over the past two decades. For instance, Chinese state owned enterprises have collaborated with Brazil on several remote sensing satellites. China has targeted and attracted developing countries to become consumers of its space program by offering low cost or free products and services, providing financing for governments in need, financing and building massive infrastructure development projects in exchange for market access for the use and mining of natural resources, and land lease agreements.

Although none of the sales of space products thus far are from China's commercial space sector, the growing presence of China's state owned space industry in these countries may have indirectly opened the doors for China's commercial space industry to enter these developing markets in the future. As one expert noted, "Belt and Road Initiative has been very helpful for opening up potential markets for Chinese commercial space companies. These countries really did not have much of a choice if they wanted space assets or access before. Everything was predominantly from the U.S. and it was costly for these countries. But now Chinese companies present an option for these countries."

Prior to launch, the Ministry of Industry and Information Technology organized and completed the necessary frequency coordination procedures and officially issued the license, providing TEE with radio frequency and orbital resources to support the establishment of a commercial remote sensing satellite constellation.

Emposat Co., Ltd., founded in 2016 and headquartered at Shangdi East Road, Haidian District, Beijing, is a National High-tech Enterprise, a Zhongguancun High-tech 'Double High' Enterprise, and a National Specialized, Sophisticated, Innovative and Emerging 'Little Giant' Enterprise. With the mission of "making satellites more usable and easier to use," the company's core team consists of experts with extensive experience in aerospace systems. It focuses on the Commercial Aerospace sector, primarily providing satellite tracking, telemetry, and command services, ground station construction, and integrated space-ground communication solutions.

Its services cover over half of the commercial satellite tracking, telemetry, and command demands nationwide. The Ningxia Zhongwei Remote Sensing Satellite Calibration and Validation Site it operates is China's first commercial comprehensive satellite calibration site. In 2017, it built China's first third-party commercial satellite tracking, telemetry, and command station.

In 2018, it obtained the first radio station license for a commercial satellite tracking, telemetry, and command station. In 2019, it completed the construction of a nationwide commercial satellite tracking, telemetry, and command network and participated in the full-phase tracking, telemetry, and command support for China's First Solid-Propellant Rocket Sea Launch.

Most of the innovation in the remote sensing industry comes from generating new applications from remote sensing data, which fall under downstream remote sensing data analytics. Most satellite companies do not seem to focus on developing their analytics capabilities, although many may offer limited analytics services. The satellite remote sensing industry companies compete on a small number of capabilities, especially the resolution and the swath of satellites. Most commercial startups do not have the technology or the resources to compete with the more advanced companies, deterring them from entering this industry.

However, commercial space companies are likely to have access to only a limited customer base for sales of remote sensing data. Similar to other countries, government agencies are the main purchasers of remote sensing data in China. However, the Chinese central government already has many remote sensing satellites, built and operated by Siwei, a large SOE owned by China Aerospace Science and Technology Corporation.

The Chinese government produces its own remote sensing products. Despite the central government's remote sensing activities, according to interviews, provincial and municipal governments may be unable to access remote sensing data from central government departments, so some government entities may be forced to use commercial companies for

remote sensing needs.

This limited market is unlikely to be able to support more than a few companies. If the market is to expand, the Chinese central government would have to pursue policies similar to those of the United States regarding commercial remote sensing. It would have to choose to purchase remote sensing products from commercial sources in order to grow and support its commercial remote sensing industry. However, this is unlikely to happen because the government historically purchases all its goods and services from state owned enterprises and established government suppliers.

The other major customer base for remote sensing data are downstream analytics companies. Industry analysts revealed that the downstream market will determine the viability of the commercial remote sensing industry. Most Chinese remote sensing data analytics companies currently rely on free data from foreign government satellites, such as Landsat, as they are unable to access Chinese government remote sensing data.

Chinese remote sensing companies may be able to sell imagery to these companies, especially if they are able to offer higher frequency imaging, even if the images are lower resolution. Some satellite remote sensing companies are trying to sell remote sensing imagery directly to the public, but consumer demand for such images is currently small.

As many of the remote sensing companies are currently focused on imaging, not analytics, this sector will rely on companies to purchase their data and transform the data into relevant products for other businesses and consumers.

Despite these limitations, some market factors may favor satellite remote sensing over other means of collecting remote sensing information. According to industry players, drones are prohibited from flying at altitudes over 1,000 meters in China. Consequently, satellites are one of the only ways of capturing wide-field remote sensing data. For industries that require remote sensing information for broad areas, satellite remote sensing companies are the only supplier. Ultimately, even if remote sensing companies are able to offer exclusive data products, the demand for their images will depend on uncertain downstream demand from several sectors.

In China, remote sensing data have generally not been made available for private and commercial users in part due to reasons of national security. Prior to the establishment of commercial satellite operators, private companies could only access remote sensing data from non-Chinese sources. Consequently, the Chinese remote sensing data analytics industry is not very developed. Because the government and research centers possess full rights to government satellite data, most data processing and data analyses activities are conducted by dedicated in-house departments. As founders of a remote sensing analytics company stated in an interview, they wanted to work on remote sensing data processing upon graduation, but in the early 2010s there was not a single company in China that specialized in such activity. As a result, they founded one of the first companies dedicated to processing remote sensing data.

Today, there are over 20 companies that engage

in remote sensing data analytics, including a few subsidiaries of state owned enterprises. These companies are primarily downstream service providers. Although many of these companies do not own or operate their own satellites, sometimes from other satellites as well. For instance, Space Eye, a 21AT subsidiary, processes and packages data from the 21AT satellites as well as from the government TH-01 satellite series. According to interviews, commercial start-ups that do not have their own satellites acquire remote sensing data from various sources, seeking the cheapest distributors of imagery on China.

Most of these data analytics start-ups have found some success in agriculture, most notably Jiahe Info and Jiage Tiandi. These companies currently provide data to agricultural insurance companies on an expedited timeline, allowing insurers to quickly evaluate damages after natural disasters. Chang Guang has also provided such services to insurance companies. These remote sensing analytics companies also provide crop-monitoring services for farmers, informing them when and where to irrigate, fertilize, or harvest.

Without divulging its methodology, the Chinese think tank FutureAerospace has forecasted that by 2025, China is expected to have about 3,100 commercial satellites; this market could be worth \$2 billion. This is about half the number of small satellites projected globally over this timeframe.

Whether Chinese companies will actually launch this number of satellites over the next 5 years is uncertain, especially as many of these companies do not have access to large amounts of capital. Chinese commercial satellite and launch vehicle component manufacturers and integrators may be able to sell to state owned enterprises.

The literature claims that the Chinese government has encouraged state owned enterprises to include commercial space companies in their supply chains. Although some satellite manufacturing services have been provided by foreign companies such as SSTL, trends in recent years suggest that China is moving to solely procuring satellites domestically.

Therefore, selling services that have historically been provided by companies with close ties to the government, such as mobile services, are likely to be restricted to domestic companies. Chinese satellite companies face export control laws that do not allow satellites to be launched on foreign providers without approval, reserving this market for domestic launch providers.

Approximately industry players noted that two strengths of China's commercial space sector are that China has a large domestic market, and that the sector can leverage China's established manufacturing infrastructure. According to one expert, "there is a huge market in China and we have lots of manufacturing experience built up over the past few decades and we have all aspects of the supply chain within China so we can cut down production costs. This is a

strength for China."

By having exclusive access to the potentially large domestic market, Chinese space companies may be able to establish themselves and their products prior to competing with large, established foreign space companies. Many of the employees pointed to high-speed railroad equipment and app-based services where the market was first proven domestically and then expanded abroad as models for the commercial space sector. IoT could be another market that follows this trend.

The biggest challenge facing China's commercial space sector is that the Chinese commercial space industry does not have a clear understanding of the market. In a public presentation, Commsat's CEO warned of the dangers of companies primarily focusing on R&D, and not enough on profitability and meeting customer needs. He stated that the Chinese commercial space sector "must understand the demand of clients first, then we can talk about what services should be provided." He also noted that his own personal philosophy is to "find out what

Commsat's clients need in terms of service and products, and then Commsat can go look for the appropriate services and products to provide." Similarly, the CEO of OneSpace noted that his largest concern for China's commercial space sector was that it would repeat the mistakes of other failed sectors, such as focusing only on technology development and not profitability, nor identifying market demand for products and services developed.

One employee of a satellite company also observed that "the biggest challenge to China's commercial space sector is that there is no real understanding of market needs for satellites. It is easy to send satellites into orbit; the real question is 'what are they doing once they're up there?' Finding possible clients, figuring out what the satellites are going to be used for these are the difficult questions. Market forces and needs are not clear on these issues so this is the biggest challenge."

A representative of a satellite manufacturing company noted that a lack of understanding of market needs is actually hindering China's commercial space sector. As an upstream provider of satellites, the company depends on downstream demand. The representative "hopes the downstream companies can figure out what they need so companies like ours can offer the right products."

A representative of one launch company observed that "there are a lot of companies in China focusing on small satellites and they can launch a lot of satellites and constellations quickly, but the bigger question is 'who's going to be their customers?' "What will be the applications of these satellites?" Chinese satellite companies need to know their market.

Why losing GPS could cost billions



The United States is losing its position as owner and operator of the world's premier space-based PNT system, after decades of over dependent upon the use of GPS for national security, homeland security, and economic security, and yet has no reliable and resilient terrestrial backups to GPS, including its asymmetric vulnerability to Navwar.

For the armed forces, GPS is the main source of positioning, navigation and timing. They depend on it not only to find their way but to synchronize their movements and ensure the accuracy of guided weapons. It's very good at all those things, which is why adversaries want so badly to take it away. The strategy is this: Jam a GPS signal, or hijack it with false information, and you essentially control the other side's ability to operate.

The Global Positioning System GPS delivers an extremely precise positioning, navigation, and timing signal to users around the world. Originally

launched for U.S. military use, in the years since its signal was made available to the private sector, it has enabled innovators to develop a host of applications, services, and products. These advances have led to substantial gains in productivity, efficiency, and personal enjoyment.

China's Beidou versus GPS

Unfortunately, GPS has been surpassed as the premier space-based Positioning, Navigation and Timing system in the world. Both the People's Republic of China's Beidou and European Union's Galileo satellite navigation systems are more accurate and provide better coverage in parts of the world than GPS. Indeed, the U.S. National Space-based Positioning, Navigation, and Timing Advisory Board warned last year that "GPS's capabilities are now substantially inferior to those of China's Beidou." China's system, for instance, has a larger satellite constellation, more ground antennas, signal post-processing, and a text messaging service for communications which makes it better than GPS, Galileo, and Russia's GLONASS

satellite navigation system.

The BeiDou constellation has grown rapidly from 2000 to 2020, and is now the world's largest GNSS with 45 operational satellites. As a result, BeiDou satellites are today more easily observed and provide more signals in most global capitals.

Beijing is supporting BeiDou overseas with additional ground infrastructure that monitors the system and improves data accuracy. BeiDou also has advanced signal features including two way-messaging which could create commercial advantages as well as pose security risks. As this dual-use technology improves and becomes intertwined with China's infrastructure exports and consumer products, BeiDou's global use will likely grow. BeiDou's most obvious comparative advantage is a larger constellation that offers greater Positioning, Navigation and Timing data availability in many parts of the world.

BeiDou satellites are more frequently observed than GPS satellites in 130 of 195 United Nations member countries and in more than 100 of the 137 BRI participating countries. In order to support this network, China has built 120 worldwide ground monitoring stations abroad, whereas the United States has built just 11 abroad.

BeiDou also offer more advanced signal features, including a two-way messaging function that could pose security risks. While other GNSS simply broadcast signals, BeiDou can send and accept messages. This means that BeiDou can identify the location of two-way messaging users.

Applications of GPS

From people driving to some place new to offices, multinational corporations coordinating complex logistics networks, hundreds of millions of users rely on GPS every day for navigation and positioning. Its precision timing capability supports industries as diverse as finance, electricity, and telecommunications. Even the term GPS has entered the popular vernacular to mean one's specific location at a specific point in time. For the United States alone, it was estimated that GPS has generated roughly \$1.4 trillion in economic benefits since it was made available for civilian and commercial use in the 1980s.

"This is a capability that used to be in a package the size of shoebox, and now it's in a device the size of an iPhone that U.S. Army troops can carry in the palms of their hands on the battlefield." GPS is the gold standard. It's reliable and it's accurate, meaning it's always the first choice for the military and many of its allies.

The ability to measure time intervals and frequencies extremely precisely is what allows GPS users to pinpoint their location anytime, anywhere in the world. The launch of Sputnik in 1957 and the resulting space race led the United States to accelerate scientific efforts deemed essential for national security and spaceflight capability, including the creation of what is today the Defense Advanced Research Projects Agency.

However, one important breakthrough occurred after researchers discovered they could discern the location of ground-receiving stations based on Sputnik's radio transmissions and accurately determine the satellite's orbit. That realization catalyzed research and development programs within the U.S. national laboratories, the military, and contractors in the private sector to develop satellite systems to further American geopolitical and defense interests. Programs from the 1950s and 1960s were combined in 1973 to form what is the GPS program today.

GPS has been called the "silent utility." It is easy to take for granted because it is both invisible and everywhere. Positioning, Navigation and Timing data allow text messages, phone calls, bank transactions, and photographs to be precisely timestamped and embedded with location

data. Modern infrastructure, from transportation to financial services, relies on GPS. The growth of new industries such as self-driving cars and precision agriculture is driving demand for increasingly accurate and resilient Positioning, Navigation and Timing.

Since achieving global coverage in 1993 with 24 satellites, GPS has enjoyed a privileged role as the world's GNSS of choice. Although the Soviet Union offered a second alternative, GLONASS, most users worldwide preferred the quality, availability, and reliability of GPS data. Providing a global "silent utility" helped maintain U.S. political, military, and economic relationships and influence. Yet while GPS is accessible everywhere in the world, not all regions have sufficient space- and ground-based infrastructure to calculate the type of precise positioning to which Western users are accustomed and upon which the next generation of Positioning, Navigation and Timing enabled devices rely.

In 2008, the United States expanded the GPS ground monitoring network from six to 16 stations, which helped improve GPS accuracy by 10-15 percent. These ground monitoring stations are unevenly dispersed, however, and they are especially rare in the developing world.

The telecommunications industry relies on continuous, error-free information transfer across a large country and a myriad of independent network operators, all of which requires sophisticated synchronization systems. Today, this synchronization is predominantly accomplished by leveraging precision time and frequency signals from GPS. GPS functions as a common source of synchronization for the entire industry.

Prior to GPS' availability, all telecom networks used analog switching and were synchronized using a precise frequency signal from an ensemble of cesium clocks operated by AT&T in Hillsboro, Missouri, and distributed over a hierarchical network. With this system, everything was traceable to a single source.

Because it was critical to unlocking advanced wireless networks with the implementation of 4G LTE, we estimate the economic impact of GPS to range from \$81 billion (based on firms' willingness to pay for spectrum) to \$686 billion based on consumers' willingness to pay for increased bandwidth and speeds.

During a 30-day outage of GPS, we estimate the economic loss would range from \$5.5 to \$14.2 billion. This analysis considers the role of GPS in both the wireline and wireless telecommunications networks but does not consider other telecommunications services such as home internet services, cable television services, and broadcast radio and television.

Precision timing enables a number of telecom services, including the synchronization of traffic between carrier networks and across wide geographic areas, initializing calls between wireless handsets, wireless handoff between base stations, carrier aggregation, directional antennas and adaptive transmission power control, and billing management. On wireless



networks, higher levels of precision timing enable service providers to increase bandwidth and handle more devices within the same infrastructure and wireless spectrum as technology evolves.

GPS chips in smartphones and other consumer devices receive satellite signals and generate precision location information that software applications use to deliver services and experiences to users. Apps help users navigate, learn what or who is nearby, track location in real time, check in and interact, play games, and enjoy experiences tailored to their geographic position. Cell phones and in-car portable devices became popularly available between 1999 and 2001. The first mobile phone with a GPS component, the Benefon Escl, became available in 1999.

In the early 2000s, several advances reignited Location Based Services development. Qualcomm developed "assisted GPS," technology, which combined GPS signals with cellular signals to provide accurate location to users within a few feet.

The first iPhone was released in 2007, kicking off production of smartphones with built-in GPS components and providing a platform for location-based apps. Smartphone ownership by American adults has increased from 35% in 2011.

The location information needed for location-based service to operate is obtained from a combination of GPS, Wi-Fi hotspot, and cell towers. However, GPS is often the most critical of

these. LBS would be far less precise without GPS, which could undermine some applications' utility. For example, without GPS, navigation systems could not accurately track a driver's position and deliver live turn-by-turn directions.

Apps like Google Maps, Yelp, and Foursquare brought location-based service to the mainstream. In 2011, approximately half of smartphone owners reported having ever used GPS for directions, by 2012, about three quarters of smartphone owners said they had used location based systems on their phones at least once. Location-based services are now integrated into the everyday lives of millions of consumers. They can be a valuable part of one's entire day, from locating car keys in the morning, checking traffic and choosing a faster route to work, to looking up a nearby restaurant for lunch and reading its reviews, getting a geofenced reminder to complete an errand after leaving the office, tracking the route taken on a run, and finding a nearby date. GPS is used pervasively in commercial shipping, fishing, and recreational boating for navigation and tracking. GPS is the primary means of navigation for nearly all vessels. This case study focuses on GPS' use in the maritime sector, what would have been used for navigation and port operations if GPS had not been made available, and alternatives should there be a GPS outage.

The maritime sector uses GPS for precision positioning and navigation and as an enabling technology of the Automatic Identification System, the Global Marine Distress and Safety System, and Vessel Monitoring Systems. GPS is the primary means of

navigation for nearly all vessels except for smaller recreational boats. GPS acts as an enabling technology for several technologies in the maritime sectors.

GPS acts as an enabling technology of Automatic Identification System. The system is a shipboard broadcast system that acts like a transponder designed to be capable of providing information about the ship to other ships and to coastal authorities automatically.

The mining sector relies on precision positioning signals provided by GPS to explore and identify promising ore bodies and support mine-site construction, extraction, and hauling processes. GPS also has been a key technology for making mines more productive and safer by reducing collisions and reducing the number of workers who are exposed to dangerous situations.

Given the breadth and depth of dependencies on GPS services as well as the range of threats, the system's unmitigated vulnerabilities could result in potentially profound domestic and international implications if exploited by an adversary or adversaries.

First, disruption or loss of GPS services could adversely affect America's political prestige and international influence. U.S. preeminence in space activities and its associated strategic advantages, already being eroded by foreign rivals, could be significantly undermined. National pride as well as international admiration for U.S. scientific, engineering, and technological accomplishments exemplified by our space operations in general and GPS in particular could be diminished. International perception of diminished U.S. power could translate into reduced international influence on the decisions and actions of foreign nations, organizations, and individuals.

Mobile phones and the War in Donbas

by Roman Horbyk



Arguably the first 'smartphone' war, the ongoing conflict in Ukraine has underscored the important role these devices continue to play in this war, and that they will play in the future. At the military level, smartphones can be a useful tactical communications alternative to military transceivers. Smartphones let people stay in touch or use the internet when conventional telecommunications may be damaged or unavailable.

These devices have been invaluable for collecting and sharing evidence of Russian-perpetrated atrocities. Worryingly, smartphones are also effective conduits for the torrents of Russian propaganda,

disinformation and outright lies Vladimir Putin's regime spews into the ether. Many soldiers describe how they made rules to prevent calls from relatives in the heat of fighting. Often, the rule was that it is the soldier who calls, not the relatives. Ignoring any incoming calls in dangerous situations becomes the norm, an exemption from the culture of connectivity. Many would simply prohibit calling them at any time: "The right time comes; I'll text myself that all's good".

Many, however, do not see "calling the frontline" as something transgressive. One respondent would easily call his comrades on duty when on leave

himself: "I simply make a call and see if it is answered. If so, then all is well. If he is out of reach, then he must be in the blindage or under shelling

. Then I wait for him to return the call". The main message is the very fact of connection, and the most important information is that the soldier is alive and well. As one relative revealed, "I could instantly figure from his tone whether he could talk. I called with the sole objective, to find out if he was alive".

"The Pentagon knew enemies could track phones for years, now they are," highlights a

growing reality that extends far beyond military operations: smartphones have become one of the most significant operational security vulnerabilities in the modern world. According to the report, U.S. military officials were warned for years that commercially available location data could reveal the movements and locations of troops, yet many of those warnings went unaddressed until adversaries reportedly began exploiting that information in active conflict zones.

The lesson is not limited to the battlefield. Today, every organization responsible for protecting people, assets, facilities, or sensitive information faces a

similar challenge. Whether it's a military installation, correctional facility, government building, corporate campus, or critical infrastructure site, the presence of unauthorized personal electronic devices PEDs can create security risks that are often invisible until it's too late.

However, the broad use of mobiles in the warzone disrupts the closed nature of the military as state institution and "an island within society-at-large", introducing new corporate actors beyond the traditional weapon manufacturers to the frontline concatenation, now embracing mobile phone producers, Big Tech, small local IT enterprises. As a non-human actor, mobile is a focal point that bundles participatory efforts of civilian individuals, volunteer groups and small businesses to support the army.

Mobile is the hardware on which the participatory war runs. Of course, smartphone use involves the social media companies and their culture of connectivity, dataveillance and consequently, mobile phone is both an asset and a liability in combat that requires soldiers to work out clear but informal rules around its use. The mobile phone has actively intervened in the course of war in Donbas and functioned as a mediator in the human associations necessitated by war.

It can provide just enough edge over the enemy in combat. But it is also the actor that helps stabilize, support and make resilient to the army as an institution, its link to the civilian support base that consists of relatives and volunteers, and each individual member's network of social ties. It extends the lifeline from the civil society and their networked publics to the army, often bypassing all other state institutions, and in so doing enables the crowdsourced and participatory war. It makes the nexus of the Ukrainian army and society more robust in confrontation with more powerful but state-centric Russian military machine, and it represents a communicative refiguration of the military.

Moreover, the modern soldier is no longer possible without a mobile. It is no longer a mere means to keep in touch and have fun, wisely left at the base before the expected engagement. It is an inherent, integral part of the assemblage of engagement and war.

This war is fought in large part with a civilian tool, a corporate product, a private belonging and even an intimate object turned into a weapon, an ultimate form of hybridity. Inasmuch as Clausewitz's war is a continuation of politics by another means, and politics itself now, in the era of hybrid warfare, is a continuation of war with other means, the war phone is also a political object.

Still, the frontline communication policy was often violated by anxious family, and phone

conversations occurred even during engagement. "Parents sometimes called from Lviv just as the barrage targeted us. I would hide somewhere and say, 'I'll call you back, I'm busy', so that they wouldn't hear that cannonading". These dangers, normally remote and imagined but now brought home in vivid mediated images of sounds of shelling in real time, photographs, videos, are clearly unsettling for families. Simultaneously, soldiers also feel pressed to maintain emotional stability of the close ones. As a result, well-intended deceptions become more normalized than in peaceful everyday life.

A report published in February by ENEA takes a detailed look at the questions surrounding the use of cellphones on, and near, the battlefield. In January 2023 the Russian military blamed cellphone signals from Russian troops for helping the Ukrainian Army locate a target in Makiivka in southeast Ukraine. Reports say scores of Russian troops were killed when a college they were using was hit on 31st December 2022. Russian troops are banned from using their cellphones within range of Ukrainian weapons. As ENEA's report makes clear, whether these signals were responsible for the geolocation of the Russian troops is debatable.

Some avoided telling outright their loved ones the truth that they were now at the frontline and not at a training unit. "We ain't pick the phone. Cause just as you pick, they go like, 'Oh sweet Lord, what are you up to poor things?' The best is not to tell you're in the thick of it. You hide deep and tell you're at a base", an enlisted private from a rural area mused.

While many, including the spouses I spoke to, believe that the permanent connection made life easier and even reduced anxiety and stress, another respondent, a junior officer, reflected on how he imagines the feelings of his mother and wife. "I think it was actually harder for them because of the possibility to call. It was better for them not to know where exactly I was and what was happening to me".

Some of soldiers noted that the family had quickly figured these "little lies", and the entire communication turned into a game where both parties pretended to believe one another. There are also those who could use their situation to manipulate relatives emotionally.

Many saw video shooting as entertainment and created own archives of mediated memories. For some, early combatants were an adventure, a form of military tourism, such attitude is hardly surprising. On the other hand, cameras had a practical role as a tool to document events, such as Prisoner of War interrogations or enemy shelling. These also enabled the rise of unusual "war porn" genres, such as filmed phone conversations with the relatives of soldiers killed in action practised by Russian irregulars and the spread of frontline blogging, encapsulated in the figure of Valeriý Markus and his rise to a practically celebrity status.

Mobiles are used for wiretapping, fire targeting,

minefield mapping. A variety of personal purposes, such as intimate communication and entertainment, are combined in the same device with combat communication that supplants old and unavailable equipment and fills gaps in military infrastructure. At the same time, the mobile increases risks to be wiretapped or targeted.

Thus, the context of relationships back home extended to the frontline and integrated it: "We had a hutsul guy from Transcarpathia who called his wife at night and said: 'Oh, Halya, there's real hell over here.' A single mortar shell landed like hundreds of meters away, and he goes like 'this is hell, I aren't know if I live to see the morning!' Just to raise his authority, make himself a victim or a hero. There are many like him".

Nevertheless, temporal change is substantial, too. The combatants in 2014 felt that they were navigating an unknown territory where many things were possible and felt the urge to share their new experiences. "At first it was like 'hey mom, look at me'.

That was a real case of a soldier who was wounded and showed it to his mom via a videocall and said: 'Mom, look I am wounded' as he bled". Later, with war becoming static and routine, and after many hard-won lessons, this attitude was replaced by complex rules and avoidance of unnecessary risks. One could observe a gradual shift from that "call mama" mentality to communicating from safer bases behind the frontline, in pace with professionalization and routinization of the conflict.

War also raises the status of voice and oral communication, seen as more authentic and trustworthy than suspicious text. Voice calls were in particular prioritized over texting. The soldiers stress that it was vital to hear the voices of their wives and especially children, and spouses describe the effect they experienced as therapeutic as well. Texting, on the contrary, is pictured as fishy: "When you get a text, God knows who is actually texting. When you text, God knows who will read it on the way". This leads to another broad area of frontline media ecology: wiretapping.

In the US, the Army fears that its massive electronic footprint is becoming a major vulnerability that could leave troops more exposed and open to detection. Electronic signals emitted by U.S. forces make it easier for tech-savvy enemies to keep tabs on units' locations and movements. The spying tools are relatively cheap and ubiquitous: iPhones, Google maps, commercial tracking software. 'It's an unbounded battle space,' said Lt. Gen. Robert Ashley Jr., Army deputy chief of staff for intelligence. The idea that anywhere the Army goes there might be people out there 'pushing pictures' fundamentally undermines 'our ability to have operational security.'

"General: Marines, put down those cell phones!": "Neller said the Marines and Navy had seen exercises in which their personnel's use of mobile devices could give away positions to adversaries. 'What do you think the largest electromagnetic signature in the entire MEF headquarters emanated from?' The billeting area. Why? Because everybody had their phone on. The Navy has come up with plans to reduce its reliance on modern electronics to make its force harder to trace, going so far as to have sailors relearn navigating by the stars instead of using the Global Positioning System', he said."

"China's military bans Apple Watch": "The Asian power's military has banned the smartwatch and other wearable technology over cybersecurity concerns that the devices could be used to track troops, record audio and video and capture military secrets," according to latest report.

Lately, the easiest and the most typical makeshift constructed by soldiers in a trench is a charging station for their mobiles. This improvised charging stations are also a well-known staple of the peaceful military life at Soviet-era barracks with very few sockets.

However, other needs required advanced IT skills. One such area is mapping of own anti-tank minefields by pioneer soldiers using civilian GPS navigators hacked to ensure the acceptable margin of error between 1–2 m. Eventually, the need for up-to-date maps brought to life a volunteer-driven project, Armiya SOS, whose live, real-time map of the battlefield could be accessed and edited to the minutest detail by soldiers on the ground using standard tablets connected to local network.

Civilian professionals also developed a software called Bronya with a purpose to automate all calculations that any canon fire requires. The software is installed on tablets donated by volunteers to the military and is also well known among the respondents. One of them, a gunner, was himself involved in development and introduction of the earliest version in his brigade, which is an interesting example of a participatory practice that influenced decision-making. According to a soldier, the software became a key factor in the success of Ukrainian artillery because it allowed the army to reduce the calculation time from minutes to seconds, which is a light-year difference in today's warfare. At the same time, the military had to learn from the risks such high-level digitalization entails as one similar app was hacked by the Russians allowing them to target Ukrainian batteries.

"I watched all seasons of Game of Thrones there"

One of the most vital smartphone functions, and our major dependencies on them, is providing access to news content. With



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official military media unpopular and dismissed as “brainwashing”, Facebook accessed overwhelmingly through smartphones became the principal source of news on par with relatives’ word of mouth. This forced soldiers to sort out and fact check a variety of sources by themselves and to develop media literacy skills. Some are now aware of fake news and manipulation, and many developed that awareness first after they had arrived on the frontline.

Under these conditions, it was again the power of oral word that held the most authority. As one officer remembers, “To get the news, we called each other”. However, in words of another interviewee, a journalist in civilian life, “soldiers are not very interested in information about the war”.

Actually, the content in high demand is entertainment. Mobiles, and to a lesser extent tablets and laptops (especially at the “second-line” bases), provided entertainment on what interviewees oftentimes describe as a “boring frontline”. “It is very boring. You get used to that circus, and then it gets so silent and you think: ‘There’s something fishy about it’. And weird thoughts start coming to your mind”.

Soldiers used phones to watch films and series, play games such as mobile versions of chess that could also be played as a boardgame, listen to music, watch TV and receive news on the frontline. This was also stimulated by the systematic TV signal jamming from the Russian side (reportedly up to 15 km deep). Poor connection stimulated use of torrents that allow downloading about one-hour worth of content a day even with unstable connection.

“We once occupied a position for a month during Christmas and New Year holidays. It was a ceasefire. We were underground, the weather was a nightmare, snow and rain for a month in that Donetsk clayish soil. Knee-deep in mud, and no internet. We ran around: ‘Who’s got movies?’ There, I watched every but the last season of Game of Thrones on the phone. The guy copied to my 64 GB phone memory card as much as could fit, I watched and deleted it to make room for the next batch”.

Information sharing would thus become a communal act: “Those who hanged out at the headquarters, in more civilized conditions, would simply download stuff to a memory stick and pass it to us”. Also, media amalgamations would form around places with better infrastructure and stronger bandwidth. “We often used the fact that Bakmut had a better 4G connection. It was our downloading hub”.

Many soldiers read books, and mostly on mobiles or tablets with saved ebooks, effectively getting rid of the extra weight and increasing the amount of available reading. The priest, who since 2015 is dividing his time between his parish in northern Ukraine and the frontline units he services, says that he never leaves for the warzone without his smartphone, tablet and laptop.

The weight of all the service books I need to carry

would have been prohibitive, but I have all of them electronically on my tablet, as well as music and records of liturgies. I am carrying out different rites, including marriages and baptism, because I am also trying to embrace local civilians with spiritual care to the best of my capacity as I have founded a church and a parish in a frontline village.

Another important affordance of the mobile is the presence of camera. Taking photographs and filming was part and parcel of killing time on the boring frontline.

These participatory practices could be as simple as making video pranks, or in this story from a private: It was prohibited but who would tell you anything if nobody ever visited us? All fear for their butts I even have a memory stick full of all those pranks. Like, we would be bored to death in winter, and would take a hood from a Žygul’ car, wire it to another car and ride on it like a sledge through the town, with pirouettes.

“God knows who is listening”

The mobile phone is among the soldier’s first non-human allies alongside their weapon, but it is not a trusted one. If it is still a friend, it is the kind of friend you would not let in on the most important secrets. In such extreme conditions the “basic trust in justness and non-failure of these systems” that legitimates mediatization is extremely low. Electronic eavesdropping pervaded the frontline of the War in Donbas, and the relevant equipment was used by both the Ukrainian and separatist and Russian units. Walkie-talkies, mobile phones and even radio stations were monitored, and commanding officers tended to discuss issues that matter in person whenever possible. Surveillance is not an abstract concept on the frontline it is the lived reality. This communication literacy to the point of distrust also developed from trust that initially was excessive.

ENEAs’ study says that cellphone signals can be located through passive radio frequency sensing and then triangulated to determine their point of origin. This method relies on the cellphone actively transmitting. Active direction finding is a more complex approach involving a tracking station. The station will communicate with the phone making it generate a signal as a response. Once this signal is generated it can be geolocated.

A pioneer officer recollected how he was instructed by his senior commander in 2014 to report on a task by sending a picture of the installation in question to a private email on the Russian service Mail.ru, which was almost as good as sending it directly to FSB. Such practices no longer happen, as the informants testify.

Wiretapping, though, remains a problem and is aggravated by the similar equipment used by both sides. The cheapest and most hack-prone appliances are also the most widespread: “Just turn on the autosearch, and it finds by itself all the nearest active signals, you listen to it and all”. But Ukrainian soldiers did not feel they were merely passive victims, and freely admit they often did the same.

Back then we used old Motorolas with a real mighty antenna, both from volunteers and organic equipment [Štatni]. We mostly used the Chinese junk, and we could listen to them via that autosearch

function. Our guys would come once a week to reflask it so that they couldn’t do the same to us.

Soldiers were also used to permanent wiretapping not only by the enemy rumored by some to reach up to 25 km deep behind the Ukrainian lines but also by what they perceive as eavesdropping by their own security services, something that my respondents believe in unanimously. The conversations are made banal on purpose, and certain keywords are avoided altogether: “Once my wife called and asked, ‘where are you now?’

And I heard at once a characteristic sound in the background, meaning they are recording. I say, ‘Guys, turn it off, let me talk with my wife, I’m legit”.

Although many, particularly the signal troops serviceman I talked to, doubt the possibility to identify hacking by noises and network jumps while the device catches signal from a new station, this does nothing to the fact that such stories are a core element of the soldier lore, remain widely believed and provoke counteractions, such as code words as a strategy to resist eavesdropping:

“For example, I can call and say, ‘the table is served, waiting for guests.’ Then, ‘guests on the way, serve hot meal’, and there goes the artillery”. Other soldiers use numerical codes; for instance, 450 can stand for “all clear”. Real or not, this perceived wiretapping is part of soldier’s world and mobile use.

On the other hand, soldiers admit their phones would catch signal from base stations from “separatist”-run and Russian mobile operators in certain areas, which obviously creates opportunities for tampering with their data. The informants cite documented cases of Russians installing a fake base station masked as that of a Ukrainian operator, with a purpose to get access to communications through the mobiles of soldiers deployed in the area.

Russian intelligence may also target soldiers with online gaming addiction by identifying devices with large traffic to gaming sites, to use this addiction in their recruiting efforts. For all these reasons, online communication has been restricted. While Skype, Telegram until about 2018 and WhatsApp were at least allowed, the use of Viber was banned (due to its poor security and Russian links) but it still may be used for planting disinformation with the enemy.

Others, though, continue using Viber but avoid going into any significant and potentially sensitive details. “We were instructed to disinform via the phone, even the battalion commander told us: ‘You talk to parents, friends mess your traces”.

According to others still, the connection was often too poor even to call, let alone use online messengers. Short range wireless and peer-to-peer tools, such as Bluetooth and SHAREit, were seen as safer alternatives to send files to comrades-in-arms.

Soft targets: targeting and spotting

The phone can let you down in many ways. Even as the phone’s screen lights up in darkness, it may be visible miles away and become as dangerous as lighting up a cigarette. Even phone directories can be risky. Our company commander had a notebook with our contacts and necessary contacts to next of kin in case of trouble. There was one critical moment when the risk of massive shelling was imminent, and we had no time to pull away. I saw the commander simply destroy the notebook. He made a small fire and burned it.

Another danger the phone may bring on its owner is fire by enemy artillery. Here is one of the shocking cases from an experienced officer: I went with a guy who had to broadcast coordinates. I cleared the field, he set it up, then I check with the map and see we came to a wrong area.

He says, ‘I know.’ And then the area where we were supposed to be is shelled. He says, ‘Got it?’. I say, ‘Got it.’ And then a new strike hits very close to us! And the guy goes nuts: What bastard took the phone? And a young soldier comes forward and says, ‘I just called mama.’ In 5 min we were gone, and the place was pulverized.

A more routine situation is when artillery targets many mobile numbers that simultaneously become active in an unexpected place, such as in the middle of a field or wilderness. Tracing this requires access to base stations, which is often unproblematic at the digitally porous frontline.

One informant told me it is even possible to calculate the unit’s strength by weighing the number of active phones with a certain factor, the expected number of people who routinely turn off or leave their phones behind apparently the military tried to gauge it.

Aware of the risk, soldiers are also trying to use it to their advantage and target the enemy phones. “When our mortars started shelling, they asked us to turn off our phones that interfered with their targeting in some way. As soon as they were done, they let us turn them back on”. However, as the gunner informant admitted, this job is often done by highly specialized units, is not advertised and somewhat exceptional.

At the same time, some reports indicate that specialized devices, privately owned by some of the troops, could be used to identify mobile phone signal.

During that moment, the explanation is that there were too many mobiles anyway, which created much noise and decreased the relevance of targeting mobile phone signals. Introducing the human actor raised the network’s precision. Spotting was also done by mobile and often involved civilians a further blurring of the military/civilian line. By 2018, most of the spotters would have been caught, but they had been an ordinary element in the fighting earlier.

Like, a guy with a phone, who is riding on a motorbike and shouting, ‘to the right’, ‘to the left’. We see someone like that, we send out an assault team. There is even a base of the numbers those spotters call. We didn’t have those and had to correct with a drone. The strategies employed to deal with the



targeting risk are a lesson in the futility of prohibition. Commanders tell to leave phones at the base often yet inconsistently because it is inapplicable for some tasks and there would always be those who disobey. In July 2015 the Ukrainian parliament banned the use of mobile phones, cameras, radio receivers and computers by soldiers in the warzone.

Mobiles remained in use de facto as the most reliable communication tool in absence of secure systems. The effort refocused from banning what cannot possibly be banned to coping strategies. In particular, activists published soldier’s guides on the use of mobiles, with advice ranging from “no earplugs!” in the field to how to protect a smartphone from mice. Eventually, mobiles were allowed again in August 2017 after an outcry and what soldiers

described as mass disobedience of the personnel. Mobile use may now be officially permitted by respective commanders if necessary for performing a military task, but soldiers point out that most of the ways in which they use phones can be excused as connected to a military task. Communication is vital. It is the air the war breathes.

In other words, people had to enter a complex negotiation of the frontline connectivity consequences. He said: “The disadvantages of turning off the phone are self-evident, such as being unable to communicate during combat, but sometimes appear too basic. One soldier complained that, as their unit was told to turn off their phones and dislocate batteries amid incessant enemy shelling, he had a difficulty with his sentry duties”. “I just couldn’t follow the time because I had no wristwatch.

I just simply couldn’t tell when my duty was over, and when it was my turn to do sentry. Imagine not sleeping a few nights before, and that we were only two to cover sentry all night”. Phone is thus often seen as an acceptable risk: people are not very concerned with security. Liberty trumps safety, as often in Eastern Europe, especially when safety appears as illegitimate and whimsical imposition

in absence of ostensible threat in a place known to be dangerous anyway. To be sure, civilians are reported by my respondents to be as much or even more negligible. In any case, there are many other ways to find information and target fire, so abstaining from the phone use does not remove dangers while taking away all the benefits, and it

makes little difference to many whether one dies in a shelling targeted through one’s own phone or an enemy drone.

Safety was also less significant under conditions of stagnant, static warfare. “Everyone knows anyway that such position exists”, a military paramedic explained. She continues: Fighters are aware of the risks but it is perceived differently there.

When you’re in it for years, people stop caring for armour vests, helmets, because you can’t escape your fate. If you’re having a smoke under barrage, so why care about the phone? I saw people using mobiles under shelling. Myself, I didn’t turn it off when we were under artillery fire. Conversely, I felt an urge to send fare farewell texts to all who I know. Really. But I didn’t do it because, what if not, what if I survive?

Startup Agnikus Cosmos lift-off world's first 3D printed rocket engine

On July 18, 2026, Skyroot Aerospace's Vikram-1 rocket reached a 450-kilometer orbit and released four payloads, making the Hyderabad-based startup the first Indian private company to reach orbit and in turn making India only the fourth country, after the United States, China and Russia, with demonstrated private orbital-launch capability. Coverage of the launch understandably focused on Skyroot itself, a decade-old startup backed by a valuation of roughly \$1.1 billion, which succeeded where the state agency ISRO had taken decades to build comparable capability.

Indian Space Research Organisation ISRO congratulated Agnikus, saying it is a major milestone, as the first ever controlled flight of a semi-cryogenic liquid engine realized through additive manufacturing. The achievement showcases Brilliance of our young innovators.

We are proud to present India's first semi-cryo rocket engine, which is also the world's most integrated single shot 3D printed piece. It signals the ability to rapidly assemble rockets that is unparalleled, said Prof. Satyanarayanan R Chakravarthy, founding advisor Agnikus Cosmos and head of National Centre for Combustion Research and Development, IIT Madras.

But Skyroot's achievement, and the more technically ambitious effort underway in parallel at Agnikul Cosmos, are best understood not as standalone entrepreneurial success stories but as the visible edge of a reorientation of Indian space policy that has been underway since the mid-2000s in which a program historically centered on civilian development has taken on a growing security and national-prestige dimension alongside it.

Vikram-1 is a small-lift launch vehicle, designed to launch satellites weighing around 300 kilograms to Low Earth Orbit (LEO). That places it in between the ~250 kilograms Rocket Lab's Electron rocket has been pushing to the same orbit class and the ~350 kilogram range ISRO's SSLV rocket can pull. Today Electron, the leader in the small-lift space, launches far less frequently than originally envisioned. What started out as a plan for 50+ launches annually has in practice hovered around a single dozen. That's because medium-lift rockets like SpaceX's Falcon 9 have launched the vast majority of orbital probes. Many upcoming

market entrants like Rocket Lab's own Neutron rocket are medium-lift vehicles too, hoping to slice the Falcon 9 pie. As such, it's doubtful if small-lift rockets have a sizeable market to begin with in order to be revenue positive. The fact that the Hyderabad-based Skyroot effectively also competes with ISRO's own SSLV rocket, and both vehicles compete internationally as well, further constrains the chances of business success in a limited market.

For most of its six-decade history, India's space program was defined by the developmental vision of Vikram Sarabhai and Homi Bhabha. Space technology existed to solve socio-economic problems and address issues involving rural communication, weather forecasting, agriculture and disaster management, not to project power or compete for status. India was, in fact, a vocal critic of the superpowers' Cold War-era antisatellite tests and of Washington's Strategic Defense Initiative, and deliberately kept its civilian space program separate from its defense establishment.

SatishDhawan Space Centre

India's only active orbital spaceport is the SatishDhawan Space Centre in Sriharikota on the country's south-eastern coast, a low-latitude location suitable for many kinds of launches. The port primarily houses two launchpads, and their many associated facilities. The two pads are literally called the First Launch Pad (FLP) and the Second Launch Pad (SLP) respectively. India built the FLP in the early 1990s for ISRO to launch the then-new PSLV rocket. Today, the pad also supports launches of the SSLV rocket. Vikram-1 was launched from the FLP as well. The company does not have a pad of its own yet. As for ISRO's SLP, it can also host PSLV or SSLV launches but does so less frequently as ISRO built that pad in 2005 to primarily launch the heavier rockets GSLV Mk II and LVM3. These latter two vehicles cannot be launched from the FLP due to them sporting cryogenic upper stages.

India's private space race should not be understood as a retreat of the state from the space sector. It instead represents a reorganization of national capability. The government continues to set priorities, control critical infrastructure, authorize operations, transfer mature technologies and

shape demand, while private firms are assuming a greater role in design, production, service launches and technological experimentation. The emerging model is better described as state-enabled commercialization: capability is distributed across a wider ecosystem, but the strategic direction remains substantially public. In January 2007, China destroyed one of its own aging weather satellites with a ballistic interceptor, scattering thousands of pieces of debris and demonstrating a capability no other Asian power possessed.

Indian officials continued for a time to insist publicly that India opposed the weaponization of space, but the test, in the words of Indian security scholar Rajeswari Pillai Rajagopalan, forced "a re-evaluation of India's traditional declaratory policy against the militarization of space." Twelve years later, that re-evaluation produced a demonstrated capability of its own: on March 27, 2019, Prime Minister Narendra Modi announced that a DRDO interceptor had destroyed an Indian satellite in low Earth orbit under Mission Shakti, making India the fourth country, after the Russia, United States and China, to test a kinetic antisatellite weapon (ASAT).

A tri-service Defense Space Agency, approved the previous year and headquartered in Bengaluru, was built to institutionalize that capability, and by November 2024 it was running its first simulated space-warfare exercise, Antariksha Abhyas. Yet the old ambivalence has not entirely disappeared. In December 2022, India abstained rather than vote in favor of a UN resolution calling for a moratorium on destructive antisatellite testing, as it was unwilling to fully foreclose an option it had only recently exercised of its own accord. The link between security reorientation and the decision to privatize launch-vehicle production is not merely doctrinal.

It is in part a capacity issue. Rajagopalan and her co-author Dimitrios Strokios identify "capacity crunch within the state space agencies" as one of the drivers of India's turn to the private sector, and the numbers bear this out. ISRO operates on a budget of roughly \$2 billion and a workforce of around 16,000, a fraction of what China or the United States commit to their space programs, while being asked to sustain a growing military satellite constellation, a human spaceflight program (Gaganyaan), and routine commercial launch demand. Something had to give, and what gave was ISRO's monopoly on building rockets.

The 2020 reforms and the Indian Space Policy of 2023 formalized that shift, establishing IN-SPACe as a single-window regulator and

directing ISRO to transfer mature launch systems, including the Polar Satellite Launch Vehicle, to industry. The regulatory response was immediate. Some 290 companies applied for authorization in the policy's first years, and the number of registered space startups grew from a single company in 2014 to 189 by the end of 2023. The government's ambitions are stated in equally concrete terms: Officials have set a target of growing India's space economy from roughly \$8 billion today to \$44-50 billion, and from about 2 percent to closer to 9 percent of the global market, by the end of the decade.

Skyroot and Agnikul emerged as the two companies furthest along the path toward independent orbital launch, though they pursue markedly different engineering routes. Skyroot relies on conventional solid-and liquid-fueled staging; Agnikul has built a 3D-printed, semi-cryogenic engine and India's first privately built and operated launchpad, with technical support from the Department of Space. Agnikul has not yet reached orbit. Its planned Mission-02 aims to combine an orbital debut with recovery of the first-stage booster, a more ambitious sequencing that suggests the coming competition will be decided by reusable architecture as much as by who arrives first.

The strategic stakes extend well beyond who wins that competition. Retired Air Marshal R. Radhish has argued that India's security establishment needs to integrate commercial space capability into national defense planning, much as the US Department of Defense and NATO have formalized their own commercial-space strategies, precisely because dependence on foreign providers carries real operational risk. The most frequently cited case is the interruption of Starlink service to Ukrainian forces in 2022. A domestic private launch industry gives India redundancy, a faster technology-refresh cycle, and reduced exposure to foreign leverage during a crisis, a lesson India's military planners have drawn explicitly from the war in Ukraine.

The strategic implications of commercialization are not confined to defense. An internationally competitive private space sector would allow New Delhi to offer launch, satellite and data services to partners across the Indo-Pacific and the Global South, strengthening India's position as an alternative technological partner without requiring formal security alignment.

Private space capability therefore serves not only domestic resilience and economic growth but also India's broader pursuit of status, strategic autonomy and influence over the emerging governance of space.

None of this should be mistaken for a mature industry. A single successful orbital flight resolves neither the capital constraints that have historically made Indian space startups harder to fund than their American or European counterparts nor the multi-year gap between a demonstrated capability and a sustained commercial launch cadence. It is clear, however, that Skyroot's July 2026 flight was not just a commercial milestone. It was the latest and most visible marker of a policy reorientation that began not in a boardroom but in the debris field left by a Chinese missile test in January 2007.

Rise of commercial space sector

The rise of the commercial space sector in India is a new phenomenon. This has been led by companies like Team Indus, who were finalist at the XPRIZE, but bowed out in the final months due to lack of funds. In fact, none of the five finalists were able to claim the \$30 million prize. In a statement, the X Prize organizers stated that "This literal 'moonshot' is hard, and while we did expect a winner by now, due to the difficulties of fundraising, technical and regulatory challenges, the grand prize of the \$30m Google Lunar XPRIZE will go unclaimed."

In response to the development of a vibrant space commercial sector, India established a NSIL in 2019 in order to build a platform for Indian space industry to sell their products to a global clientele. This shift for India from being a state driven space nation to becoming more open and privatized was observed when a large amount of the space budget was allocated to NSIL, with ISRO adopting the role of a facilitator for space innovation.

NSIL now has the authority to solicit participation of the private sector directly. Today, Indian private sector can manufacture rockets, once the sole domain of ISRO. This in turn has created the development of a private space sector generating employment, as well as retention of talent since not all who want to work in the space sector can get jobs at ISRO. In October 2021, Modi launched ISPA billed as the premier space institution for space and satellite companies. Modi stated on its foundation:

"Today is the day the Indian space sector



receives new wings. For 75 years since independence, Indian space has been dominated by a single umbrella of Indian government and government institutions. Scientists of India have made huge achievements in these decades, but the need of the hour is that there should be no restrictions on Indian talent, whether it is in the public sector or in the private sector. In a way, the country has given a new gift to the talent of India's entrepreneurs by opening up India's space sector in its 75th year of independence.

Amongst the newspace companies in India are Astrome, Bellatrix Aerospace, Earth2Orbit, Exseed Space, ReBeam, Satsure, Skyroot Aerospace, SmartEnovations. Bellatrix Aerospace is developing a rocket propulsion system, aspiring to build a small launch vehicle and is the first company to be offered a contract with ISRO. Bellatrix has also raised about \$3

million in funding becoming the first Indian startup to accomplish that. This funding will be utilized to demonstrate its thruster technology specifically its electric propulsion system that runs on water. In February 2021, Bellatrix and Skyroot Aerospace signed a Memorandum of Understanding to build a vehicle termed a 'space taxi' aimed at offering ridesharing for small satellites and dropping each satellite to its orbit. Skyroot Aerospace is building India's first private rocket, the Vikram I and have successfully tested its upper stage engine Raman and Solid fuel demonstrator Kalam-5 in 2020. Satsure aims to utilize space systems towards building sustainable eco systems.

Sature and Bellatrix signed an MoU early 2021 to power its fleet of remote sensing satellites. Astrome seeks to develop wireless millimeter wave technology.7Exseed Space is the first entirely private Indian space start-up to succeed in building and

launching its own satellite on an international commercial launch. ReBeam aims to build wireless transmission of power for technologies like Space Based Solar Power.

SmartEnovations is focused on developing space systems to include virtual testing, simulation and validation. Earth2Orbit aspires to support global climate action using space data analytics. Pixmap India is planning to launch a constellation of Earth imaging satellites aimed at monitoring every part of the globe, and beam back high-resolution imagery useful for urban planning, agriculture and monitoring climate change.

However, the company could not meet its stated launch date on ISRO's PSLV C51 in March 2021 due to software issues. However, the launch of the satellite was viewed as special given it would have been India's first privately developed satellite to launch on an ISRO rocket.

SPECIAL REPORT

ICEYE: "Reducing external dependence is key to space intelligence sovereignty"



Between February 27th and March 1st, heavy rain fell over Kentucky with some locations picking up more than 6". The rain caused multiple river and creek basins to swell and inundate communities statewide. Multiple communities had to evacuate as flood waters reached levels not seen in decades, and nearly 50 counties made disaster declarations.

The flooding event was severe and historic. County officials in the hardest hit areas stated that the event was unlike anything they had seen and will be one for the record books. The two river systems most affected both saw dramatic and rapid rises in water level. The Red River rose up to 9 feet above flood stage, and the Kentucky River rose up to 14 feet above flood stage². The majority of the water rise occurred in just 24 hours, leaving residents little time to react. One town on the

Kentucky River within the ICEYE analysis area, Boonesville, hit record water levels.

ICEYE monitored Kentucky for the potential of flooding in the days leading up to the event. As soon as flooding became imminent, ICEYE tasked the satellites to acquire multiple images over the course of the event. ICEYE then performed extent and depth analysis within 24 hours of image acquisition.

A Shift in Earth Observation

The satellite data and Earth observation sector is undergoing rapid change. According to ICEYE's leadership, the focus is moving away from simply purchasing satellite imagery toward building and operating complete intelligence systems.

"Governments are no longer satisfied with buying images alone," explains company representative Gonzalo Garcia Munoz. "They want systems that can control that deliver usable information in near real time."

This shift toward sovereign intelligence has accelerated since the war in Ukraine, which has highlighted both the operational value of continuous SAR (Synthetic Aperture Radar) monitoring and the risks of relying heavily on external partners for critical data.

A key development in the industry is the growing importance of satellite constellation size. One or two satellites are not enough to provide frequent coverage. As a result, countries investing in sovereign SAR capabilities are increasingly planning constellations of four, eight, or more satellites.

This reflects the need for persistent monitoring: the ability to observe the same location several times a day. Whether for defense, disaster response, or environmental monitoring, frequent and reliable coverage has become a basic requirement. SAR technology is playing a larger role in disaster response and climate resilience. Unlike optical satellites, SAR can operate at night and see through cloud cover, making it particularly useful during emergencies when visibility is often limited.

ICEYE provides near real-time data related to floods, wildfires, and hurricanes for governments and insurers worldwide. As extreme weather events become more frequent, dependable monitoring systems are increasingly seen as part of essential public infrastructure.

Sovereignty is reducing external dependence

Pekka Laurila, co-founder and Chief Strategy Officer of Finnish space intelligence company ICEYE, said the competitive axis of the satellite industry is shifting from sharp imagery to AI-powered intelligence analysis. ICEYE has built a mass-production system for SAR satellites weighing under 100 kg, and its AI system automatically classifies ships, aircraft, and vehicles with over 90% accuracy. The company was valued at more than 10 billion euros approximately \$11 billion in June and aims to produce 100 satellites annually starting in late 2027.

Laurila emphasized that for South Korea to secure true space intelligence sovereignty, reducing external dependence matters more than satellite ownership itself. He also confirmed ongoing commercial collaborations in South Korea, including flood monitoring with KT SAT and an agreement with South Gyeongsang Province.

Pekka Laurila, co-founder and Chief Strategy Officer CSO of Finnish space intelligence company ICEYE, emphasized that the competitive axis of the satellite industry is moving from "sharp imagery" to "AI-based intelligence analysis." He will deliver a keynote address at Smart Cloud Show 2026, South Korea's largest tech conference, held at the Westin Josun Hotel in Sogong-dong, Seoul on the 26th of this month.

ICEYE is Europe's largest space intelligence company, having been valued at more than 10 billion euros approximately \$11 billion during a funding round in June. Founded in Finland in 2014, the company reduced synthetic aperture radar (SAR) satellites, which previously weighed over one ton to under 100 kg and established a mass-production system. Since placing ICEYE-X1, the world's first commercial SAR satellite under 100 kg, into orbit in 2018, the company has launched 76 satellites to date.

How AI is reshaping the competitive landscape

ICEYE's AI system "Detect and Classify" automatically detects and classifies ships, aircraft, and vehicles in SAR imagery. According to the company, accuracy exceeds 90%. "As the number of satellites and observation frequency increase, there's a limit to how much imagery humans can manually review," Laurila said. "AI is the key tool for automatically identifying meaningful changes within vast amounts of satellite data and accelerating analysis speed."

He stressed that repeat observation is becoming more important than a single ultra-high-resolution image. "A single SAR image only shows one moment in time. When you observe the same location repeatedly, you can see what's changing over time," he said. "If you can only revisit an area of interest once every few days, that's closer to surveillance than intelligence. True intelligence capability means being able to observe the same area multiple times a day, regardless of weather."

ICEYE's latest fourth-generation (Gen4) satellites offer resolution down to 16 cm. Laurila explained that the vertically integrated structure from satellite design and manufacturing to ground infrastructure, AI analysis, and operational support is the core of the company's competitive edge. He particularly emphasized that the sovereign satellite system is built in Europe and therefore not subject to U.S. International Traffic in Arms Regulations (ITAR)

controls. Military equipment subject to ITAR may require U.S. government approval for third-country transfers, technology sharing, or modification.

Battlefield credentials proven in the Ukraine war

ICEYE has grown its presence in the military and security sector in the wake of the Russia-Ukraine war. In 2022, Ukraine secured dedicated use of one ICEYE SAR satellite and access rights to the satellite constellation's imagery, using it to track Russian troop movements and military facilities. According to Ukraine's Defence Intelligence Directorate, the number of Russian target images obtained through ICEYE satellites reached 4,173 by June 2024. As SAR satellites which can observe the ground with minimal interference from clouds or darkness proved their value as intelligence-gathering tools on an actual battlefield, ICEYE's technology drew significant attention. Regarding the "Europe's SpaceX" label, Laurila drew a clear distinction: "We solve different problems." "SpaceX solved the problem of 'getting to space' by lowering launch costs and increasing frequency through rocket reuse. ICEYE solves the problem of rapidly and continuously acquiring intelligence from space for defense, environmental monitoring, insurance, and disaster response," he said.

Production capacity expansion is also underway. Initially, annual launch volumes were in the single digits, but the company has recently built a mass-production system, raising production rates to around 50 satellites per year. It plans to expand to 100 per year by late 2027.

Cooperation with South Korea and Space intelligence sovereignty

Laurila emphasized that for South Korea to secure true "space intelligence sovereignty," reducing external dependence matters more than satellite ownership itself. "True sovereignty is less about what you own and more about what you depend on. If a foreign supplier or government can restrict what South Korea sees, how quickly it receives information, or who it shares information with, that cannot be called full sovereignty," he said.

He explained that South Korea needs satellites it owns and commands, ground systems installed on South Korean territory and operated by South Korean personnel, independent tasking authority that cannot be interfered with from abroad, and data stored and processed domestically.

On the current state of cooperation with South Korea, he said, "South Korea has already built independent capabilities through Project 425. Separately, ICEYE has also begun commercial collaboration in South Korea. We are conducting flood monitoring with KT SAT and have signed an agreement with South Gyeongsang Province." Project 425 is a program to deploy five military reconnaissance satellites to give the South Korean military independent surveillance and reconnaissance capabilities.

On the possibility of expanding cooperation into satellite production or technology transfer, he responded, "We are open to deep cooperation in all areas. What matters is defining the scope of local participation according to each country's needs. It could be production, it could be operations, or it could be developing domestic talent."

ICEYE delivered a fully operational sovereign space intelligence system to the Polish government in May 2026. It took 12 months from contract signing to achieving full operational capability. "Capability doesn't emerge just

from having satellites. You need to connect sensors, satellites, ground systems, and AI analysis into a single end-to-end intelligence system," Laurila emphasized. "Our strength lies in integrating all these elements into one system and turning them into genuinely operational intelligence capability."

Progress of ICEYE throughout the years

ICEYE is an innovative space technology company that was founded in 2014 in Finland and has since grown to become a leader in the global space industry. ICEYE is best known for its revolutionary satellite technology and its ability to provide real-time data from any location on Earth. The company's mission is to enable everyone to better understand and use Earth's resources. ICEYE has made significant progress in the past eight years.

It has achieved numerous milestones, including the launch of its first satellite in 2016, which marked a major step forward for the company in terms of technology and progress. With its second satellite launch in 2018, ICEYE became the first company in the world to successfully launch two commercial imaging satellites. This demonstrated the company's ability to deliver on its promises of providing high-quality imagery and data to its customers.

In 2019, ICEYE launched its third satellite, SAR-X, which marked a major breakthrough in the field of synthetic aperture radar (SAR). This technology allows ICEYE to access radar data from any location in the world and has been used to provide images of the Earth's surface in areas of extreme weather conditions. This technology is used for a wide range of applications, such as disaster response and humanitarian aid, as well as for military and security purposes. ICEYE has also invested heavily in developing new technologies and applications.

One of these is the ICEYE-X2 satellite, which was launched in 2020. This satellite is equipped with advanced X-band SAR technology, which allows it to capture images of higher resolution than any other existing SAR satellite. This technology is being used to provide real-time data in areas of natural disasters and other emergencies, as well as for more commercial applications.

ICEYE has made significant progress over the last six years and has established itself as a leading provider of space-based data and services. The company's mission to enable everyone to better understand and use Earth's resources is being achieved through the innovative technologies that it has developed. With its continued focus on innovation and progress, ICEYE is well-positioned to remain a leader in the space industry for years to come.

Future of ICEYE

The future of ICEYE and the space economy is filled with promise and potential. The next decade promises to bring even more opportunities for ICEYE and the space industry as a whole. The global space economy, now estimated to be worth over \$350 billion, is projected to reach \$1.1 trillion by 2040, according to McKinsey.

This growth is driven by a growing demand for satellite data and services, along with the emergence of new players in the market, such as drone companies and startups, who are leveraging the power of the space industry to create new products and services. ICEYE is well-positioned to take advantage of this potential. The company has already launched multiple satellites into space and is actively developing new technologies and services.

Looking ahead, the satellite industry will require expertise that bridges space engineering, defense operations, and AI-driven analytics. ICEYE sees its greatest growth potential in supporting countries building their first space-based intelligence systems, including the delivery of turnkey, sovereign ISR (Intelligence, Surveillance, and Reconnaissance) systems.

SPACE STARTUP PROFILE

From capability to confidence: India's path to space power



India's space economy is currently valued at \$8.4 billion and is projected to grow to \$44 billion by 2033. The government aims to achieve the target with enhanced participation of private sector in space domain. Pioneers such as Skyroot Aerospace, which launched India's first privately developed rocket, Vikram-S, in 2022, and Agnikul Cosmos, working on a semi-cryogenic launch vehicle, exemplify this transformation.

India's space sector has evolved into a rapidly expanding and increasingly commercial arm of the services economy. Reflecting strong global demand, India's commercial launch services facilitated 399 foreign satellites after 2014, out of a total of 434 foreign satellites launched by ISRO, generating nearly \$233 million and €323 million in revenue. Of the projected \$44 billion Indian space economy by 2033, the launch segment alone is expected to contribute approximately \$3.5 billion. This highlights the growing importance of launch services within the overall space sector growth

trajectory. India's vision has always been to possess autonomous space capability. At present, the country designs, develops, builds, launches and operates its indigenous launch vehicles and all classes of satellites for applications in the communication, remote sensing and scientific fields. India has two major operational satellite systems.

They are the Indian National Satellite system (INSAT), used for telecommunications, television broadcasting and meteorological services, and the Indian Remote Sensing Satellite system (IRS), used to monitor and manage natural resources, as well as other earth observation applications.

Indians take great pride in their space program. When in 2014, India's *Mangalyaan* Mars mission entered Mars orbit, there were celebrations on the streets with a sense of accomplishment, well documented in

popular culture via the movie *Mission Mangal*. Space accomplishments are viewed as demonstrating India's prowess as a technological power and adds to its prestige at the global stage.

It adds to a sense of nationalism. Within nationalism are four sub-components that are worth understanding. These include nation building, regime legitimacy, internal national development, and external status. Since India became independent in 1947 from British colonial rule, there has been a push to develop the scientific temper for nation building. Space was and was viewed as one such technology for critical infrastructure. Early on, under Jawaharlal Nehru, India's first Prime Minister, development of space capacity was viewed as a priority for nation building. His focus on science was further enhanced by Indian scientists like Sarabhai and Homi Bhabha, writing a letter to Nehru on the importance of space for nation building, which led to the establishment of

the Indian National Committee for Space Research in 1962, later renamed ISRO.

This perspective has been carried forward by later day Prime Ministers, to include current Prime Minister Narendra Modi who views space as an important component of India's space power projection capacity and nation building. Indi's former Prime Minister Nehru believed it was his scientific temper that led to India's space achievement thereby adding to the legitimacy of democratic India. This perspective was followed by Lal Bahadur Shastri and Nehru's daughter and India's first female prime minister Indira Gandhi. It was under Gandhi's leadership that India launched its first indigenous SLS-3 with a cost of \$25.25 million. Gandhi in a speech to a joyous Indian parliament stated, "This is a great day for India and for Indian science". It was during her tenure as prime minister that the first Indian former Indian Air Force Officer, Wing Commander Rakesh Sharma] went to LEO in 1984 aboard a

Soviet rocket. Gandhi showcased that as an achievement of her administration. Space has continued to play a critical role in the shaping of achievements of current Prime Minister Modi, with him highlighting the importance of space for India's national development, and personally launching space reforms and developing India's commercial space sector.

India's path to super power

For India, space has played a critical role in internal national development to include Satellite Instructional Television Experiment for developmental purposes, e-education. India developed the Satellite Telecommunication Experiments Project to build the country's communication capabilities, viewed as a precursor to Indian National Satellite System supported by nine operational communication satellite placed in Geostationary orbit. Space offers weather forecasting that helps crop yield, agriculture, fishery as well as early warning for natural disasters like cyclones. Space is also instrumental in maintaining e-commerce, e-banking, telemedicine and tele education. Indian private companies are planning on developing satellite constellations that could support satellite internet services to remote areas not serviced by fiber internet services.

During his time as chair of the Indian Space Research Organization (ISRO) from 1994 to 2003, Dr. K. Kasturirangan wanted ISRO to play a small role in India's ambition to become a superpower. This planted the seed for undertaking more ambitious missions. The idea of a Moon orbiter was floated around and was received positively by everyone.

At the time, ISRO already had satellites designed for geostationary orbits, which could carry plenty of fuel on board. The basic infrastructure was ready and the only change required was adapting a geostationary satellite for the Moon. Initial calculations showed that India's PSLV rocket could provide an Earth-bound orbit beyond which the fuel on the spacecraft could be used to go to the Moon and perform orbital capture. In all, Chandrayaan-1 was a logical extension of ISRO's capabilities. Finding water on the Moon was a primary scientific objective when ISRO was planning Chandrayaan-1. Space agencies globally were keen to confirm water's presence, hopefully in relatively large amounts, as that would have implications for future human settlements as well as the Moon's origin. NASA pitched and got to fly two of its water-hunting instruments on Chandrayaan-1.

Chandrayaan-1's discovery of lunar water helped revitalize global interest in exploring our Moon. This includes NASA's Artemis plans to return humans to the Moon and use resources like water to sustain future habitats as well as the flurry of upcoming robotic missions seeking the exact nature, state, and amount of lunar water. There's also India's own Chandrayaan-2 orbiter, which uses its advanced radar to better map and quantify water ice on the Moon's poles. South Korea's first lunar orbiter KPL0 will also help detect vast polar water ice deposits using its ultrasensitive camera. And NASA's Lunar Trailblazer orbiter will map the form, abundance, and changes in water in sunlit regions on the Moon.

Less-noticed aspects of the Chandrayaan-1 mission are its total cost of less than \$100 million and its collaboration model. As evidenced by the mission's discoveries, welcoming foreign instruments proved effective in increasing mission science without increasing costs.

For the participating agencies, they got to fly their instruments without having to build and launch an entire mission of their own. At the same time, experience gained from collaborating with NASA and ESA in developing planetary instruments helped ISRO make fully indigenous, state of the art instruments for the Chandrayaan-2 orbiter. South Korea is now following this very model for its first lunar orbiter KPL0.

Chandrayaan-1 was the first time India explored another world. To materialize the mission, ISRO developed a number of new technologies. They established the Indian Deep Space Network to communicate with the spacecraft and made the Indian Space Science Data Center to process and archive scientific data from the mission. Future missions like India's popular Mangalyaan Mars orbiter would go on to leverage this infrastructure. Even Chandrayaan-1's spacecraft structure design formed the basis for Mangalyaan. Later this decade, ISRO also intends to launch a Venus orbiter.

India has tied the investment of its space program on the external status it brings. India is hailed as being able to develop low-cost launch systems as Modi is fond of boasting that India's Mars mission cost less than the making of the movie Gravity, or that India became the first Asian nation to reach Mars in 2014. ISRO enjoyed the distinction of launching the largest number of satellites about 104 to orbit in 2017; a record now broken by SpaceX's launch of 143 satellites in a single launch in January 2021. These external status, recognition of India's space capacities by other nations matters and is one of the major drivers for India's nationalistic space program where indigenous capacity building matter to the extent that falling behind in a particular capacity is deemed acceptable.

India also aspires to play an entrepreneurial role in space capacity building. In 1992, India developed the commercial arm of ISRO, Antrix Corporation, for building a global customer base for Indian space technology. The mission of Antrix is to identify technologies that have marketability, and to accelerate 'commercial and technical partnership' with private industry. India has strived to develop public-private partnership by establishing the NSIL in 2019, to coordinate the new space sector in India.

In October 2021, the Indian Space Association (ISpA) was launched by Modi to promote space technology. In his speech, Modi highlighted that the Indian government's approach to space reform was based on developing freedom of innovation in the private sector; the role of the government as an enabler and identifying the space sector as a resource for progress. Modi went on to state that 'the space sector is a major medium for the progress of 130 crore countrymen. For India, the space sector means better mapping, imaging, and connectivity facilities for the common people. Also, the space sector means better speed from shipment to delivery for entrepreneurs. It also means better security and income for fishermen and better forecasts of natural calamities.'

ISRO's Indian Regional Navigation Satellite System or NavIC is offering accurate position system to users in India and the Asia Pacific Region. Today, the growth of the private sector or 'Newspace' in India has risen exponentially in the last few years bringing about many of the

regulatory and space sector reforms in India. Entrepreneurship, especially a motive to profit from a \$400 billion space industry is becoming an increasingly powerful space driver for India.

The critical role that space plays in Nuclear Command, Control and Communication (NC3), military command and control, Global Positioning System GPS, Positioning, Navigation, Timing PNT, Intelligence, Surveillance and Reconnaissance ISR is now recognized by India as an important driver for investing in its space program. Consequently, India has developed its own navigation system, developed ISR capacities by launching its own military satellites and established a Defense Space Agency in 2019 to coordinate military space activities. In March 2019, India tested an ASAT weapon in order to showcase its counter space capacity as a credible deterrent to adversarial counter space capacity.

The launchpads of India

Last January 12 2026, India's PSLV had launch rocket that failed after the third stage's mysteriously anomalous performance, resulting in tumbling of which was visible even on telemetry screens in the mission control and livestream. 16 spacecraft were lost to the air and sea, spanning a key national hyperspectral satellite, seven private Indian ones, five from Brazil, and one each from the UK, Nepal, and Europe. The European one, called KID, briefly survived and transmitted some information despite experiencing loads up to 30g.

This was the 64th flight of a PLSV, a vehicle which has served India for three decades and is supposed to be the country's workhorse in space. The flight being PSLV's second consecutive failure, following the one in May 2025, that invited heightened public criticism and scrutiny.

India's only active orbital spaceport is the Satish Dhawan Space Centre in Sriharikota on the country's south-eastern coast, a low-latitude location 13.7 degree North suitable for many kinds of launches. The port primarily houses two launchpads, and their many associated facilities. The two pads are literally called the First Launch Pad (FLP) and the Second Launch Pad (SLP) respectively. India built the FLP in the early 1990s for ISRO to launch the then-new PSLV rocket. Today, the pad also supports launches of the new SSLV rocket, a PSLV-derived but much smaller vehicle dedicated for lofting small satellites.

As for the SLP, it can also host PSLV launches but does so less frequently as ISRO built that pad in 2005 to primarily launch the heavier rockets GSLV Mk II and LVM3 and LVM3. While these vehicles share some aspects like the liquid Vikas engine with the PSLV, their biggest differentiator lies in their cryogenic upper stages which deliver enhanced performance. However, the same stages make the FLP unable to launch the Mk II or the LVM3. The increased preparatory requirements for these cryogenic stages are hard to retrospectively fit on a launchpad that predates them.

Given these launchpad availability dynamics, it becomes clear that when a PSLV rocket fails, India effectively loses access to its First Launch Pad. The SSLV exists but is not a sufficiently distinct rocket. Its second stage motor is derived straight from the PSLV's third stage one, precisely the stage that has now failed twice in a row. As such, the PSLV getting grounded has

been pulling down the SSLV along with it. Similarly, the PSLV and the GSLV Mk II share their core stage S139 solid rocket booster.

When the PSLV was flying reliably like a workhorse all these years, ISRO rightly considered the modular reuse from it for the SSLV or other vehicles to be an advantage. Now, however, that has become a restraint. Even when the SSLV gets its own Launchpad, planned for later this decade, the issue of potential two-way technological dependency of one vehicle on the other would remain.

In its early days, the PSLV was a humble rocket that allowed India to place modest satellites in orbit to meet the country's most basic space applications needs. ISRO then evolved the PSLV with variant to increase and optimize the vehicle's overall performance and payload capacity. Through continuous refinements, ISRO has been able to use a PSLV in some form to successfully launch a lunar orbiter, a Mars orbiter, a space telescope, a solar observatory to the Earth-Sun L1 point, a record 104 satellites in one flight, and also important missions for other space agencies such as the recent launch of the Proba-3 Sun-studying craft for ESA. This is what people mean when they say India takes pride in the PSLV.

As India's space ambitions have risen this century, and this decade in particular, the PSLV has reached its ceiling of novelty at last. The next set of complex space missions executed by ISRO involved much heavier launch vehicles to get the job done. To launch Chandrayaan 2 and 3, ISRO required its LVM3 rocket to enter operations. India also needed the LVM3 to loft satellite constellations and heavy commercial craft. A Venus orbiter will also await a ride at the end of the decade.

Even more complex missions India has announced to fly soon enough include the Chandrayaan 4 sample return, Gaganyaan human spaceflight missions, the first module of the Bharatiya Antharishh (BAS) astronaut habitat in Earth orbit, and indigenously launched heavy geostationary satellites. But for all of these to work, the LVM3 core stage needs to be upgraded with a semi-cryogenic engine, a project that has been delayed for years now. In the meanwhile, the Indian Government has approved the building of a third launch pad (TLP) in Sriharikota for \$460 million, which will support launches of ISRO's upcoming heavy-lift NGLV rocket starting next decade.

The TLP will also act as a secondary pad for robotic LVM3 launches, and be a standby for human spaceflight ones to handle contingencies and emergencies. The TLP can support launching the GSLV Mk II as well but ISRO is planning to phase out the vehicle itself since the LVM3 is superior to it in performance, price, and reliability beyond bespoke launches.

It's important to note that just like how the LVM3 and Mk II can't launch from the FLP, the upcoming NGLV rocket won't be able to lift off from the SLP. From a technical standpoint, this is obvious. But it's interesting that the same dynamic that ties the PSLV with the FLP also ties the LVM3 and SLP. This means India cannot afford to lose an LVM3 even more so than a PSLV. And that's why ISRO's culture and communications being authentic matter even more today than it did in the past.

MIDDLE EAST REPORT

UAE's giant leap into space science and technology



As the president of UAE, H.H.Sheikh Khalifa bin Zayed Al Nahyan said: “Our target is set UAE as one of the big countries in the feild of the space since before the year 2021. We have great faith in Allah and our faith in the young Emiratis is big. Our determination races our ambitions, and our plans to achieve our goals are clear “.

It is obvious that the investment in the space and aerospace field and operating the national satellites are key factors to build the national capabilities in the space science. This will direct the new generation to build the interest in learning and exploring this field and its technologies. They will be part of the new development and exploration. This direction already started, for instance, one of the UAE based satellite operator, Yahsat, has more than 60% of its employees are Emiratis,

while their main satellite controller and operators are more than 97% Emiratis who got a special training. The new KhalifaSat is being designed and built by Emiratis only. This considered as a giant step in the direction of the independent in this field.

Working together with other nations to gain the needed knowledge in UAE to be able to design and build its own satellite. Similar to the cooperation between MBRS and Korea which was resulted in building and launching DubaiSat-1 and DubaiSat-2. The same team is now designing and building the KhalifaSat. In 2016, the Mohammed Bin Rashid Space Centre MBRSC based in Dubai, the United Arab Emirates (UAE) launched the CubeSat development project “Nayif -1” through partnership with the American University of Sharjah and Innovative Solutions in Space Netherlands.

Nayif-1 is the UAE's first cubesat mission aiming to make space technologies more accessible to universities in the UAE. The mission was developed by a team of seven Emirati engineering students from various engineering disciplines from AUS with the guidance and support of MBRSC and ISIS NL.

The mission was carried out by the students as part of their Senior Engineering Design project. Nayif-1 is a 1U Amateur Radio communications satellite to be launched by 2016 on board a falcon 9 rocket. The ground station has been developed at AUS's campus and operated by engineering students who will be responsible for mission planning and operations.

Nayif-1 mission has four main objectives, to

characterize, validate and study the accuracy of its thermal model with in-situ temperature measurements in space, determine and study the evolution of the solar cells performance in space during the mission design life of 1 year, and to allow high school level students to determine Nayif-1's orbital velocity using the Doppler shift effect observed through the Ground Station, and allow secondary and tertiary students to emit short text messages using the Nayif-1 satellite.

Mohamed Bin Rashid Space Centre, MBRSC, was established in 2015 to increase the level of the national core knowledge in space science, promotes scientific development in space science in the UAE. Also, it will be responsible for the scientific space related programs. Currently MBRSC is operating two satellites, DubaiSat-2 and DubaiSat-3, and in process of manufacturing

its third satellite KhalifaSat which is named after the UAE president His Highness Sheik Khalifa Bin Zayed Al Nahyan. KhalifaSat is fully developed by Emirati engineers, which is considered an achievement to the UAE space program.

Emirati Mars Mission

In 2014 the UAE's President His Highness Sheikh Khalifa Bin Zayed Al Nahyan and the UAE's Vice President and Prime Minister His Highness Sheikh Mohammed Bin Rashid Al Maktoum announced a strategic national Emirates Mars Mission. The first such mission planned by a MENA region country, the intention is for its 'Hope' satellite to enter Martian orbit in 2021, exactly coinciding with the fifty-year anniversary of the founding of the UAE. Hope will then study the Martian atmosphere, gathering data to generate the first truly holistic model of the planet's weather system. The analysis and insights generated will help us better understand the atmospheric composition and ongoing climate change of our neighbour planet.

The Emirates Mars Mission is more than a space science mission or celebration of the UAE's first fifty years. Beyond the science objectives, the mission is a national project that seeks to develop some of the capacities needed to better engage with the economic, social and geopolitical forces of the 21st century. It aims to inspire a young generation into pursuing of unfamiliar and innovative career pathways, and thereby support a diversification of its economy into a post-oil era. Mission success is therefore at least as much, if not significantly more, about nurturing capacities, than it is about the eventual scientific outputs it could produce.

Over the past fifty years the development of the Middle East region has been dominated by economies based on hydrocarbons and the unipolar influence of the United States (US). However, this is rapidly changing, in part because states within the region are diversifying their economies but also because the US is seeking to disengage from an all-embracing regional role and only engage on selective issues.

It is commonly observed that this is happening at a time of not only rising regional tension and increasing incidents of conflict, often through the use of proxies, but at a time of the emergence or re-emergence of nations seeking to exploit the void created by recent US foreign policy.

The important actors engaging in the region today include Russia, China and, increasingly, Turkey. In the case of Russia and Turkey involvement is principally in a security context. In the case of China, it is seeking to use its economic power to develop a strategic vision, centred on the Belt and Road initiative; one that competes with the US and is not always to the benefit of third nations. At the same time, there has been a global shift in many countries towards trying to create more knowledge-based economies, accompanied by greater policy focus on science and innovation and greater expenditure in these areas. However, to date and for a variety of reasons, many countries within the Middle East have not engaged in this transformation. They are, therefore, not enjoying current and potential benefits.

The UAE finds itself at a crossroad. Growing in stature in the region, it can focus on continuing to provide leadership and working to address the issues that it perceives as driving instability, something that it has found itself increasingly involved in this decade. Alternatively, it can do this but also work to play an increasingly important role in economic and political activity based on science and innovation as it seeks to tackle the challenges of the 21st century, including those identified in the Sustainable Development Goals.

Outer space missions typically depart with a question for science before they ask how their value can extend to the society behind it. The Emirati Mars Mission inverted this traditional logic. Instead, its conception arose from a quest to fundamentally redirect a nation's trajectory. Through its design and execution, the Emirati Mars Mission pursues a UAE future in which its economy diversifies from traditional activity, including oil and finance, and inspires a generation towards scientific and entrepreneurial careers – and away from other, less societally beneficial pathways. This is a mission for national development before it is a mission of science.

Equally remarkable is the mission's journey to its launch date. Despite no previous domestic space exploration experience, an absence of planetary science capacity, lack of the requisite infrastructure, and a deadline within approximately half the time used by other comparable missions, a core mission delivery team constituted 100% of local, Emirati staff with an average age of under 35, are on time and within budget for launch. Where a few years ago the UAE had no presence in space, it now joins, as the first Middle Eastern mission, the small cadre of nations who have sought to reach Mars.

Strategic space program

Before the launch of the UAE space program, the Arab and Islamic countries achievement in stepping to the space was very limited to launch of two satellites used for TV broadcasting such as Arabsat and Nilesat and followed by Thuraya as communication satellite.

These three satellites were designed, built and launched by other nations. At the launch of the UAE Space Agency, the President of UAE commented “this new Mars exploration probe will be the first of its kind that enroll both the Arabic and the Islamic countries to space exploration era. This probe will be moderated by Emiratis team and our goal will be building the Emiratis knowledge and capabilities in the field of exploring the outer space. Which will contribute in exploring the far planets and placing UAE with the countries that advanced in the space science “.

Over the past few years, the UAE built a fare internal knowledge in relation to the latest satellite technologies. This was due to a close collaboration between different commercial entities, supported by UAE government, and international satellite industry experts and manufacturers. Those UAE experts can educate the end-users

about the satellites industry capacities which is owned by the UAE or that can be procured from other nations. Also, the local experts have the vision of the new customer who can be benefits from the satellite industry.

Those new either have a limited satellite applications or are not aware that they can use satellite applications. However, there is still a shortage on the technology knowledge where the UAE still needs to depend on other nations. This is mainly due to the lack of the local development of satellite technologies and the advancement of other nations is such area.

Today, the experts in the UAE can provide a proper analysis to the gathered information from different sources about the end-user requirement and can provide the right solution in term of the suitable satellite that can meet those requirements. Also they can provide the area of interest that helps to achieve the end-user immediate and future requirements. However, they still have a lack of a capbility for deciding the best frequency to be used. This is due to the shortage in technology knowledge as the technology advances rapidly in such manner. The UAE is well developed in terms of national expertise to identify the orbital slots and the filing with the ITU. In this manner, the UAE can be self-sufficient. On the other hand, part of this coordination it should be with other nations and satellite operators, in which they need to release or exchange some of critical information and leave some of the needed capabilities in the satellite to meet a mutual agreement with other nations or satellite operators.

During the past few years, UAE successfully developed the experts that can understand the risks in each milestone in the satellite industry. Also, it developed experts on raising the required fund for the same. However, the different type of satellites and different application on those satellites changes the insurance requirements.

As the UAE focuses on the industry in the last few years, some of the capability available in the UAE can be used to build the satellite components such as Masdar who can provide the technology to build the solar panels needed on the satellies and Strata who can provide the aerodynamic to the satellites. The cleanroom is available at MBRSC who is testing some of the space equipment related to their latest satellite, KhalifaSat. However, manufacturing the components that can be fitted in the satellite is still not available in the UAE. Also, the assembly and testing labs for testing those components are partially available in the UAE.

UAE has a relatively small geographic area and is surrounded by other nations. Also, it has no remote land on the equator which makes it difficult to build and launch a rocket. Also, the cost of building a launch pads is huge when compared to the benefits. Even if the UAE tried to commercialize it, it will need many years to gain the market confidence as the main players till today struggle with their quality and stability. The UAE does have many mathematicians who can run the numbers of the aerodynamics and the drop off points, etc. but the cost of the investment will be too high for the return. Today the UAE has the capability to run and operate its own satellites. Plan the missions and execute them. Also, it has the capability to maintain the satellite and the ground terminals. The missing parts is fixing the faulty units of the ground terminals

and this shortage due to the fact those equipment are not manufactured in the UAE. The UAE still need to rely on other nations in this part.

On the flying the satellite, the UAE has its national expert who can fly and operate the satellite. Also, it has the national experts. For instance Ms. Fatema Al Yammahi is the Senior Flight Synamics Engineer at Yahsat is the first woman in the GCC that does this task. Fatema and her team developed new technique in maneuvering of the satellite that can save its fuel which extends the satellite life span. She, and her team, can predict accurately the space asteroids and other debries and maneuver the satellite to avoid them.

With the current capability available in the UAE, the UAE government and the local industry working always on the sustainability. It can be proven by looking to the group of each of the satellite operators in the UAE. For example, Thuraya just released its request to the market to build and launch its Thuraya-4, MBRSC is in final stages on constructing KhalifaSat, Yahsat is launching its 3rd satellite this year and the UAE government has launched FalconEye satellite.

Also, the UAE is investing in the support technologies such as Strata and Masdar. Another key factor of the sustainability is the UAE investment on the human capital. Building the knowledge in the space and satellite industry by introducing such programs in different universities and institutes in the UAE. For example, Khalifa University, Zayed University and UAE University have bachelor programs in subjects related to the aerodynamics and space. Also, Masdar institute, with collaboration with Yashat and Orbital ATK, launched a master program that is endorsed by MIT in the satellite science. This program is first of its kind in the GCC.

Today the satellite owned by UAE served many commercial purposes for UAE and provided answers and products to other nations. For example, DubaiSat images is used to monitor the daily development on the UAE projects which uses the Proprietary imaging software that was developed by the engineers of MBRS. It was also was on of the main resources that were used during the Tsunami that hit Japan in 2011, the flood in Pakistan and the demolition of the mines in Chile on 2010.

However, there are massive obstacles to overcome to achieve this target. The number of states around the globe that are racing to enter the space industry are multiplying. The government of the United Arab Emirates joined this international race by establishing and growing its own space industrial sector.

On several occasions, and by many bold actions, the UAE demonstrated to the world its enduring interest and burgeoning capabilities in this industry. For example, in the last few years the number of satellites owned by the UAE has jumped from two Thuraya-1 and Thuraya-2 to six satellites in operation Thuraya-2, Thuraya-3 the replacement of Thuraya-1, DubaiSat-1, DubaiSat-2, Al Yah 1 and Al Yah 2.



SATELLITE TRENDS

How Planeteers achieve a breakthrough in the space industry

Planet Labs was officially founded in December 2010 under the name of Cosmogia Inc. But its history begins some years before when the founders, three young NASA scientists, Robbie Schingler, Will Marshall and Chris Boshuizen met at the United Nations trying to find a way to use space to help people around the planet, protect biospheres and stop deforestation. They came from three different continents, but they realised they shared a feeling of disillusionment with the established space industry. Specifically, with how it had become trapped in a tradition of requirements-driven approaches to design and testing, because that was leading to increasingly unaffordable spacecraft in terms of cost, mass and schedule.

Landsat 8, for instance, cost the US government about \$850 million to build and launch, and five years of operations are estimated to raise the total to nearly \$1 billion. Landsat 8 was launched in 2013, a year after the three scientists decided to leave NASA illustrating how the old approach that had frustrated them was far from changing. That same year, in fact, the White House asked NASA to find how to drive down the collection cost of future Landsat data, directing the agency to design what they called a "sustainable and sustained" system of spacecraft.

As a result, NASA's Earth Science Division Director Michael Freilich argued they had thought of several "more or less viable architectures, but none of them is perfect" and claimed that "the problem would be a whole lot easier if we had a lot more money". None of these make it look like the change was perceived as an urgent necessity by the space agency.

Marshall, Boshuizen and Schingler had long wanted to change the space industry. They just had not found how to do it yet, and probably needed to find whom to do it with. It was the early 2000s when they met at an international conference held at the United Nations aimed at young professionals to make policy recommendations on how space could benefit humanity. That event would bond them to a global community of scientists and led to a relationship of regular collaboration over the next decade.

Sometime afterwards the three of them were working on small scientific satellites at NASA Ames Research Centre. There, Engineering Director Pete Klupar would often hold his Blackberry in his hand and ask his staff why satellites were so expensive and carried outdated technology. "My smartphone is better than your spacecraft", he used to say. After hearing this a few times, Chris Boshuizen and Will Marshall realised how smart that thought was. This was exactly the idea behind PhoneSat, a NASA project devised by Boshuizen and Marshall that put a mobile phone with extra batteries aboard three CubeSats to be launched in 2013. Again, by that time they two, together with Schingler, would have already left NASA to found their own startup. \

In 2005, they started living in a house together and, in what today would be considered a typical Silicon-Valley style, turned their garage into a workshop where they spent the weekends playing with satellite technology. When it got more serious, they started

hiring friends. Eventually, they decided to leave the space agency. It was in that garage that they built their first satellite, called Dove. While it has become quite standard now for startups to start in a Silicon Valley garage, they proudly claim to be the first ones to literally build a satellite in such place. In February 2012, the startup moved into the SoMa co-working space in the trendy South of Market neighbourhood in San Francisco, where it remains today. Other than its premises in the San Francisco and Mountain View in California, and Seattle in Washington, it has offices in Amsterdam and Berlin. From there, its imagery is delivered to an International network of customers and partners in over 100 countries.

Dare to dream

Reinventing space business is not easy, but Planet Labs has been quite consistent in its announced launch program. It launched its first satellites in 2013. Two years later, in July 2015, the company announced its future acquisition of BlackBridge and its RapidEye 5-satellite constellation, together with an archive of 6 billion square kilometres of imagery captured over the previous years.

By the time that acquisition was complete in October 2015, five years after being founded, Planet Labs was already operating the largest constellation of Earth-imaging satellites ever. Only months after, the corporation signed an introductory contract with the National Geospatial-Intelligence Agency, the largest of geospatial customers.

The business has kept expanding at a fast pace since early 2017. After hitting the headlines with their record-breaking launch of 88 nanosatellites on February 15 and bringing the constellation of Doves to 144, on April 19 same year the company announced it had completed the acquisition of Terra Bella, a rival satellite imaging company. It also confirmed that, as part of the deal, Google was now a noteworthy shareholder in the firm. Google had previously purchased Terra Bella then named it Skybox Imaging in 2014 for an estimated price of \$500 million.

In 2017 both Planet and Google have declined to disclose any other details about the deal other than the fact that Google has now a deal for some years to buy imagery from Planet. Though Planet acquired Terra Bella business and satellites, the search engine giant will keep on licensing the satellite imagery for its mapping products such as Google Maps, so it will still keep control over the satellite imaging company.

At that point, Planet Labs expects to reach its primary goal: to be able to image every point on Earth's landmass at least daily, at resolutions up to 3.7 m. As the startup likes to say, good enough to count all the large trees on our planet. And of course, recount them every day to make sure they are still there.

Life at Planet Labs

The number of employees at Planet has been experiencing exponential growth, reportedly 40 in January 2014, rose to 100 in March 2015 and reached over 300 in April 2016. While the organisation has not released any statistics about its employees' profile, anyone looking at Planet's images on the media will notice a predominance of young people.

Uptill today, two of the three co-founders remain in the company: Will Marshall and Robbie Schingler. Will Marshall is the Chief Executive Officer, leading the overall company strategy and direction. Robbie Schingler, who spent 9 years at NASA, is now Planet's Chief Strategy Officer. In November 2015 the third co-founder, Chris Boshuizen, who at that time was responsible for satellite production and the leadership of the engineering team as Chief Technology Officer, announced via Twitter he was leaving the company.

Along with Schingler and Marshall, there are seven more people in management positions in Planet Labs these days providing their lengthy experiences. Among them, Tom Barton is responsible for the company's business operations and Ryan Johnson the President, whereas Karthik Govindhasamy leads the engineering section and David Oppenheimer is in charge of the financial aspects.

Of Doves and Flocks

Satellites designed and built by Planet Labs are called *Doves*. Planet refers to a group of Doves deployed simultaneously into a single orbit as a *Flock*. A Dove is a standardised 3U CubeSat varying from 10 cm by 10 cm by 30 cm weighing 5 kg. Its payload is an optical system and camera: a Bayer Masked CCD camera with 90-mm aperture and imaging systems with a resolution of 3–5 metres per pixel. Each of these shoebox-sized spacecraft is equipped with Global Positioning System and a star camera that allow to position the image on Earth.

Planet Labs operates the largest fleet of Earth-imaging satellites in orbit, known as Doves. The fleet consists of over more than 200 satellites. These small, agile satellites are equipped with imaging sensors capable of capturing detailed images of Earth's surface with clarity and precision. Besides the Doves, Planet Labs also manages another satellite constellation called SkySat. This is a smaller constellation of 20 satellites that can image any point on Earth in high resolution. Planet Labs decided to provide limited open access to that information. The company is situated in North America, Asia-Pacific, and Europe. As we will discuss in the next section, the company went public via SPAC in late 2021, joining other aerospace companies who did the same.

In addition to its main activities, Planet Labs has developed data analytics tools and platforms together with other companies to extract extra insights Using machine learning algorithms and geospatial analysis techniques. The company can identify patterns, trends, and anomalies in the data, empowering

customers to make data-driven decisions and gain a deeper understanding of complex Earth systems. Beyond those commercial applications, Planet Labs also contributes to scientific research. The company collaborates with academic institutions, research organizations, and government agencies to support scientific studies.

The analytic products are calibrated multispectral imagery products that have been processed to allow analysts to derive information products for data science and analytics. This product is designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The orthorectified visual imagery is optimal for value-added image processing including vegetation indices, land cover classifications. The San Francisco-based startup's mission has always been not only to photograph the entire Earth every day but also to make these data accessible to everyone. In line with this, the company is reportedly planning to make this imagery available to the public, using the offering model of free basic access on the one hand and premium accounts to more quantity and quality data on the other hand.

Doves are designed to be frequently updated and replaced, having each an expected operational lifetime of 1 to 3 years, depending on the type of orbit. In order to keep this continuous cadence of launches, Planet uses an agile aerospace approach to technology development. This means it uses rapid iterative design and frequent testing in space, which results in continually deploying improved spacecraft and payloads. The complete Planet's constellation built up of Doves is designed as a constellation of approximately 120 satellites to be able to image the whole land surface of the Earth every day with a daily collection capacity of 150 million km2.

Despite how innovative Doves' external appearance, the real breakthrough is what is on the inside. These spacecraft carry batteries normally found in a laptop and semiconductors similar to those in a smartphone. "Nothing here was prequalified to be in space", Will Marshall said. "We bought most of our parts online".

Production system

Planet is fully vertically integrated; it operates all aspects of its business except launch. The company uses an agile aerospace approach for the design of its satellites, mission control and operations systems, as well as the development of its web-based platform for imagery processing and delivery.

Planet Lab's satellites do not contain a single component directly sourced from the space

industry. Instead, they use commercial, off-the-shelf COTS components. Planet found out that efforts made by the consumer electronics industry to reduce price and schedule had resulted in an extraordinary component catalogue available to everybody. The startup is convinced that it is no longer required to develop a specialised Application Specific Integrated Circuit when nearly all electronic functionality is already available in catalogue parts.

For instance, Planet takes advantage of the tools developed to perform the heat transfer analysis on the latest Ford Diesel engine, the electronic design tools used for the PlayStation 4, or some of the electronic testing houses present in Northern California available to perform environmental tests for the consumer electronic industry.

Traditionally, the space industry has been proudly acting like a global R&D department, pushing the technology limits and enabling advanced technologies to be developed and then adapted to everyday usage. At some point though this seems to have been inverted. Today, it is the consumer electronics industry who is behind the massive miniaturisation of electronics and technology that is enabling Planet to produce remarkable capability in a 5-kg satellite.

Lessons Learnt from the Consumer Electronics Industry

From the beginning, Planet Labs reports investing significantly in the packaging and the miniaturisation of satellite capability. Aiming to compress most of the capability of a traditional small satellite, its engineers accepted the challenge to create an ultra-high density microsatellite. In order to achieve this, they drew lessons from laptop Personal Computer, tablet and smartphone industries. Putting some inevitably large components like reaction wheels aside, a Dove looks similar to those state-of-the-art consumer devices: printed circuit boards with a lot of layers, outstanding high density of surface mounted electronics components, and hardly any internal cabling.

Planet remarks a trend not only towards further miniaturisation but also towards higher levels of integration, inspired by the levels of hyper-integration or shared resources in the automotive and electronics industries. Knowing that an effective integration or sharing resources among single components in a spacecraft is key to increasing the system's functionality and density, Planet has adopted this no-boxes approach: power supplies and other resources are shared by all instruments, radios or consuming elements.

As Planet Labs puts it, "Small parts make tough systems!". This summarises an additional benefit of this ultra-dense architecture: fundamental

modes become higher and stiffness is increased. Likewise, smaller busses lead to smaller, less complex payloads, which in turn reduce the team sizes, materials, costs and development timelines.

Planet follows the software team management motto "release early, release often". This means small iterative steps and early customer engaging. And, in this case, is literally reflected in the startup's continuous cadence of launches.

One complete iteration of a Dove satellite takes 8 to 12 weeks from design to manufacturing. Most importantly, this prevents obsolescence by continuously integrating the latest technology improvements. Chester Gillmore, Planet's director of manufacturing, explains, "We're building satellites with computers that are six months old. Lots of satellites have 10-year-old computers". Also, the iterative process is continuously improved: Gillmore estimated version no. 9 of Doves cost around 35 percent less than the no. 7 and was completed four times faster.

Distributed risk

Even if the satellites you build are the size of a loaf of bread, "It's a risky business going into space, which we've experienced. We've had 10 launches, two of which exploded. One was the Antares rocket and one was the SpaceX rocket. We had 26 satellites on one and six satellites on the other and yeah, that sent our satellites to smithereens", CEO Will Marshall admitted.

However, as Marshall points out, the startup was smart enough to put just a limited amount of its satellites in each of those launches. Planet fosters a culture of risk tolerance and failure acceptance. Embracing risk means managing risk, which is basically done by distributing it. Planet Labs has an original way of dealing with redundancy: "Rather than building redundant systems into a single satellite, which requires a larger team and more materials, thus higher costs, we build redundancy into the overall constellation. This puts the cost burden on the production rather than R&D, which is proportionally less expensive".

The company allows for a part of its satellites to fail, and designs the constellation taking that into account. In my opinion this similar to the engine-out design rule in aeronautics: engineers design each aircraft as if one engine was to fail during takeoff. In Planet's case, this approach provides reduced development times and results in an overall risk reduction.

And it has the additional benefit of allowing testing. Putting different satellite variants across the constellation is a good practice to keep improving the technology used without risking the whole mission, and it enhances adaptability to change.

This capability to respond to market shifts helps Planet amortise its satellites over shorter lifetimes, which is the reason why it is economically feasible for the startup to build its constellation in VLEO.

Operations and the pipeline

Planet Labs utilises a fully automated data pipeline that is designed to manage heavy data loads from a target fleet of up to 150 satellites operating in a constant monitoring mode. It uses two low-speed UHF systems for spacecraft operations and high-speed X-band system for downloading the imagery files.

The startup has developed its own network of 30 ground stations, located in the US, UK, New Zealand, Germany and Australia. This network has been designed to ensure both efficient mission operations and successful downlink of imagery data. Each of those ground stations consists of an antenna and a Radio Frequency system, supported by a local computer server, connected to centralised services via secured Virtual Private Network access.

Downlinked imagery is transferred from the local ground station servers to the company's cloud infrastructure. From there, it is introduced into Planet's data processing and distribution pipeline to finally be delivered to customers.

Such infrastructure can collect and process 11 terabytes of imagery data every day. All those image files will be available to customers within 24 hours from capture through the company's web product.

A good illustration of the high degree of automatization of Planet's operations is an incident that once took place. Two of their satellites got deployed overnight in a completely unscheduled deployment from the ISS. No one was on duty. The team went to work the following morning and just found a new pair of Doves on their screens. They had successfully commissioned themselves and started contacting the ground stations. Will Marshall say, this is how Planet accidentally became the first company to commission a satellite actually two "without anyone in the loop".

Planet Labs' applications and customers

Planet's satellites are not tasked with searching for particular images; their *Mission 1* as Planet puts it, is to scan the whole Earth every day. Customers can then search for the images they want using GPS coordinates. A spatial resolution of 3–5 m and a daily revisit time, along with the global scanning mission, make possible for Planet's imagery to track everything from crop yields to the evolution of

Syrian refugee camps.

The company does remark, however, that its products can be especially helpful for climate change monitoring. Fighting deforestation has always been the founders' favourite application: "The use case that inspires me the most is deforestation", Marshall specified. This monitoring approach instead of a more traditional tasking one is translated into always-on operations that allow what Planet calls "catching serendipitous events". That is exactly what happened in the summer of 2014 when its satellites randomly captured images of a just-starting forest fire in southern California.

One of the objectives of the constant monitoring mission is to be able to report changes on the Earth mass land. A probably unforeseen application of this took place around the 2015 earthquake in Nepal. Planet Lab's images, taken before and after the tragedy, revealed two remote towns no one was counting with. Aid workers could send in medical assistance and supplies. CEO Will Marshall considers this a success in his original mission to use space remote sensing to help people on Earth: "It was the first time our data actually helped people in the real world. Not just some sort of Silicon Valley bubble of hypothetical, you know", he said.

Another of Planet's ambitions has always been to democratise access to data. When an earthquake struck Ecuador and a wildfire erupted in Alberta, the startup made their high-resolution imagery of those regions available under an open usage license. Partly, the idea behind Planet's mission is that of building an all-seeing eye that supervises everything on our planet without missing a spot, with the ultimate goal to catch anyone doing something wrong in the act. Be it cutting a tree or illegally building in conflict zones.

The Amazon Conservation Association, for instance, used their satellite imagery to map illegal gold mines in Peru. But the San Francisco-based startup also intends to make money by selling its products to commercial clients. Images tracking daily agricultural production across the world, mining output, ships movements or even the number of cars in Disneyland parking lot. Planet has currently over 100 customers, ranging from humanitarian organisations to giants of the agriculture business like Bayer Crop Science.

In 2014, then-CTO Chris Boshuizen explains that they advocate for the idea that early customer engagement and collaboration reduces the time required to learn key lessons. It also lowers the risk in emerging markets as the company can build what the market is demanding. As he explains, this approach of user-centered design transforms end users from simple customers into producers, as their needs and knowledge of the market are integrated into the design process from the very beginning. In accordance with this understanding, Planet states it integrates customers into its development process, which it claims to be more cost effective than investing in contract negotiation.





SATELLITE TRENDS

How South Africa became Africa's space leader



Space is booming. The industry is projected to grow to \$1.4 trillion by 2030. From private launches to satellites, government to commercial uses, there are many faces to this growing industry.

Humans have been fascinated by space for thousands of years. From the first astrological charts created by the Babylonians in the second millennium BC to the discovery of Mars in the 1600s and launch of the Sputnik mission in 1957, the universe has forever been a source of intrigue. But today space represents one of the most lucrative industries globally. Valued at \$360 billion in 2018, the space sector is

projected to grow at an annual average of 5.6 percent and reach \$558 billion by 2026, driven in no small part by the massive demand for nano-satellites and re-usable launch vehicle systems from the likes of China, the USA, Russia and the European Union.

In Africa, the space industry is somewhat smaller but one that is developing fast given its comparatively lower spend. This spend is not insignificant, however. According to industry report, around \$3 billion has been spent on space projects across the continent since the launch of NILESAT 101 by Egypt in 1998, defying the view that Africa is

home to little or no space activities.

South Africa has emerged as something of a regional flagbearer. While the exact size of the country's space industry is unclear, the national aerospace sector as a whole is worth \$1.8 billion, and many commentators believe it is a sector primed for growth.

"South Africa has one of the oldest space agencies in the world and has always been an active role player in the global space sector," comments Davis Cook, CEO of the Research Institute for Innovation and Sustainability (RIIS), an innovation consultancy that works closely with the South African National Space Agency.

"Although still relatively small, the South Africa space sector is well positioned for significant growth in future. The availability of highly skilled engineers, data scientists and other innovators with a good understanding of African, emerging market challenges, means that we have a higher probability of solving real local issues."

The explosive growth of space monetisation can be largely attributed to the enormous variety of use cases being explored and developed. Be it telecommunications, GPS, SANSA's Earth Observation (EO) mapping or data access, there is barely an aspect of the modern

world that is not in some way impacted by extra-terrestrial technologies.

SANSA's ambition is for South Africa to become a recognised player globally over the course of the next decade. Mandated in 2008 by the country's government, it is recognised as the primary, but not sole implementer of South Africa's National Space Programme to direct the government's investment in space science and technology.

Cook describes some of the collaborative work which is helping to realise this mandate. "Through telecommunications, GPS, SANSA's Earth Observation (EO) challenges we help to identify novel uses for space technology," he

explains.

"Over the last few years, we have helped organisations solve problems as diverse as human rights, logistics, land ownership, communicable diseases, banking and insurance, agriculture, and even video games. All of this is achieved through a combination of data acquisition, data analytics, and the development of platform-based data delivery systems for EO data.

"The role that space sciences, and earth observation in particular, can play in solving social, environmental and economic problems is unmatched. It is therefore critical that we as a group build a collaborative, open space technology ecosystem

across South Africa and Africa."

The EO programme is the primary way in which RIIS assists SANSA in building an innovative and entrepreneurial ecosystem for the country's space industry.

"RIIS has delivered a series of innovation programmes every year since 2015, focused on identifying promising technologies and entrepreneurs working in earth observation and space sciences," Cook continues.

"Over this time, more than 70 innovators and technologies were identified, received training, and have been further supported in growing successful businesses together with various partners such as Airbus and DigitalGlobe."

The global nano satellite market size is expected to reach USD 1,336.9 Million in 2030 and register a revenue CAGR of 20.4% over the forecast period, according to the latest report by Emergen Research. However, rise in demand for Earth observation related applications and increasing number of aeronautics, communications, and satellite development companies are factors driving global nano satellite market revenue growth.

Nano satellites are miniaturized artificial satellites that weigh less than 10kgs. Nano satellites are more convenient and take less time to build than conventional satellites owing to their smaller size.

Nano satellites are launched at lower altitudes, and cost of launching is also relatively lower. These devices travel at high speed and circle the Earth in a polar orbit. Nano satellites are used for purposes such as remote sensing, land observation, and communication, among others.

"Our ability to develop and design solutions that utilise these platforms to solve our own developmental and economic needs is therefore critical, and these will be best addressed through the development of local technology entrepreneurs."

And it is this nurturing of local space-based innovation which Davis believes will lead South Africa to a global standing in the future.

An optimist for the coming years, he concludes: "I think the SA space sector has enormous potential it is the most advanced such sector on the African continent, and with access to the best infrastructure and data architecture. "We have all the ingredients for success, but need to add to it political will, ambitious innovators and dynamic entrepreneurs. We have all three, and so my view is that the sun is just

beginning to rise on this industry."

Leading Africa's space industry

The establishment of the South African National Space Agency SANSA in 2010 expanded the country's space activities and contributed to the development of the national space program and space technologies in both the public and private sectors.

SANSA's work is primarily focused on Earth and environmental monitoring, involving the collection and processing of data used to ensure the stable operation of navigation and telecommunications systems, as well as weather forecasting services. This has been made possible by Africa's only Space Weather Warning Center, which is located in South Africa. The data it gathers is also used in the defense sector.

South Africa's path to satellite development began with the launch of SunSat in 1999. Designed for Earth observation, radio data transmission experiments, and educational purposes, the project involved more than a hundred students from Stellenbosch University. In 2009, the microsatellite SumbandilaSat, also known as ZASAT-002, was launched for Earth observation, specifically for monitoring and managing disasters such as floods, oil spills, and wildfires in South Africa. These launches were key milestones in building experience in space missions and played a significant role in advancing satellite engineering in the country.

South Africa is currently among the top five African countries with the highest number of satellites, and as of August 2024, it had launched 13 satellites. Another one, this time a radar satellite, is planned for 2025. It will be used for continuous real-time remote radar sensing, covering the entire continent.

The satellite will provide new surveillance capabilities for defense and intelligence services, assist in disaster management, and support infrastructure and crop monitoring. Overall, South Africa aims to maximize the use of its own space technologies and achieve independent launch capabilities by the end of the decade.

South Africa's international partnerships in the space sector

South Africa is currently involved in several international space science projects, including partnerships with NASA, ESA, and Roscosmos. This cooperation allows the country to participate in global space missions while also strengthening its own space capabilities.

NASA's relationship with South Africa, however, has not always been straightforward. In 1961, the agency built a tracking station in the country for monitoring probes sent to explore space beyond Earth's orbit: the Deep Space Instrumentation Facility. However, by the summer of 1971, the station was shut down as a result of growing international opposition to the apartheid regime, which was dominated by the white minority.

The next phase of cooperation with NASA came in 1999, when the United States helped South Africa launch the SunSat satellite, and the partnership is currently expanding, including a project to build a new deep-space ground station in Matjiesfontein, located in the Western Cape province. This facility will play a key role in supporting communications for future U.S. Artemis missions to the Moon and Mars.

South Africa will be the fourth country, after the United States, Australia, and Spain, to host a deep-space ground station. The location, climate, and infrastructure made Matjiesfontein an ideal site for the antenna, which will enable near-continuous communication between Earth and astronauts aboard spacecraft. At the same time, however, South Africa is also strengthening its collaboration with China. In August 2023, Chinese President Xi Jinping signed two agreements with South Africa on cooperation in space projects. One focused on crewed spaceflight, while the other included South Africa in the team for the planned Chinese-Russian International Lunar Research Station.

In addition to partnerships with the U.S. and China, South Africa is also working with the European Space Agency (ESA). In 2024, SANSA became the 28th regional support office of UN-SPIDER, the United Nations Platform for Space-based Information for Disaster Management and Emergency Response. This partnership will improve disaster management and reduce response times using data obtained from space research.

Development of South Africa's private space sector

The African continent is currently experiencing a NewSpace boom, with more than 500 companies operating in the sector. Of these, over 30 major companies and startups are based in South Africa.

The term "NewSpace" describes a new type of commercial space company and characterizes the modern wave of commercialization and privatization in the space industry. In this model, the private sector plays a key role in developing, manufacturing, and operating space technologies in collaboration with national space agencies.

The already well-developed segment of remote sensing and Earth observation in this part of the continent continues to expand, driven by the growing need for climate monitoring to support precision agriculture technologies. Meanwhile, the development of GNSS (Global Navigation Satellite System) services is fueling demand for smart infrastructure applications.

PyraLink Aerospace is South Africa's space launch pioneer, and is currently engaged in designing and operating launch vehicles capable of placing satellites into orbit. Among the most successful South African space companies, including Dragonfly Aerospace, NewSpace Systems, Cubespace, and Simera Sense, have attracted significant investments, created new jobs, and continue to drive the growth of the private aerospace sector.

Dragonfly Aerospace is South Africa's leader in space innovation

Dragonfly Aerospace, headquartered in the Stellenbosch Techno Park near Cape Town, is one of South Africa's largest private space companies. It offers commercial satellite solutions and advanced engineering services, including payload development and operational solutions using space and related technologies.

The company was founded in 2019 by five engineers led by Brian Dean. Initially, their goal was to establish mass production of satellites and payloads for small and microsatellites. Today, however, the company is best known for its imaging systems, which capture high-quality satellite images with enhanced resolution. Aerospace engineers are already quite familiar with its CubeSat imaging products, such as the Gecko imager, the Mantis imager, Chameleon, and others.

The company's chosen development strategy is well-founded: Euroconsult experts predict that by 2029, the global Earth observation data and services market will reach \$8 billion. Additionally, by the end of

the decade, more than 50 new space companies plan to launch over 1,800 small Earth observation satellites weighing less than 50 kg.

Dragonfly Aerospace actively collaborates with international partners and, in February 2022, announced a partnership with the Australian Government's Office of National Intelligence (ONI). As part of this project, Dragonfly Aerospace provided a high-performance Gecko camera for a satellite used in testing onboard machine learning technologies. This partnership opened the door for further use of small satellites to enhance data collection and processing.

According to Dragonfly Aerospace's CEO, Brian Dean, "The Gecko camera and optical system from Dragonfly Aerospace will improve the satellite's imaging capabilities and enhance the quality of images sent back to ONI."

The same camera, this time installed on the LICIACube satellite, was used by NASA during its 2022 DART (Double Asteroid Redirection Test) mission. This was the first successful attempt by humans to deliberately alter the trajectory of a celestial object. The Gecko camera captured the moment of the DART probe's impact with the asteroid Dimorphos, providing valuable data for assessing the feasibility of orbit modification.

In early 2023, Dragonfly Aerospace launched its first satellite, EOS SAT-1, aboard a SpaceX rocket as part of the Transporter-6 mission. EOS SAT-1 was one of only two out of 114 satellites launched by various companies and became the first private Ukrainian satellite in space. Equipped with two high-precision DragonEye cameras, the satellite collected Earth surface data to support informed decision-making in agriculture.

Another major milestone for Dragonfly Aerospace was the development of a line of COTS and ITAR-Free space components that meet the European Space Agency's ECSS standards. In August 2024, the company announced that these components had reached Technology Readiness Level 9 (TRL 9), confirming their reliability and high performance in extreme space conditions. The new product line can be integrated into various space missions. In January 2025, Dragonfly Aerospace announced a partnership with the Australian Earth observation company LatConnect 60. The company will receive three state-of-the-art Chameleon SWIR (shortwave infrared) thermal imagers for its upcoming SWIRSAT satellite constellation, expected to launch in 2026. This collaboration will expand Earth observation capabilities and potentially benefit various industries by enabling the collection of precise geospatial data.



SATELLITE TRENDS

Why spacefaring states are suspicion of debris removal technology?



The state of the space environment is changing rapidly. Each year, the European Space Agency ESA releases a report to provide an overview of current debris mitigation efforts and to raise global awareness of space activities in general.

The recent report emphasizes the steady increase in the number of objects in space and their combined area and mass, which has led to harmful collisions between operational payloads and debris. In addition, the report explains that despite improvements in sensing capability and thus the size of objects that can be tracked, the orbital debris problem is complicated by the miniaturization of space systems and the deployment of large constellations.

On Monday, 2 September 2019, the European Space Agency ESA modified the trajectory of one of its

satellites, Aeolus, in order to avoid a collision with a satellite in the Starlink constellation of SpaceX, Elon Musk's corporation. This was the first time that the ESA had to perform such a maneuver to avoid collision with an operating satellite. Previously, such maneuvers were made to avoid debris or derelict satellites.

Many smaller objects elude detection; and the proliferation of debris will soon make such maneuvers more difficult and probably less effective. The costs resulting from this proliferation of debris can mount, in terms of human lives for astronauts and people on ground and in economic terms were sophisticated satellites to be destroyed.

A key finding from the report is the evolution of the number and types of objects in space.

On 10 February 2009, a declassified Russian military satellite, Cosmos-2251, rammed the telecommunications satellite Iridium-33 head-on at an estimated speed of more than 11,000 km per second. The collision probably produced more than 3000 pieces of debris, however, estimates vary. This was the first large-scale accident in space recorded. Since the start of the space age in 1957, the quantity of space debris has increased exponentially.

This has been called Kessler's syndrome as the accident reportedly produces a multitude of new pieces of debris, which might well cause other collisions in a chain reaction. At present, there are reported to be in space: 34,000 objects above 10 cm in diameter, 900,000 above 1 cm, and 128 million above 1 mm. Based on this, an object of one millimeter can, given its speed in space, cause

major damage to a satellite in orbit. In proportion to the increasing number of observation and communication satellites, the risk of collisions is rising.

The report shows that as of 2020 there are close to 30,000 objects of a size that we can track orbiting the Earth. In reality, there are estimated to be 100 million pieces of space debris that are 1 millimeter or larger and even the smallest of these fragments can cause serious damage to spacecraft.

There are many significant risks posed by the growing number of objects in space. The most serious of these is the increased likelihood of collisions between active payloads, between a payload and debris, or between two pieces of debris.

In an interview after Blue Origin's historic first crewed spaceflight in July 2021, the company's founder

and owner, Jeff Bezos, expressed a newfound inspiration to fight climate change on Earth by expanding space operations: "We need to take all heavy industry, all polluting industry, and move it into space and keep Earth as this beautiful gem of a planet that it is." The prospect of exporting polluting industries like rare Earth mineral mining may welcome more unknowns than benefits. It also reveals a specific spatial and temporal outlook on outer space.

While the collision itself would likely cause serious or critical damage to the asset, the secondary debris produced by the collision is even more problematic. This is because the new debris then increases the risk to the existing objects. The situation in which the amount of debris orbiting Earth would only create more and more debris because of these fragment-producing events is known as Kessler syndrome.

Reaching that point would make space

unusable and the critical space-based services we rely on would become unreliable. For instance, the 2009 collision between the inactive Russian communications satellite Cosmos 2251 and an active commercial communications satellite operated by Iridium produced almost 2,000 pieces of debris with at least a 4-inch diameter and many thousands of even smaller pieces. Analysis has shown that more than half of the Iridium debris will remain in orbit for at least 100 years.

Compounding the problem of the amount of debris that already exists is the shifting trend towards launching large constellations of small satellites into LEO. The advantage of this kind of mission plan is that each satellite is cheap and easily replaceable, which spreads out the risk to the operator from potentially losing one satellite.

This is contrasted with a traditional mission of one satellite that might cost billions of dollars and decades to

produce. However, with large constellations comes added concerns of their impact on space sustainability.

Jonathan McDowell, a renowned astrophysicist at Harvard's Center for Astrophysics, creates many resources on the space object population. His General Catalog of Artificial Space Objects provides useful insight into the population of orbital debris. In a presentation at a NASA forum on space junk, McDowell noted that there are about 23,000 artificial objects that we have good data on, in part due to their size. These objects are ten centimeters or greater in diameter, making them easier to monitor. Many are also in orbit closer to the Earth, also aiding in tracking. However, there are countless objects that we are unable to track either because they are smaller than ten centimeters in diameter or they are farther away from Earth or both. McDowell noted in the forum that there could be as many as a million objects of one centimeter in size and even a billion, by some estimates at a millimeter in size." Given that space objects in LEO move at rapid speeds, even these tiny fragments can cause major damage if they collide with another object.

McDowell's orbital debris population visual provides an important insight: not all orbital debris is the same. Building off of this insight, a group of experts created a list of the "50 statistically-most-concerning derelict objects in LEO." The authors of the paper used algorithms that considered four factors in assessing the risk of objects in space: their mass, their proximity to operational satellites, their encounter rates, and their orbital lifetime.

The first twenty objects on the list are large rocket boosters owned by Russia. These boosters could cause catastrophic damage if they collided with one another as the crash would create a haze of debris. Darren McKnight, lead author of the study, noted elsewhere that "Two 9,000 kilogram objects hitting would double the low Earth orbit debris population in one instance...You would make 15,000 trackable objects. That's the most consequential event that is possible." Forty-three of the fifty objects are owned by Russia. The remaining seven belong to Japan, China, and France. However, these are not the only states that are responsible for the mess of orbital debris. Russia, Japan, China and France just happen to be the owners of the objects that these experts argue should be prioritized for removal.

Orbital debris

Orbital debris are the objects that

remain in space as a result of human activities. Their sizes vary greatly. Some pieces, like spent rocket bodies, can be as large as a school bus. However, many other miniscule fragments may be as small as a speck of paint. With their rapid speed of movement, even these tiny bits of debris can cause major harm if they collide with another object.

Objects in low Earth orbit LEO, the region of space stretching from 160 to 1000 kilometers above Earth have an average velocity of over 25,000 kilometers per hour. That is eight times faster than a speeding bullet. Similarly, objects farther from Earth can move more slowly without getting pulled into Earth's atmosphere. This is because their distance frees them from the slowing impact of proximity to Earth, known as "atmospheric drag." It means that the region of space where human activity is increasing most rapidly, particularly, the LEO is also filled with objects that are moving extremely fast by necessity. Today, the most congested region of space is buzzing with activity. Space debris has existed since humans first entered space in 1957 with the launch of the Soviet Sputnik satellite. The oldest piece of debris still in orbit belongs to the United States: the 1958 Vanguard I, which was the second satellite launched by the United States.

Much of the debris in orbit today is a vestige of the Cold War era, when U.S. and Soviet jockeying for geopolitical superiority extended into the cosmos. Newton's first law of motion explains why orbital debris lingers: "An object at rest remains at rest, and an object in motion remains in motion at constant speed and in a straight line unless acted on by an unbalanced force." This means that an object left in space will continue moving at the same rate unless it is impacted by another object, or unless it uses fuel to adjust its course.

Objects closer to space are, however, affected by Earth's gravitational pull, which plays an important role in keeping the space environment clean. Atmospheric drag, a force that acts opposite to the relative motion of the object pulls objects in space towards the Earth. Many objects will eventually be pulled into Earth's atmosphere, which is why it is preferable for objects to be placed in LEO as opposed to higher orbits. The vast majority of objects that reenter Earth's atmosphere will burn up entirely upon reentry, a natural means of tidying up the space environment.

Bustling activity in LEO

Like all ecosystems, low Earth orbit has a carrying capacity with the "highest number, density, or biomass of a space objects that a specific region of space can support sustainably." Despite our perception of space as a vast, limitless space, it is a finite resource. There is a comfortable range of space objects that it can host without creating negative outcomes, like the disruption,

degradation, and loss of space-based services. This atmospheric drag is akin to ecological force which helps to maintain equilibrium in the population of space objects by not exceeding its carrying capacity.

In the space environment, the rapid increase of activities in LEO stands to also challenge that ecosystem's carrying capacity. This uptick in activities has been driven in part by the commercial sector. In the third quarter of 2021 alone, there was \$9.8 billion in space investment activity, according to a report from the Space Foundation.

Bank of America estimates that the global space industry will triple in value by 2030, reaching a global sum of \$1.4 trillion. States are also contributing to the increase in space activities. A European Space Policy Institute Report on emerging spacefaring nations notes that in "the past five years alone, more than ten countries have established their national space agencies."

As traditional barriers to entry of the space domain continue to decline this trend will only accelerate. These barriers previously included high cost, limited launch opportunities, and limited expertise challenges that have all waned in recent years.

Of all of the space activities that contribute to orbital debris, the increase in the development of satellite constellations might be the most pronounced. Satellite constellations, sometimes referred to as "mega constellations", are groups of small satellites which can collectively offer groundbreaking services.

They do so in a few ways. First, small satellites, and "cubesats" in particular, are far more accessible than traditional satellites. Cubesats are small satellites that have a standardized design, enabling would-be operators to purchase them in part or in whole off of the internet.

This reduces the cost of the design and manufacturing process, a traditionally lengthy and expensive endeavor. New actors, like universities, non-profit organizations, and emerging or non-spacefaring nations, have therefore been able to use and benefit from cubesats.

The second way in which cubesats have revolutionized the industry is their ability to provide high-speed connectivity to new regions of the

world. Some allege that this technological advancement "could banish the days of struggling with spotty Wi-Fi and cellular connections, while also transporting the estimated three billion people who are currently offline into the digital age." A third groundbreaking feature of cubesats is their ability to "piggyback" on other launches as rideshare or secondary payloads.

Unfortunately, due to their cheaper design and the necessary sacrifices which must be made to keep the spacecrafts small, cubesats are often more prone to defect than their traditional counterparts. Dr. Mark Skinner, Senior Project Leader in Space Traffic Management at the Aerospace Corporation, has written about the technical and legal complications associated with CubeSats.

One technical barrier is the high rate of dead-on-arrival satellites which, for a variety of reasons, are never identified by the operator or fully brought online after reaching their target orbit. This higher rate of premature failure is all the more troubling given that many CubeSats are not maneuverable. Their lack of maneuverability means that they cannot be redirected into Earth's atmosphere to be disposed of, and they also cannot change course in the event of a possible collision. Cubesats therefore remain in orbit, posing a possible threat to other space objects, until atmospheric drag does away with them.

Active debris removal

Debris remediation is the actual removal of debris from space. This is more commonly referred to as active debris removal ADR, the process of rendering a piece of orbital debris non-threatening by either disposing of it entirely, dragging it into Earth's atmosphere or by migrating it to the graveyard orbit. The graveyard orbit serves as a landfill for regions further away from Earth that are not affected by atmospheric drag specifically, geostationary orbit (GEO), which is at the altitude of 35,786 kilometers from Earth.

Operators of spacecrafts at higher orbits can maneuver their spacecrafts to this graveyard upon the end of their mission if they have allotted an adequate amount of fuel for this maneuver.

So far, there is no piece of space debris that has successfully been removed from space using an active debris removal technology to date, but there are many promising debris removal tools being developed. One such tool is Astroscale's ELSA-M servicer spacecraft. Astroscale is a Japan-based, global

startup that specializes in on-orbit servicing technologies that are geared towards enhancing the sustainable development of space. The ELSA-M spacecraft is one such technology. Companies that have contracted Astroscale for end-of-life services will install a magnetic docking plate on their spacecraft before launch. Upon the end of that spacecraft's mission, or in the event of a premature failure, the ELSA-M will perform a capture maneuver, dock with the target spacecraft, and deliver it to a "low drop-off altitude" so that it will re-enter Earth's atmosphere and burn upon re-entry.\

Astroscale's magnetic capture mechanism is but one example of a rendezvous and proximity operation. The term "generally refers to orbital maneuvers in which two spacecraft arrive at the same orbit and approach at a close distance" typically, for the purposes of servicing, including performing a repair or refueling.

However, there are thousands of pieces of debris in orbit that have no such docking plate. Therefore, in order to remove these pieces of space junk, a different type of technology will be needed.

One major problem with all varieties of rendezvous and proximity technology is that they are, by nature, dual-use technology. Consequently, depending on their operator's intentions, rendezvous and proximity operation technology can commit hostile or malicious acts in addition to their benign servicing capabilities. A robotic arm, for instance, can be used to grab an adversary's satellite.

The Center for Strategic and International Studies' Aerospace Security Project produces an Annual Space Threat Assessment that discusses, among other things, rendezvous and proximity operation technologies that have possibly hostile capabilities.

The 2021 edition of this report discusses the "notorious Chinese inspector satellite", Shjian-17 or SJ-17. The authors of the report note that while this spacecraft has stated peaceful intentions, it could be repurposed for hostile ends. This is because of the design of the satellite's robotic arm, which would require an extremely close rendezvous that would not work with a tumbling, uncontrolled target, like orbital debris. Rather, the arm would most likely only work with a target in a "predictable motion in an established orbit," meaning that the "design of this satellite lends itself to a co-orbital anti-satellite weapon, even if that is not the stated intent." This report details how Russia has exhibited similar rendezvous and proximity operation capabilities, and other research indicates that the U.S. also has vast capabilities



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