



SPACEWATCH

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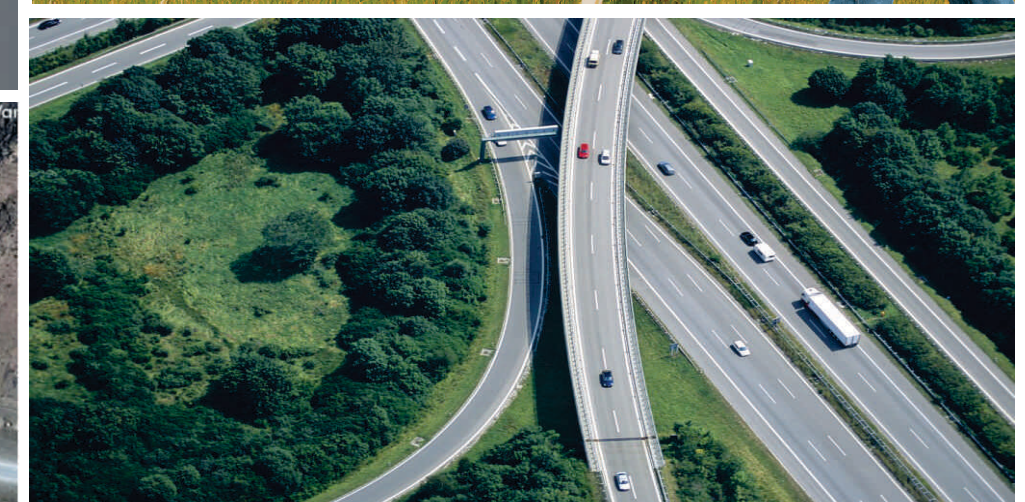
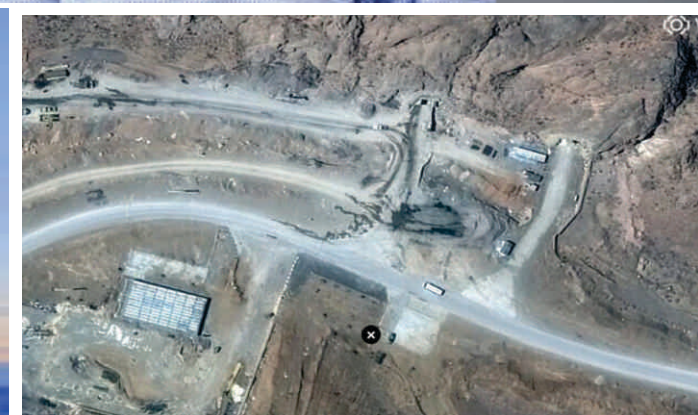
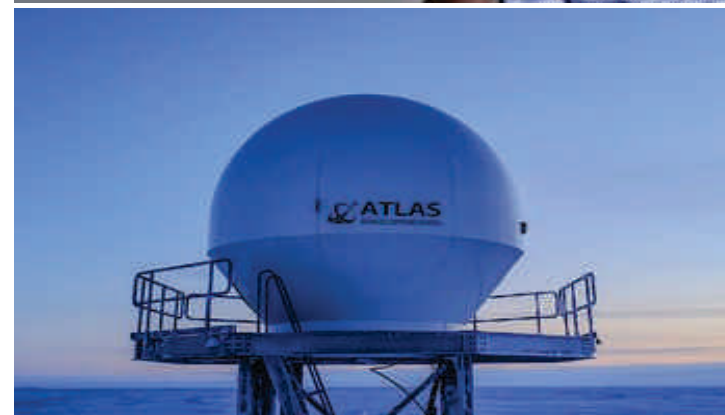
SPECIAL REPORT

How commercial satellite imagery make nuclear secrecy very difficult

Spacewalk!



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MANAGING DIRECTOR OF SAMBUS GEOSPATIAL

A short interview session with the M.D of Sambus Geospatial

Tell us about how Sambus Geospatial started.

Sambus Geospatial was established over 33 years ago by the late Mr Samuel Aboah as he partnered with his friend, Jack Dangermond who is the president of ESRI. Before its inception, Mr Samuel Aboah witnessed first-hand the contributions computer-based mapping and analysis made to geographic planning and environmental science in the USA, which was pioneered by Jack Dangermond and decided to introduce the technology in Ghana. He named the business “Sambus” which was the shortened form of Samuel’s (i.e Sam) business (i.e bus). Later, the late Mr Samuel Aboah teamed with the two trusted associates who became co-founders of Sambus Geospatial, as their expertise became the foundation needed to build the company. Eventually Sambus Geospatial expanded to become distributor of ESRI, ENVI, Trimble, Wingtra and Microdrone with representation in Ghana, Nigeria, Gambia, Gabon, Sierra Leone and Liberia.

How would you explain the current state of the company now as compared to 10 years ago?

The major difference has to do with operational expansion. 10 years ago, Sambus Geospatial was operating within Ghana. Today the company’s operational countries spread across West Africa, with a Country office located in Nigeria to focus on the Nigerian Domestic Market.

Give us your inputs about how Sambus Geospatial operational regions are embracing GIS technology.

Although the company is actively involved in the selling of solutions, we work closely with organizations and government entities to solve potential and pending problems within our society and West Africa. However, in the last few years, many have resorted to the use of geospatial tools as a requirement for the execution of projects and others integrate it into their workflows.

Realizing the essence of geospatial technology different industries, organizations and institutions better appreciate the use of geospatial technology today.

In the next 5 years, where do you see Sambus Geospatial reaching as a corporate entity?

I envision Sambus Geospatial having a staff presence in every West African country, with an overall staff of 150 and an annual turnover of 25 million USD and looking at growing in the Central African Region.

Elaborate on some of the opportunities a GIS professional can find in the geospatial industry.

Many institutions are integrating location intelligence and predictive analysis in their workflows today, as they have recognized the competitive advantage it gives them. Embracing this innovation, the demand for GIS Professionals have increased because, the system can be fully utilized by professionals with a deep level of expertise in the use of geospatial technology. There is no limit to the industry it can be used in, thus professionals tend to specialize in utilization of geospatial technology within specific industries, making them more relevant in the market.

What has been your biggest challenge, and how did you overcome it?

Well, the succession planning in a family business was very challenging but through Humility and the willingness to learn, I was able to overcome it.

Tell us about biggest accomplishments so far as the managing director of Sambus Geospatial?

Expanding the business footprint across Ghana’s border.

How do you prepare for major industry or company changes?

The process involves understanding the initiative, planning it inclusively, explaining to the team and rolling it

What major threats do you foresee for the Geospatial industry business?

Our geospatial products are commercial use. Its only natural for open source technologies to become a rival. However, open Source technologies always have limitations to its use. Developers who try to overcome this shortcoming usually fail. As a result, they turn back to us for our full suite of services, as they need these functionalities to execute their projects well. With Covid, the breakdown of international borders and the universal acceptance of digital systems across all regions – international and regional threats will also surge. For instance Amazon.

Do you have any message you would like to share with all geospatial users and non-users out there?

We currently live in a world where making rapid decisions is a must. If we must ensure that these rapid decisions are 80% accurate so we can avoid the trial and errors then such decisions must be backed by research, analysis and data. Geospatial forms the soul of such research, analysis and data from planning out a health care infrastructure with proximity to its intended audience, to siting a dam, or theatre or fertilizers for crop production. It is time to embrace and drive this train of Geospatial solutions so quality decision making will better our world and our lives.

Brief about the MD

Akua Aboabea Aboah - Baffoe, assumed her role as the MD for Sambus Geospatial in 2013.

She is very optimistic about the development, and the reduction of poverty in Africa through incorporation of GIS technologies in governance and policymaking.



AKUA ABOABEA ABOAH – BAFFOE (Mrs.)

Managing Director: Sambus Geospatial



Source: Sambus Geospatial Newsletter

SPECIAL REPORT

How space software is finally catching up to Earth



For all of human history, there has been an innate and consistent fascination with the celestial bodies of the sky. From the invention of the telescope to the first space shuttle, humans have sought to find answers for our place and destiny in space.

This passion to explore the final frontier is a global commonality that transcends race, culture, and time. However, the venture into space is not only an existential, political, or philosophical ambition.

A national space program provides economic opportunity, astronomical research, and broadband access for its citizens. Satellites can observe the impact of climate change or predict devastating disasters, allowing poorer countries to prepare and prevent. Furthermore, a country's stake in space can create a rippling effect across the social and cultural mentality of its people.

A launch into space is not solely reliant upon scientific and technological ability. Bureaucratic elements, government support, and sufficient funding are necessary for space initiatives to take flight. The politics behind human space flight create debates of whether the pursuit is worthy or even necessary for certain countries.

The question arises if human space flight should be a priority when a country's human rights still remain an ignored or neglected issue on Earth. In recent years, companies such as Blue Origin and SpaceX have erupted as powerhouses of commercial space flight. It appears that in a few decades' human space flight will become fairly normalized, thanks to these independent vendors who work in tandem with national space programs, with plans for colonization of the moon and Mars in the works.

While capital in space chases rockets and satellites, a less visible but growing part of the market is the software without which the entire fleet is useless.

The number of spacecraft in orbit has grown by an order of magnitude, and with it, demand for onboard computers, ground control systems, and data processing. Yet space software as an industry has always lagged a good decade behind its terrestrial counterpart: weak hardware, radiation shielding, and strict mass constraints left no room for the luxury of modern architectures. That's changing now!

From onboard computer to orbital data center

When I began my career at Mission Control as a developer. We were building a system that uses ground-based instruments, particularly telescopes to monitor outer space and predict

dangerous close approaches and collisions between satellites. I was responsible for forecasting the trajectories of spacecraft and debris, translating the physical equations of spacecraft flight dynamics into code. That experience gave me a front-row seat to how space software actually works under the hood.

The "Onboard" and "Ground" categories are essentially about infrastructure. "Development and Testing" is about building and testing that infrastructure, "Data Processing" is about operating the infrastructure and the results it produces, and "Space Services" is the product itself.

Onboard hardware and software

Here we mean the spacecraft itself, the

vehicle carrying the payload. The key component of a satellite is the onboard computer, the brain of the spacecraft, which issues commands to all subsystems and oversees their operation.

Interestingly, your smartphone is more powerful than a satellite's onboard computer. The reason is that in space, the main enemy of electronics beyond the cold and the vacuum is radiation. Charged particles can flip a single bit in the processor's memory, a "bit flip," 1 instead of 0 or vice versa or knock a chip out entirely, and while on Earth such an error would at worst freeze an app, in orbit it can mean the satellite losing its orientation or breaking down with no chance of repair.

That's why the industry trades performance for reliability. Instead of the latest process nodes used to make chips for iPhones, satellites fly on components based on architectures that were used on Earth 10-15 years ago, but have been extensively tested for radiation resistance.

On top of that come strict constraints on mass and power consumption: every watt on a satellite has to be harvested by solar panels and somehow dissipated as heat, and every extra gram is a line item in the launch cost. As a result, a typical satellite onboard computer is comparable in processing power to an early-2000s smartphone and that's not the industry falling behind, but a deliberate trade-off between "fast" and "will survive 15 years in orbit with no tech support."

Ground satellite control

Here we're talking about the software behind Mission Control and this is where some of the most interesting changes are happening right now. When I worked at Mission Control five years ago, we had strict procedures for controlling the spacecraft. Operators worked in shifts, 24/7, with a scripted scenario for every communication session, manual confirmation of every command, a log recording everything down to the second, and a separate team standing by to analyze telemetry. And that was all for a single satellite.

Now we've entered the era of multi-satellite constellations and that old model simply doesn't work anymore. I shudder to think how many operators it would take to manage 10,000 Starlink satellites without automation. So the operator's role itself has changed, they no longer fly a specific spacecraft, but instead oversee an automated system that manages entire clusters of satellites on its own. Routine procedures are automated, maneuvers are calculated without human involvement, and AI monitors the health of all systems in real time.

Another key change tied to the growing number of satellites is the massive increase in the volume of data transmitted from space. There are more images, and the images themselves are larger. Meanwhile, a ground station only sees a given satellite passing overhead for about ten minutes per session and physically pushing that much data through such a narrow window is difficult. Building your own global network of ground stations to solve this isn't something every company can afford it's expensive.

Two solutions have emerged from this. The first is ground stations as a service: instead of building your own network, you plug into a provider that already operates a global network of ground stations, they pick up the data from your spacecraft and deliver it straight to you on the ground. Speaking as someone who's launched a satellite myself, it's a genuinely convenient

option. The second is onboard data processing. Since you can't push the entire volume through such a narrow communication window anyway, part of the work shifts to the satellite itself: AI and increasingly powerful onboard computers make it possible to compress and pre-process data right in orbit, so what comes down isn't a raw stream, but an already refined result.

What's more, satellites have learned to exchange data with each other directly via laser communication. This makes it possible to distribute the load across the constellation more evenly: an overloaded satellite can hand off part of its data to a less busy neighbor, which then sends it down to Earth during its own communication window.

Satellites development and testing

Naturally, as the number of satellites grows, so does the need for their development and with it, the need for software. This area includes some very specific tasks, such as supporting the testing of low-thrust engines and similar work.

Since I worked on calculating satellite trajectories myself, let me tell you what's going on here. There are, of course, ready-made commercial solutions for this kind of task AGI STK, for example. But an enterprise license can cost several hundred thousand dollars, and even then it doesn't always cover the full range of functionality you need, so you end up building custom solutions on top of it anyway. On top of that, many companies deliberately choose to develop this kind of software in-house, for the sake of reliability and information security, rather than relying on an external closed-source product.

This is where open-source libraries come in, especially the Orekit library, for instance, is used by ESA, CNES, and other agencies, covers nearly the entire spectrum of orbital mechanics gravitational harmonics, atmospheric drag, solar radiation pressure, and is free. The learning curve and software development is steeper than with commercial alternatives, but for a team with strong engineering expertise, it's a viable alternative to STK. But, of course, developing the software in-house even when using off-the-shelf libraries is also expensive and quite time-consuming. Even so, you often still end up doing manual work on top of it.

Payload data processing

A satellite can be roughly split into two parts: the BUS all the supporting systems onboard computer, data transmission channels, power system and the payload, the actual reason the spacecraft exists in the first place. And even if every component of the satellite is bought ready-made from suppliers, you still have to develop software specific to each payload software that makes it work exactly the way your particular mission needs it to.

When we were developing our satellite, one of the biggest challenges turned out to be getting our payload software to talk to the software of components bought from suppliers, the onboard computer above all. Interfaces, data exchange protocols, timing none of this tends to line up smoothly on the first try, and without support from the supplier, you can end up chasing down these mismatches for weeks. Supplier tech support really saved us here.

This is where a key economic feature of payload

software comes in one that sets it apart from almost any other industry: it's hard to reuse across missions.

In regular IT, you write software once and sell it a thousand times that's the whole economic logic behind SaaS. In space, it's the opposite: every new payload, even one tackling a similar task to the last, needs software built almost from scratch different sensors, different interfaces, different precision requirements. That's why the industry doesn't have, an "app store for satellites" the way it has an App Store on Earth and that's one of the reasons satellite development stays so expensive and slow: every time, you're paying not just for the hardware, but for software written from scratch for that one specific job.

You'd think the obvious fix would be standardization common standards that universal software could be built around, like USB or HTTP on Earth, where a single protocol works across billions of devices. There have been attempts at this, the Consultative Committee for Space Data Systems standards for data formats and communication protocols, for instance, but in practice the industry never fully standardized, and each company and mission still writes much of its own software. And this, too, ultimately comes down to economics: payload tasks are so varied and unique that no single standard can cover them all. Unlike USB, which solves the same simple problem "move data between two devices," payload software solves hundreds of fundamentally different problems that have no common denominator.

Space services

It's probably no surprise to you that as the number of satellites grows, a huge range of space services has sprung up around them including earth observation data as a service (EO-as-a-Service; connectivity as a service; ground station as a service; and launch as a service especially rideshare brokering. And on the more forward-looking side such as in-orbit servicing and debris monitoring and Space Situational Awareness.

Taken together, these examples point to a broader pattern: the space market is following the same path that land-based IT walked about fifteen years ago, a shift from selling hardware to selling services. Buying a presence in space used to mean buying a satellite or a rocket.

Today, more and more often, you can just buy the outcome, an image, a communications link, collision insurance while all the infrastructure and physics stay on the provider's side. It's the same shift that happened on Earth with the move from "buy a server" to "rent the cloud" space is just replaying it with a couple of decades' delay.

What's changing? The data center hype

AI is, of course, absolutely everywhere these days. We covered this in a separate article a year ago. Beyond the market's evolution from selling hardware satellites, rockets to selling services and subscriptions, there are other interesting shifts underway. The industry is moving toward a point where computing power in orbit becomes a sellable resource in its own right, rather than just "a feature of the satellite."

We've already talked about part of the data processing moving onboard. But there's a more radical idea the industry has arrived at: what if computing power in orbit becomes a standalone product not "a feature of a specific satellite," but a resource you can sell the same way you sell cloud computing power on Earth?

It looks like we'll see spacecraft whose actual payload is powerful computing hardware that can simply be rented. And naturally, at the largest scale, data centers are impossible to ignore. In November 2025, Google announced Project Suncatcher, a research moonshot aimed at putting data centers into space. The idea: a constellation of 81 satellites equipped with Google's own TPU chips the same ones used to train models like Gemini, linked by laser communication and powered by solar panels. The startup Starcloud has already launched Starcloud-1, a satellite carrying an Nvidia H100 chip on board, and is aiming for a 5 GW data center built on a 4 km solar array.

A Word on security

Naturally, more and more data is being transmitted from space and with computing moving into orbit, the stakes are only getting higher, making security an increasingly pressing issue.

There have already been cases of spacecraft being hacked, which you can easily find online. But there's a telling pattern across these incidents: attackers most often go after not the satellite itself in orbit, but the ground control software or the communication link to it — the very link we discussed in the Ground section. And as more constellation-management functions get automated and shift into software, the attack surface only grows. That's why cybersecurity is more relevant to space than ever.

This isn't a uniquely space problem, by the way Earth-based data centers and cloud services went through exactly the same thing. When businesses started moving to the cloud en masse in the 2000s, the industry ran into the very same pain points: researchers demonstrated that you could pinpoint where a specific client's data was physically located within "the cloud" and use that for targeted attacks.

There were also data losses caused by failures in the cloud infrastructure itself not an attack, just the unreliability of a young technology. And there were plain old stories, too, like a small cloud service's servers going down and permanently wiping out all its users' data.

So the logic of "new infrastructure new attack vectors nobody saw coming" repeats itself almost exactly. Back then, the industry responded with standardization and there's good reason to believe space will follow the same path.

The bigger picture

If you look at the whole arc from an onboard computer weaker than a smartphone to data centers in orbit, the same logic shows up at every level. Space software isn't behind Earth's because the industry is slow-moving; it's behind because every constraint such as radiation, mass, power demands its own, far more expensive solution to a problem that off-the-shelf software solved on Earth long ago.

But wherever that constraint eases up, whether it's onboard computing power, data transfer speed, or launch economics, space almost literally retraces the path IT already walked on Earth: from hardware to service, from manual control to automation, from closed systems to the same cybersecurity questions that were once new territory for the cloud, too.





AFRICA REPORT

AngoSat-2: High-capacity telecommunications satellite with high data transmission rates



3,2,1...ready for takeoff. In October 12, 2022, AngoSat-2 was placed into orbit by an expendable rocket, becoming Angola's first satellite to enter orbit. For Angola, the moment ushered in the golden age of broadband connectivity, television, and development, fueled by a desire for better technology at lower costs.

In December 2017, Russia had lost contact with Angola's first telecommunications satellite, Angosat-1, launched from the Baikonur Cosmodrome in Kazakhstan, according to a Russian space source. "Contact temporarily ceased; we lost telemetry," adding that efforts to re-establish contact with the satellite, which cost an estimated \$280 million were not fruitful.

Angosat-1, Angola's first telecommunications satellite, was launched from Baikonur by a Ukrainian Zenit-2SB rocket, which carried it into orbit. This project, costing approximately \$280 million, was financed by a loan from Russian state banks. The satellite's 15-year mission aims to improve satellite communications, internet access, and radio and television services.

Angolan Minister of Telecommunications, Information Technologies and Social Communication Mario Oliveira, said with this project, the Angola government intends to reduce digital exclusion in the country and the continent in general, through the expansion of telecommunication services to the most remote areas of the nation at competitive prices.

He said the satellite services covers the African

continent, mainly the southern region, and a significant part of southern Europe. Weighing a total of two tonnes, Angosat-2 is a High-Throughput Satellite (HTS) that will provide 13 gigabytes in each illuminated region, and it will be based on the Eurostar-3000 platform and have a design life span of 15 years. The minister pointed out that African countries, especially those of the Southern African Development Community have contacted Angola to provide them with telecommunications services.

ANGOSAT-2 is a project by the Angolan Government that is part of the National Space Program, with the aim of reducing digital exclusion in Angola and the African

continent, allowing the expansion of telecommunications services to more remote areas at competitive prices.

The satellite supports a series of services, covering the African continent, with greater emphasis on the Southern region and a significant part of Southern Europe. Its transmission capacity is seven times greater than the first Angolan Satellite (ANGOSAT-1), having six "transponders" in Band C, 24 in Band KU and, as a novelty, a retransmitter in Band KA, against 16 "transponders" relays in the C Band and six in the KU Band of the previous device, launched unsuccessfully in 2017, from the Baikonur cosmodrome, Russia.

As a High Transmission Rate (HTS) satellite, it provides 13 gigabytes in each illuminated region (areas within the satellite's signal range), based on the Eurostar-3000 platform, with

approximately 15 years of useful life.

"Four years after the launch of ANGOSAT-2, we can feel proud and satisfied with the performance of this space infrastructure, which has already allowed telecommunications operators to install VSAT terminals in more than 150 remote areas of the country", highlights the owner of the folder in this sector

Today this satellite is a key part of both Angola's National Maritime Coordination and Surveillance Centre and Angola's first satellite Mission Control Centre MCC, both of which were inaugurated by President Lourenço in January 2024.

Angola launches ANGOSAT-2 connectivity hub

Since its launch in October 2022, ANGOSAT-2 has enabled key milestones, including migrating local telecom operators to the satellite and delivering first-time connectivity through ConectaAngola.

Angola has unveiled a new national connectivity hub designed to widen access to communications services through the ANGOSAT-2, with a focus on supporting startups, internet service providers and telecommunications operators serving remote and underserved areas, reported Space in Africa.

The facility was inaugurated by the National Space Programme Management Office (GGPEN) at the Satellite Control and Mission Centre in Funda. Conceived as a central interconnection point, the hub is intended to simplify both the technical and commercial pathways to accessing ANGOSAT-2 services, particularly for connectivity models built around Very Small Aperture Terminal (VSAT) systems.

By offering direct access to the satellite's capabilities, the hub aims to accelerate the rollout of connectivity solutions in regions where terrestrial infrastructure is limited or non-existent. GGPEN general manager Dr Zolana João said the initiative is designed to reduce entry barriers for smaller players by lowering technical complexity and streamlining commercial processes, enabling faster project deployment and broader network expansion.

The move reinforces the Angolan state's commitment to democratising access to telecommunications by making ANGOSAT-2's capacity available in a more straightforward and transparent way to startups and telecom operators alike. Officials say this approach will help extend internet access to communities that have historically remained outside the reach of conventional networks.

Alongside the hub's inauguration, authorities also launched the Conecta Angola Commercial portal, a digital platform that centralises requests for satellite kits, services and capacity linked to ANGOSAT-2. The portal is designed to improve transparency, efficiency and speed in contracting services for private-sector users, while enabling companies to work in partnership with the government to reduce digital exclusion.

Through the platform, businesses can request equipment and services in an integrated manner, supporting efforts to bring connectivity to remote parts of the country. The new hub further strengthens the Conecta Angola Social and Commercial Programme, which currently operates 31 connectivity points and has already reached more than 366 citizens, many in areas that previously had no network access.

The installation of internet services in more than 150 remote locations (communes and municipalities) in the country, as well as in public and private institutions, constitutes one of the main benefits generated by ANGOSAT-2. Specifically, the availability of internet in these locations, previously called "grey zones", results from the installation of more than 150

"Very Small Aperture Terminal (VSAT)" terminals – small antennas providing telecommunications services which are connected through the Satellite Angolan, in an action by the business class in this sector. The respective terminals were installed in 16 of the country's 18 provinces, where it is now possible to have access to internet services, increasingly reducing digital asymmetry, in addition to promoting technological inclusion for citizens.

Along the same path, in one year, the Angolan satellite has also enabled the creation of the "Conecta Angola" project, a technological tool launched by the National Space Program Management Office.. This platform, part of the National Space Program, like the ANGOSAT-2 project, also aims to expand telecommunications services in areas still considered gray or without internet.

With this, Conecta Angola allows the internet to be made available to citizens, in general, as well as contributing to the implementation of the digitalization process of public administration in the country, according to the Minister of Telecommunications, Information Technologies and Social Communication, Mario Oliveira.

Among other features, this tool can also support the civil construction sector, for example, by facilitating interaction between the contractor or specialist in charge of the work with the other participants in a given project, sending data in real time, regardless of the location where you are.

In addition to Luanda, Conecta Angola is also already installed in two municipalities in the country, namely Belo Horizonte, municipality of Cunhinga, Bié province, in June, and Canzar (Cambulo, Lunda Norte), on the 9th of this month, with forecasts of be expanded to all provinces of Angola, with emphasis on Lunda Sul, Moxico and Cuando Cubango, in the coming months.

Regarding this historic achievement, the communal administrator of Canzar, António Cabuango, highlighted that the arrival of Conecta Angola in his locality represents an added value for residents, mainly for students, who will use this tool for their studies.

Additionally, in addition to benefiting the commune of Canzar, which so far does not have a mobile phone network, the administrator said that internet services will also serve to support the State's Integrated Financial Management System (SIGFE), at the level of the County.

The expansion of internet services in remote areas of the country also serves to reduce digital exclusion and promote socio-economic development, as well as opening up opportunities for Small and Medium Enterprises (SMEs) and corporations to create business solutions in the space market.

Contribution of ANGOSAT-

2 to the extractive industry

In addition to the aforementioned technological solutions, the Angolan Satellite also offers a set of services for mining, oil and agricultural companies, among other segments of the national economy.

Among the technological platforms that already benefit from ANGOSAT-2 services, the highlight goes to "Tech-Minas", "TECH-Gest", "TECH-Agro" and "TECH-Ecologia", which use the images of this Satellite to support the monitoring of your activities.

Tech-Minas, which is included in the Top 100 of the best projects in the world of artificial intelligence, being aligned with the Sustainable Development Goals (SDGs), allows, among others, to locate minerals with precision, generate alerts and monitor the activity of industries, according to the technician from the GGPEN Market Studies Department, Hugo do Nascimento.

Meanwhile, Tech-Agro is available for monitoring and mapping cultivation areas, automatically identifying the type of cultivation and estimating harvest productivity.

Along the same path, Tech-Ecologia is used to monitor oil spills, combat desertification and restore degraded areas, while TECH-Minas allows you to accurately locate minerals, generate alerts, monitor industrial activity, among other functions.

Given the availability of these technological solutions on the national market, it is proven, once again, that ANGOSAT-2 is in the commercial phase and is being used to provide telecommunications services to national operators, according to minister Mario Oliveira.

"The creation of the respective platforms is one of the most evident examples that ANGOSAT-2 is at the service of the Angolan nation and companies operating in Angola. We have a group of national operators that already provide communication services via the Angolan Satellite, which is working normally like any satellite operating in the world", he assured.

Therefore, he continued, other companies are called upon to make the most of the capabilities of the space infrastructure, which also allows for the development of infrastructure in the country.

Namibia taps Angosat-2 to boost connectivity

The Namibian Ministry of Information and Communication Technology (MICT) has partnered with Angola to use the Angosat-2 satellite to improve

connectivity in the country's remote areas where terrestrial infrastructure remains limited.

The initiative is being spearheaded through a joint effort between Telecom Namibia and Angola's Space Management Office. The ministry said the partnership will explore the potential of satellite connectivity to deliver Internet and voice services to remote areas.

Namibia's MICT Minister Emma Theofelus, during an interministerial phone call between the two countries, added that strengthening this cooperation will expand Namibia's communication alternatives. Discussions between the two parties began in June 2025 and included the launch of a proof of concept (PoC) to assess the satellite's performance in meeting Namibia's connectivity needs.

This included providing broadband Internet services to remote areas, backhaul solutions to strengthen Telecom Namibia's network infrastructure and cost-effective alternatives to the current reliance on terrestrial systems. It enables high-speed Internet, television and telephone services even in regions lacking terrestrial infrastructure. In August 2023, Angola initiated technical preparations to extend the satellite's benefits to countries within the Southern African Development Community (SADC).

Network improvements

Namibia using Angosat-2's services comes at a time when many countries on the continent are either signing deals or launching projects aimed at connecting underserved communities. In August 2025 Mobile Telecommunications Limited launched a strategic rural network optimization initiative called Buffalo Project aimed at boosting rural connectivity in northern Namibia.

Telecoms operator Airtel Congo and Wing Wah, a private Congolese oil company and subsidiary of the Chinese group Southernpec, partnered to deploy a private telecom network at the Banga Kayo oil field in Kouilou in Congo-Brazzaville also in August 2025.

Earlier in August 2025, Airtel Africa signed a strategic infrastructure sharing agreement with Vodacom Group in Mozambique, Tanzania and the Democratic Republic of the Congo (DRC).

Congo-Brazzaville's Electronic Communications Regulatory Agency and the Angolan Institute of Communications have signed a frequency coordination agreement on their common border. In early August 2025, Liberia and Sierra Leone announced the rollout of the Economic Community of West African States free roaming initiative, designed to ease cross-border mobile roaming costs. In March 2025, MTN Group and Airtel Africa agreed to share network infrastructure in Uganda and Nigeria.

In January 2025, Vodacom and Orange announced an infrastructure deal in the DRC, pledging to jointly construct up to 2,000 solar-powered basestations over the next six years. Similarly, in January 2024, Algerian operators Algérie Télécom (AT) and Ooredoo Algeria agreed to share infrastructure and exchange ideas on innovative services.

SPECIAL REPORT

Can geospatial mapping redefine telecom assets deployments?

Geospatial mapping has undergone a fundamental shift over the past decade. What was once seen as a specialized capability, used primarily by cartographers, survey departments, and national mapping agencies, has become a foundational layer of modern digital infrastructure. Today, governments, enterprises, and technology platforms rely on geospatial systems to understand complexity, manage scale, and make decisions that are increasingly location-dependent.

Every major challenge shaping the modern world- urbanization, climate risk, infrastructure strain, logistics complexity, network expansion, public health, and national security, has a spatial dimension. Data without location is incomplete. Patterns without geography are often misleading. Geospatial mapping integrates location data with remote sensing, 3D models, real-time sensors, and advanced analytics. The result is not just better maps, but spatial intelligence, the ability to see relationships, anticipate outcomes, and act with precision in the physical world. This is why the global geospatial analytics market is expanding rapidly, projected to grow over USD 230 billion in the coming decade, with some forecasts extending even higher.

Geographic Information Systems (GIS) have become integral to the telecommunications industry, enabling operators to plan, design, build, and manage networks at scale. From strategic site selection to predictive demand modelling, GIS provides the spatial intelligence telecom providers need to accelerate deployment, reduce costs, and enhance service quality.

Telecommunications networks are inherently spatial. Coverage, capacity, interference, customer demand, and infrastructure cost are all driven by geography. As networks evolve from 4G to dense 5G and fiber architectures, the margin for planning error has narrowed dramatically. Traditional CAD-based planning methods struggle to capture real-world complexity, especially in dense urban environments. Geospatial mapping addresses this gap by combining high-resolution terrain data, building footprints, LiDAR-derived heights, and demand patterns into a unified spatial model.

The GIS market in the telecom sector is growing rapidly, with Europe projected to lead the charge, holding more than 30% of the global market share in 2024. Adoption is accelerating. According to Cognitive Market Research, Europe's GIS telecom market is set to grow at a 13.5% compound annual growth rate, between 2024 and 2031.

In Africa, with vast rural expanses; telecom providers utilized geospatial analytics to identify

areas with poor or no cellular coverage. By plotting existing cell towers and cross-referencing with population density maps, they could pinpoint optimal locations for new towers. Outcome: This spatially informed strategy enabled providers to drastically improve coverage in remote areas, offering connectivity to previously isolated communities.

However, the telecom tower industry forms the backbone of modern digital connectivity, enabling the seamless functioning of mobile networks, accelerating the rollout of 5G infrastructure, and supporting the proliferation of IoT applications. In the United States, telecom towers play a vital role in meeting the nation's growing demand for high-speed, reliable communication.

Market projections show that the installed base of telecom towers is expected to grow from 136.55 thousand units in 2024 to 148.77 thousand units by 2029, reflecting a steady CAGR of 1.73%. This growth highlights the industry's critical importance in supporting the nation's rapidly evolving digital infrastructure and positioning it as a cornerstone of economic and technological advancement.

However, this promising trajectory is not without its challenges. The telecom tower industry faces significant hurdles in regulatory compliance, operational inefficiencies, and the pursuit of sustainability goals. Federal, state, and local regulations impose strict guidelines on site approvals, environmental compliance, and maintenance standards, complicating tower deployment and management. Traditional methods for monitoring and maintaining tower assets result in higher costs, frequent downtimes, and resource inefficiencies.

One of the core applications of GIS in telecom is spatial site selection. GIS tools enable operators to pinpoint ideal locations for cell towers, base stations, and small cells. By performing spatial analysis, operators can evaluate multiple factors such as population density, existing infrastructure, and topography to support smarter site decisions. Advanced GIS technologies generate digital elevation models (DEMs) that support detailed line-of-sight analysis. This allows telecom engineers to simulate signal propagation across real-world landscapes, even in dense urban environments. These models factor in variables such as building heights, materials, and terrain elevation, helping reduce multipath interference and improve overall coverage quality.

By combining spatial data with environmental

and demographic inputs, GIS significantly improves the precision and cost-effectiveness of network rollout strategies, especially as 5G and small cell deployments increase in complexity.

With growing reliance on data-heavy applications like 5G, network capacity planning has become more complex. GIS platforms now integrate real-time traffic data, historical usage patterns, and machine learning to predict future network demand, enabling more informed infrastructure investment decisions.

GIS overlays user density maps with key performance metrics such as latency, bandwidth, and signal strength. This helps operators identify network congestion points and optimise resource allocation. Vodafone UK, for example, uses this approach to dynamically allocate bandwidth during peak usage hours, ensuring smooth service delivery.

By analyzing trends in population growth, device adoption, and Internet of Things (IoT) expansion, GIS can forecast capacity needs 3 to 5 years in advance. Leading telecom operators use these insights to prioritise upgrades, particularly in high-demand areas such as industrial zones and business districts.

Beyond planning, real-time geospatial analysis plays a growing role in operations. Outage detection, capacity monitoring, and field crew dispatch are increasingly driven by live spatial dashboards. When integrated properly, these systems reduce downtime and improve customer experience.

Geospatial services providers support telecom operators by building end-to-end network inventories, automating route selection, integrating field survey data, and creating digital twins of outside plant infrastructure that remain accurate throughout the asset lifecycle.

Cloud-based GIS platforms enable real-time collaboration between telecom operators, municipalities, and contractors. This is particularly useful for coordinating network builds with ongoing city projects, like roadworks. Amsterdam's Smart City initiative, for example, uses GIS to synchronize fibre rollouts with roadworks, integrating network planning with urban development.

Similarly, deploying fibre-optic networks in urban areas is often fraught with challenges, such as complex zoning regulations, environmental concerns, and high infrastructure costs. GIS simplifies this process by providing tools that identify the most cost-effective and efficient routes for fibre deployments.

GIS platforms evaluate variables such as trenching costs, existing duct infrastructure, and

regulatory boundaries to determine optimal routing. In one instance, GIS helped reroute a fibre deployment around a protected wetland, resulting in significant cost savings and faster permitting.

With the integration of LiDAR data and satellite imagery, GIS enables early identification of geotechnical risks such as subsidence zones. This allows operators to reinforce vulnerable sections proactively, reducing long-term maintenance costs and improving network resilience.

In light of these, GIS is no longer a support tool, it's a strategic asset. Operators that integrate GIS into their planning and operational workflows can unlock significant competitive advantages. Operators can save up to 15–25% of capital expenditures through optimised site selection and fibre routing. The use of GIS for fibre-optic path optimization significantly reduces deployment costs, while AI-driven network design minimizes operational inefficiencies.

By predicting network demand and optimizing capacity, GIS enables faster time-to-market for new services. Telecom providers using GIS can deploy 5G and other innovations more rapidly, gaining first-mover advantage. GIS platforms help operators comply with regulatory frameworks, ensuring they meet the targets for gigabit connectivity in a timely and cost-effective manner.

Geospatial automation for 5G tower rollouts

5G deployment has fundamentally changed the way network planning optimization are being approached. Unlike earlier generations where macro towers covered wide areas with predictable propagation, 5G, especially in mid-band and mmWave, demands dense, highly precise infrastructure placement. Every miscalculation in height, line-of-sight, obstruction, or access planning now multiplies into operational delays, redesign cycles, and rising field deployment costs.

In this environment, geospatial automation for 5G tower rollouts is no longer about speeding up mapping; it is about removing uncertainty from physical deployment itself. The primary shift is the relocation of validation from late-stage field discovery to early-stage digital verification. Site feasibility, RF suitability, structural constraints, access conditions, and visual impact are now validated inside spatially accurate digital environments before physical mobilization begins.

With geospatial automation, however, the entire first validation cycle is now executed digitally. Engineers can confirm whether a rooftop supports

the required load, whether the antenna has clean line of sight, whether access meets safety norms, and whether obstructions will compromise performance, without stepping on site.

Only those locations that survive this automated multi-constraint screening advance to physical inspection. In dense urban deployments, this shift alone has been shown to eliminate 40–60% of early-stage field visits, dramatically reducing truck rolls, scheduling conflicts, and redesign-driven delays. Field teams are no longer sent to discover whether a site might work; they are sent to confirm that a digitally validated site will work.

The impact is not incremental. It produces structural improvement in rollout speed, CapEx efficiency, and deployment predictability across the entire 5G lifecycle. In this blog, let's explore the systems and methods behind that shift and how operators are applying them at scale.

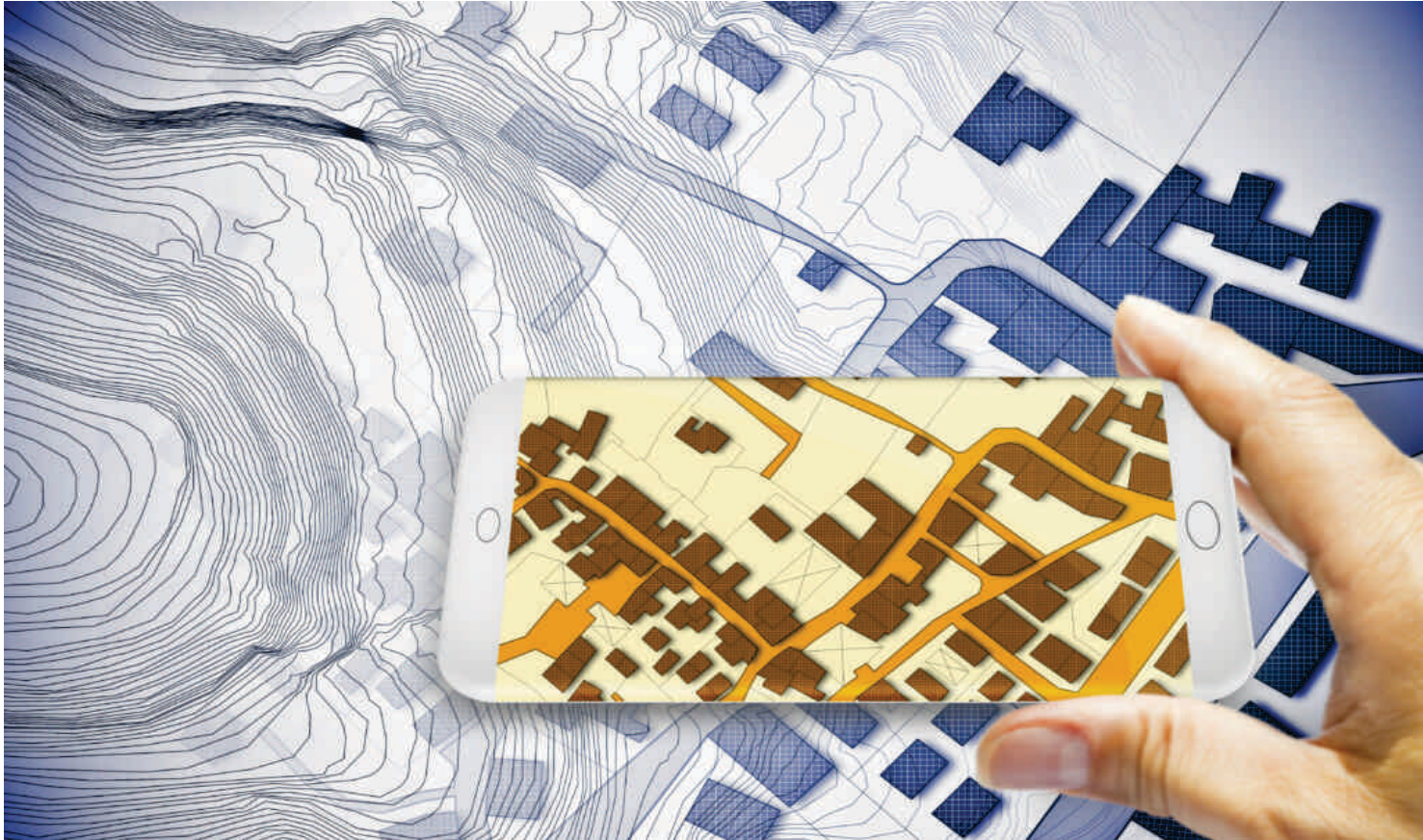
In classic 4G deployment models, one or two rounds of field surveys were often sufficient to validate site feasibility. The propagation environment was forgiving. Rooftop geometry mattered, but centimeter-level precision was rarely critical.

5G changed this completely. At higher frequencies, signal behavior becomes extremely sensitive to obstruction, building material, street canyon effects, elevation variance, and micro-clutter such as signage, trees, and rooftop utilities. A few degrees of antenna misalignment or a poorly assessed obstruction can collapse coverage in entire micro-zones.

At the core of modern geospatial automation is a very practical engineering goal, which is to make sure every critical field check is already completed inside a spatially accurate digital environment before anyone is sent on site. Instead of treating physical surveys as the starting point of feasibility, they now become the final confirmation step, only after digital validation has already filtered out low-probability sites.

Telecom tower digitization is revolutionizing the way infrastructure is managed by integrating advanced technologies to transform traditional assets into intelligent, efficient, and adaptive systems. This shift is essential to meet the growing demands of modern connectivity, driven by 5G rollouts, increased data consumption, and the proliferation of IoT devices. By employing tools such as drone surveys, digital twins, and AI-powered asset management, telecom stakeholders can significantly streamline operations, improve resource utilization, and enhance overall network reliability

This shift toward digitization not only addresses the operational inefficiencies of traditional management approaches but also supports long-term goals such as sustainability and scalability. Digitized towers are better equipped to adapt to the demands of next-generation technologies, ensuring that telecom



infrastructure remains resilient, cost-effective, and future-ready.

Geospatial Services in Telecom Asset Management

The integration of geospatial services into Telecom Asset Management has revolutionized the approach to managing telecom infrastructure, making it more precise, efficient, and predictive. By incorporating technologies like drone surveys, 3D digital twinning, detailed mapping, and AI/ML-powered analytics, Telecom Asset Management is transforming into a highly sophisticated domain that significantly enhances asset oversight and operational intelligence.

The deployment of geospatial services in telecom asset management offers unparalleled benefits in terms of operational efficiency, cost management, and strategic planning. By leveraging these advanced technologies, telecom operators can ensure the longevity of their assets, improve service reliability, and stay ahead in the competitive telecommunications

landscape. This integration not only drives better management practices but also supports the continuous evolution and sustainability of telecom infrastructures.

The telecom towers market is no longer defined by ownership; it's being reshaped by how intelligently those assets are managed and monetized. In the UK, recent structural shifts are setting new global benchmarks for innovation in telecoms asset management. One major operator's decision to divest its tower assets to an infrastructure firm marked a deliberate pivot toward financial agility. By offloading ownership and instead leasing infrastructure, the company unlocked capital for next-gen service investments and streamlined operational burdens. This signals a global movement toward asset-light models where operational control and service innovation take precedence over physical ownership.

Another turning point came when two telecom giants merged their tower portfolios into a neutral-host entity. This newly formed infrastructure company now offers wholesale access, driving higher tenancy rates and better asset utilization,

critical in a market shifting toward 5G densification and rural coverage mandates.

These strategic shifts reflect a broader rethinking of infrastructure economics, moving from ownership-centric models to value-centric ecosystems powered by digital visibility, flexible leasing, and smarter deployment.

What ties these developments together is the reliance on robust telecom asset management solutions, systems capable of managing leases, tracking maintenance, and providing real-time insights at scale. With telecom network inventory geospatial dashboards, decision-makers can visualize asset status, site capacity, and service readiness in real time.

In summary, Telecom Asset Management is vital for Towercos and Network Operators as it helps streamline operations, ensure asset reliability, and support strategic decision-making, thereby improving service delivery and operational efficiency. This integrated approach to managing assets ensures that every component of the telecom infrastructure is accounted for, maintained, and utilized effectively to meet the demands of a dynamic telecommunications environment.





INTERNATIONAL REPORT

Global space industry trends and prospects



Jared Isaacman's confirmation as NASA administrator ended a year-long saga that became a proxy fight over Artemis risk tolerance and NASA's commercial posture. Isaacman was first nominated in December 2024, then advanced by the Senate Commerce Committee in April. But that nomination was withdrawn in May. He was then renominated in November amid growing frustration with acting administrator Sean Duffy, then finally confirmed on December 17, 2025.

During Isaacman's confirmation hearing, he aligned with senators noting the need to move faster on key programs such as Artemis. And he brings a unique resume to the

role, Isaacman's both led missions in space as a civilian commander of SpaceX Inspiration4 and Polaris Dawn and built successful businesses as a startup founder and entrepreneur. This mix has driven optimism that NASA will now be more comfortable operating at the pace and risk profile of the commercial space economy and be more open to partnerships with private companies.

The following day's Executive Order from the White House welcomed Isaacman to the role by accelerating the target dates for key space milestones like returning US astronauts to the

Moon by 2028 and establishing a permanent lunar outpost by 2030. It also positioned NASA as a key piece of the Trump administration's objective of ensuring American superiority in space across civil, commercial and national security domains.

However, in 2025, European space leaders worked to translate the regional rhetoric for "strategic autonomy and resiliency in space" into concrete initiatives for developing "sovereign space capabilities." EU countries have recently become acutely aware of the increasing need to strengthen national and regional security

capabilities and reduce their reliance on existing space powers as the ongoing war in Ukraine made clear how space is now necessary to maintain military advantages. It's shown how vital imagery from space can be for survival, and to not solely rely on other countries for access to it. It's highlighted how satellite communications are crucial, and how non-state actors now have outsized control over battlefield optionality. European infrastructure has experienced disruptions linked to space related cyber and communications incidents. The region can no longer rely on Russian rockets for access to orbit and recently proposed formally barring

collaboration with Chinese institutions on research and innovation projects related to space. All this combined created a significant need for Europe to scale up its own space architecture.

Every country automatically contributes to "mandatory" ESA activities -primarily science -based on the size of their economies. But that only makes up 20% the budget. The rest is for optional programs countries can choose to fund or not fund, with the expectation that their contributions return a proportional share of contracts to their nations' space companies. Which programs were elevated in 2025?

Europe's sovereign broadband constellation was embedded directly into ESA's core budget lines for communications and navigation, with hundreds of millions allocated for early system architecture, tech demonstrations and user terminals. Unlike earlier European satcom programs, IRIS² is designed first for government and defense customers: encrypted communications for militaries, emergency services, border control, and critical infrastructure operators.

In practice, IRIS² is Europe's attempt to ensure that secure connectivity does not become structurally dependent on US commercial constellations or foreign-owned platforms. Initiatives were also funded for LEO-PNT (Celeste), aimed at building low-Earth-orbit navigation capabilities to complement Galileo, reflecting growing concern that PNT itself has become a strategic vulnerability in contested environments.

Space transportation was also a key on the agenda of European space leaders. Which led to oversubscribed funding for the European Launcher Challenge; enough to support development of all 5 rocket companies selected in the last round of the competition. That means nearly €1 billion will now flow to Isar and RFA based in Germany, Maiaspace in France, PLD Space in Spain, and Orbex based in UK with the aim of nurturing a new class of national champions across the continents.

In December 2020, the Chinese company Changguang Satellite disclosed it had raised \$375 million to build a constellation of 138 remote-sensing satellites offering high-resolution imagery of objects on the Earth's surface. When completed in 2030, the constellation will be capable of revisiting any item of interest every ten minutes. Changguang's announcement was just the latest in a series of developments signaling that the U.S. geospatial intelligence industry is being overtaken by foreign competitors. Once the unrivaled leader in orbiting spacecraft capable of monitoring the Earth, America is now only one among several players. For instance, there are currently 16 commercial satellites in orbit around the globe capable of using radar to penetrate darkness and cloud cover in pursuit of Earth observations, and 15 of them are foreign-owned.

Although the U.S. intelligence community is known to operate Earth-observing satellites utilizing various sensing technologies, the resulting collections are highly classified. The information generated by commercial remote-sensing companies, on the other hand, is generally available to anyone who can afford it. A recent study counted over 150 commercial companies engaged in marketing such information. Many are headquartered outside the United States.

Geospatial intelligence has a wide variety of uses, from mapping to mineral exploration to commercial logistics, but it is especially valuable to military consumers seeking to understand the activities of potential adversaries. It was, for example, used to identify the location of Soviet nuclear weapons during the Cuban Missile Crisis in 1962

In Q4, annual reports to Congress from the US-China Economic and Security Review Commission and the Department of Defense claimed that China views Space as a critical area for military operations, national economic development, and geopolitical influence. These publications cited China's rapid advancements in launch and satellite capabilities and growth of ground-based infrastructure across its civil, military and commercial sectors. They also conclude that these developments have been reducing the historical capability gap between US and Chinese space systems.

By offering other countries the use of its satellite networks, launch services, & space infrastructure, China has enhanced the resilience and global coverage of its space architecture. China's space program is closely tied to its Belt and Road Initiative (BRI), with the construction of a global network of ground infrastructure to support space operations. It's also actively working to embed its civil and commercial space capabilities into international applications to transform them into core components of global infrastructure, creating long term strategic and economic dependencies on Chinese technology. China has agreements with countries across Africa and Asia to expand the use of BeiDou beyond navigation promote its role in economic and environmental development.

The Action Plan, published by the China National Space Administration (CNSA) aims to deliver a "significantly expanded" scale of China's commercial space industry by 2027 and explicitly commits to deeper integration of commercial space into the overall national space development plan. It encourages government departments of all levels to expand procurement of commercial space services and opens national research and development programs for cutting-edge space tech including propulsion, navigation, remote sensing, to commercial companies for the first time.

The new department's mandate: oversee the rapidly growing roster of commercial space companies in the country and promote development to benefit the industry. It's expected to enable higher-level coordination and planning across the ecosystem. It provides a path to reduce major bottlenecks in commercial space launch approvals and satellite license issuance that the US is currently solving for. It also arrives at a crucial inflection point for China's commercial space economy. 2025 concluded with a robust pipeline of Chinese space startups looking to IPO. LandSpace, Galactic Energy, CAS Space, Space Pioneer, Yee Space, MinoSpace, and more have filed for listing on the Shanghai Stock Exchange's STAR

Market in 2026. Public market success for these companies means maturing capital markets with an exit path for space startups, which could unlock even more growth capital across the ecosystem.

Investment trends

Last year, space capital tracked \$17 billion invested across 135 rounds in Q4 2025 to eclipse \$55 billion in 2025. Space startups received robust funding across all rounds in 2025. But it was Stoke Space, \$870million, Apex Space, \$400 million, and K2 Space \$375 million that each raised more capital than 99.5% of a venture capital backed startups worldwide, with multiple mega-rounds throughout the year. This is "platform-scale" capital, with these startups being priced as new industrial primitives.

The continued convergence of space, defense, tech, and industrial-scale energy showed up in venture capital too. Space-focused venture capital s invested in nuclear-gen startups and space startups raised capital from both top tech and national security funds. Funding towards satellite manufacturers surged, especially in the US and Europe.

Amid rising investments in space and satellite stocks, strategic autonomy fueled deal-making in 2025. A major merger and acquisition wave was driven by geopolitical needs and the scale-up of sovereign capabilities. Defense demands drove vertical integration and the formation of "new space" primes. However, mid-tier manufacturers combined to form scaled suppliers to support large "programs of record."

But the ramp-up in defense spending also caused a "supply chain crunch," leading to acquisitions of component suppliers and to secure access to critical minerals including Voyager ExoTerra and Estes Energetics. Without a strong foundation in these markets, legacy players especially Airbus-Leonardo-Thales and not-yet-at-scale startups Lynk-Omnispace merged to create the scale and synergies required for survival.

The geopolitical environment also forced a "return to fundamentals" in the public equities, with defense procurement as a significant driver of revenue for space companies. Capital intensity also forced partnerships between geostationary and low earth orbit operators. Top performers like Planet and Sidus capitalized on both sovereign and global defense contracts and bottom-line milestones. But defense-centricity was also a double-edged sword in Q4 2025. The 43-day gap in operations during the longest ever shut-down of the US government led to contract and funding delays, forcing contractors like Redwire to cut revenue guidance. EchoStar's \$43 billion in spectrum sales to SpaceX and AT&T is seen to have led to share price gains and revaluations of other satellite operators with valuable spectrum they could sell Globalstar.

Space stations

In Q4 2025, the International Space Station celebrated its 25th year of continuous human habitation since the first full-time residents opened its hatch on November 2nd, 2000. Since then, the ISS has hosted visits from 290 people representing 26 countries as well as thousands of scientific investigations.

With over 750 experiments conducted aboard the ISS across 2025, including on-demand production of vital nutrients, determining DNA's ability to store data, space debris removal demos, and advancing next-generation medicines. However, a major milestone for space science was announced in September when the FDA approved Qlexa subcutaneous formulation for Merck's cancer-drug Keytruda, for essentially all solid tumor indications where IV pembrolizumab was already approved. Merck has been conducting micro-gravity research aboard the ISS since 2014. It's protein crystal growth experiments yielded early insights that led directly to the new and approved formulation, which significantly improves patient quality of life for by turning treatment timelines from 30 min to 2-hr infusions into a "one-minute every three weeks" injection.

In November, China's Tiangong station faced the same challenge that the ISS faced at the start of 2025, stranded astronauts when its Shenzhou-20 crew was left without a viable return vehicle following a suspected debris strike. A rescue spacecraft reached Tiangong 20 days later, far faster than the 286 days it took to send one to the ISS. Roughly two weeks later, CMSA doubled down on safety with the appointment of the first set of quality supervision representatives for China's human spaceflight program. There are plans to double the size of the station in the coming years.

In December, the ISRO announced finalized configurations for India's future Bharatiya Antariksh station. The first of its 5 planned modules is targeted for orbit in 2028 before the station becomes operational in 2035.

In the same month, Russia announced plans to separate its modules from the ISS once decommissioned in 2030 and use them to form the core of a new Russian Orbital Station.

In 2031, NASA will pay SpaceX \$1 billion to send a spacecraft to dock with the ISS, then steer in back down to Earth over the Pacific, completing its decommissioning. Rather than developing another fully government-funded and operated station, NASA has turned to nurturing the development of commercial space stations to help ensure an American presence in orbit. This initiative has been orchestrated through NASA's Commercial Low Earth Orbit Destinations program. Axiom Space was the first to be awarded a Commercial Low Earth Orbit Destinations contract. In 2020, the startup was allocated \$140 million to build commercial modules that could attach to ISS, then detach as a free-flying station before ISS retirement. Axiom's first major module (Hab-1) is targeted to connect with the ISS in 2026, with subsequent modules following annually. In Q4, Axiom struck deals to develop station capabilities for semiconductor production and orbital data centers.

In 2021, the Commercial Low Earth Orbit Destinations program provided awards to 3 teams for free-flying commercial stations: \$160 million to Starlab including Voyager, Lockheed, Nanoracks, \$130 million for Orbital Reef, Blue Origin, Sierra Space, Boeing, Redwire, and \$126 million to Northrop Grumman who later exited the contract to join Starlab. In October, Starlab unveiled a full-scale mockup of its planned station, which aims to supply the research capacity equivalent to the ISS. In November, 2025, it said 55% of that space has already been pre-purchased.



Egypt is on the left of frame, Israel on the right, with the border closely following the yellow boundary line.

INDUSTRY REPORT



But it was a non- Commercial Low Earth Orbit Destinations funded commercial station company that became the first to test its capabilities in orbit. Vast Space has been privately funded \$1 billion to date directly from crypto billionaire Jed McCaleb. In November, 2025 the startup successfully completed its Haven Demo mission. It's first, single-module station is targeted to launch in 2027. Vast has been working towards scoring contracts for Phase 2 of the CLD program, and recent changes to its structure may work in their favor.

Last August, NASA put the original Commercial Low Earth Orbit Destinations Contract on hold and announced it would fund Phase 2 via multiple funded Space Act Agreements instead of a single firm-fixed-price contract. It also reduced the prior plans "full-time continuous crew" requirement to

include concepts that could support as little as 4 crew in one-month increments. The new approach aims to accelerate the deployment of smaller station concepts so the US can establish a commercial presence in orbit earlier than it would waiting for larger stations. It also opens the door for additional station developers like Max Space, which unveiled plans for its Thunderbird Station, designed to launch on a single Falcon 9 rocket, in December.

Rise of orbital data centres

In 2020, Mandala, JPL, and Caltech received roughly \$100 million in funding to study the feasibility of orbital solar power stations. The technical work and early patents showed that the physics closed, and the system could work, but the economics were extremely challenging. Before then, Leon Alkalai, a PhD and 33-year veteran at Jet Propulsion Laboratory JPL, had founded Mandala Space Ventures as an accelerator focused on orbital

technologies.

As effort was winding down, Leon posed a simple question: what if we put a server on this? That reframing was the real trigger. Instead of moving power back to Earth, what if we moved compute into orbit, where power, thermal, and latency constraints look very different.

From there, Mandala and Leon began developing the foundational technology and early IP that would eventually become Sophia. At the time, he was doing venture work with SparkLabs Global Ventures. Mandala reached out in the summer of 2024 about getting involved. After several months of deep technical and strategic discussions, he joined full-time as CEO in January to build Sophia as a standalone company. Outer space offers what could be an ideal environment for data centers continuous access to solar energy,

natural thermal dissipation, and the orbital real estate to ingest vast volumes of satellite data without being constrained by ground-station downlink bottlenecks.

Today, most space station companies think about orbital computing as synonymous with terrestrial computing, essentially placing conventional IT infrastructure inside pressurized modules with tight power and thermal constraints. That model does not scale, says an expert. Latest approach, he said, enables external compute structures, wings, or appendages built from radiation-cooled Tiles that sit outside the station hull.

Thousands of technologies used in the space sector, from rocket materials to astronaut life-support systems - have been successfully used for terrestrial applications. In fact, many

modern industrial innovations have come from the aerospace industry. For example, the need to miniaturize electronics in the 1960s for NASA's Apollo programme laid the foundations of the microelectronics revolution, and, consequently, the development of modern computers.

US spaceports increasingly host and enable in-space services, especially orbital logistics, power beaming demos including optical grids for lunar, cislunar continuity, data compute platforms, refueling, assembly, and debris management. These extend economic activity into orbit and beyond, turning spaceports into launch-to-lifecycle enablers for a circular space economy.

With this, compute capacity scales modularly by adding Tiles, rather than redesigning internal station systems. For near-term stations, human servicing provides a practical path for installation, inspection, and replacement, while the underlying architecture is designed to operate autonomously over time.

In a world of exponentially scaling AI, where terrestrial data centers will be constrained by power availability, land use, cooling needs, and regulatory friction, LEO can become not just a location for data collection, but a critical extension of Earth's digital infrastructure stack.

The broader context that the industry has just began an off-planet commerce and infrastructure. The next 50 years will look more like The Expanse than Star Trek. There will be orbital manufacturing, mining, pharmaceuticals, habitats, and transportation networks.

Just like the evolution from horses to trains to highways, dropping launch costs, from ~\$55,000/kg to under \$3,000 today and heading toward \$1,000 makes space economically inevitable. Orbital compute is a foundational part of that future. AI and space computing will not fatigue public or investor interest, they're the next enduring infrastructure waves.

Over a 30-year lifecycle for a 1-megawatt data center, terrestrial sites incur constant carbon costs from land, construction, cooling, water, and continuous power use.

Orbital centers incur emissions only during manufacturing and launch. With 5–6 replacement launches over 30 years due to debris impacts and hardware refresh cycles, orbital tiles burn up on re-entry and don't create orbital debris, resulting in dramatically lower lifetime carbon impact compared to terrestrial data centers.

Advocates of Orbital Data Centres see the cost of orbital compute becoming cheaper than Earth alternatives by 2030. Today, satellites generate enormous data volumes but discard most of it due to bandwidth limits. That prevents valuable use cases like real-time missile tracking, air-traffic coordination, maritime oversight, environmental disaster response, and weather modeling. Other

major edge use cases include space debris tracking and avoidance, satellite-to-satellite coordination, and wildfire detection and response management. In the long term, orbital compute resembles terrestrial cloud economics, as some organizations will buy local compute while others use cloud-scale orbital data centers.

Global orbital access increasing

Last year witnessed a new all-time highs across orbital launch activity, confirming that access to space is entering a new phase of sustained industrial scale. 329 orbital launch attempts were conducted worldwide, a rise of 25% YoY over the 2024's prior record. 318 made it to space, marking a 97% industry-wide success rate. More than 3.3million kilograms were delivered to orbit, comprised of 4,000+ satellites -the vast majority for commercial use. The company conducted another 41 orbital launches in Q4 to reach 165 for 2025, accounting for over 50% of global launch activity and 85% of all US attempts, effectively functioning as the world's primary orbital logistics provider. In aggregate, SpaceX deployed over 3.8k payloads for 150+ different satellite and spacecraft operators.

The company remained the NASA's primary transporter to the ISS, shuttling 8 astronauts and cargo delivery, with SpaceX's Crew Dragon and Cargo Dragon spacecraft carrying 8 astronauts and 5,300kg of supplies to the station, respectively. Beyond NASA's Commercial Crew flights, SpaceX also completed 2 commercial human spaceflight missions, powering 4 private astronauts to the ISS for Axiom Space and sending 4 more flying over both of Earth's poles on the first crewed polar-orbit mission. In October, the Air Force approved SpaceX's proposal to double its launch rate at Vandenberg Space Force Base from 50 to 100 and begin using a second launch pad there.

Starship is the biggest and most powerful rocket ever built, anticipated to have a payload capacity more than four times Falcon 9's. SpaceX sent Starship on 5 test flights in 2025, steadily stacking technical milestones on the path to a fully reusable super-heavy launch system. In January, the company caught its Super Heavy booster in mid-air using the tower's "chopsticks," a critical step toward rapid reuse. On its 10th test flight in August, Starship delivered payloads into orbit for the first time, crossing a key threshold from experimental system to operational platform.

China hit its own historic highs in 2025, with 90 successful launches across 93 attempts. Q4 alone accounted for roughly one-third of yearly total -including a week with 4 launches in 4 days during December -reflecting an acceleration in tempo. But the country's launch vehicle ecosystem remains fragmented. It required 10 different manufacturers fielding 29 different rocket types to achieve that count. Many are light to medium lift, able to deploy only single-to low double-digit satellite payloads per launch. So, despite higher launch volume, total mass-to-orbit and constellation deployment capacity remained well below SpaceX. Structurally,

reusability remains China's critical gap.

In Q4, China lost the runner-up reusability race to Blue Origin, and both of their initial challengers, Landspace Zhuque-3 and SAST's Long March 12A reached orbit, but failed to land their boosters, leaving China without an operational reusable orbital system, for now. For China, cracking this challenge is essential to scaling up and sustaining megaconstellations.

Megaconstellations

SpaceX sent up nearly 1k more Starlinks in Q4 2025 for a total of 3.1k throughout 2025. There are now over 9,300 active satellites in its mega constellation, including 650 Direct-to-Device capable Starlink V2's, which SpaceX began deploying in January and completed in December. Similarly, customer adoption continues to surge as Starlink concluded the year "connecting over 9 million active customers across 155 countries, territories and other markets." That's nearly double the 4.6 million it had at the end of 2024. Last year, it began obligatory testing in India, assumed to be one of the last steps before it can rollout commercial services in the country, which could net it millions more.

In 2025, Amazon became the second largest launcher of satellites with over 180 satellites after sending up 51 more in Q4. In November, it rebranded the network from its research and development name Project Kuiper into more consumer-sounding Amazon Leo in advance of rolling out commercial services in 2026. Amazon is bringing to market enterprise offerings it is in a unique position to provide as the only operator of both a global connectivity constellation and hyperscale cloud infrastructure.

Leo will function as an extension of a company's AWS infrastructure, with the network tightly integrated into AWS regions, edge sites, and networking services. It can behave like cloud-connected "flying fiber" and provide private networks for AWS workloads with "Direct to AWS" data flows. Leo + AWS enables hybrid cloud and edge patterns including private networks that extend an AWS environment to any site, secure movement of large datasets, and deployment of applications at or near the network edge. Customers seem interested as enterprises spanning sectors like energy, agriculture, and logistics announced adoption of Leo use cases in November.

Similarly, SatNet's Guowang constellation added 50 sats in Q4 2025 to reach 136. Spacesail's Qianfan reached 108 after adding 18 in Q4. In October, Spacesail signed a cooperation agreement with Türksat based in Turkey to explore using Qianfan connectivity services for corporate data networks and in aviation, energy, mining, and maritime industries. In December, Space sail signed an MoU with Airbus to explore integrating Qianfan connectivity into Airbus' fleet of passenger and cargo airliners operated by Chinese Airlines.

Direct-to-Device services

The Direct to Device opportunity has always been clear as it frees satcom services from being tied to the maximum operating radius of specialized

terminals and opens them up to population-scale smartphone ecosystems. But in 2025, Direct to Device was still generally defined by promise rather than proof even as services were still in early trials, there was still significant regulatory uncertainty, and telcos that still saw it as a niche coverage add-on relegated to emergency messaging and gap coverage in remote areas.

Throughout the year, Starlink and T-Mobile's T-Satellite service transformed from early beta to large-scale commercial rollout. SpaceX, which started 2025 with zero D2D-capable satellites, launched 650 of them throughout the year and expanded service offerings from basic messaging and emergency alerts beginning in July to powering data and video applications by October. Rogers based in Canada also beta launched Rogers Satellite D2D services with Starlink in July. In November, Orange in UK announced Message Satellite with Skylo, offering Direct to Device services in France and 36 additional countries. Meanwhile, regulators around the world updated and introduced policies intended to boost broader Direct to Device development. Alongside this was a global wave of new satcom–telco partnerships and spectrum transactions. SpaceX alone acquired over \$20 billion of spectrum from EchoStar and submitted a trademark application for Starlink Mobile.

For Mobile Network Operators, scaling-up Direct to Device capable constellations can create opportunities to expand customer bases to previously underserved markets and provide credible, frictionless global extensions to their terrestrial networks. New "global roaming" offerings become possible, as KDDI just enabled with T-Mobile and Starlink. The activation of AST SpaceMobile's Direct to Device services to millions through its Mobile Network Operators partnerships in 2026 is set to be another major inflection point. Should all this development play out as intended, expect Direct to Device to become an essential layer for any future connectivity stack. In order to be prepared, operators will soon need to determine how new true "coverage everywhere" plans get delivered, priced, and positioned at scale.

In 2025, AST announced long-term Direct to Device deals with many of the world's top telecoms, including Verizon and slc group and a joint venture with Vodafone. Those build on similar deals with AT&T, Orange, Telefonica, Telstra and more in 2024. AST now has agreements and MoUs with 50+ Mobile Network Operators with a combined 3 billion subscribers. Commercial services with a subset of these partners will go live in 2026 as AST builds out its constellation of Block 2 Blue Birds.

Earth Observation

In 2025, the Earth Observation industry accelerated its shift from niche analytics market to foundational layer of the business intelligence stack. Rising defense demand has injected new energy into Earth Observation constellations, driving the deployment of higher-resolution sensors, faster revisit rates, and new sensing modalities. Similarly, growing geopolitical pressure for sovereign data sources has also created markets for new dual-use entrants and national champions, bolstered by a broader capital markets pivot toward defense tech. Together, these forces are expanding the scale, quality, and accessibility of Earth Observation solutions and unlocking a new generation of geospatial services that enterprise customers can now treat as core inputs to optimize operations, anticipate risk, and model real-world systems in near real-time.

INDUSTRY REPORT



As the moment, remote sensing satellites are evolving to see increasingly smaller things across a larger share of the Earth's surface. Planet already operates the largest constellation of imaging satellites, which it uses to map the Earth daily. When it began launching its 3m resolution Dove constellation in 2014, users could image objects roughly the size of large buildings, agricultural field plots, or semi-truck trailers. In October, Planet announced a new line of 1m "Owl" satellites able to image much smaller objects such as individual cars, large shipping containers, and heavy machinery from orbit. Owls will also include NVIDIA GPUs to run onboard edge AI applications like image identification and anomaly detection, enabling them to deliver insights not just images directly to customers.

Observation capabilities are also expanding below the Earth's surface. In November, the Luxembourg Space Agency awarded a

contract to Canadian Space Mining Corporation to develop Quantum Atomic Subsurface Mapper, a space-based quantum gravimetry sensor capable of detecting subsurface resources such as critical minerals and water from orbit.

Infrastructure operators are using Earth Observation to gain persistent visibility over distributed physical assets that are otherwise costly or impossible to monitor continuously. In October, UK-based SatSense secured a multi-million-pound, multi-year contract with Network Rail for satellite-data powered remote monitoring services including ground deformation monitoring, flood mapping and change detection; replacing costly manual inspections with continuous geospatial risk monitoring. Similarly, in December, Florida's Lee County renewed its partnership with ICEYE to support rapid

response and damage assessment after extreme weather events, using SAR imagery to map flooding and infrastructure impacts in near-real-time.

In addition, Earth Observation is also being used to generate competitive intelligence about industrial activity and asset performance. In December, thermal imaging company SatVu announced plans to target the data center market with its HotSat-2 satellite, using thermal signatures to monitor energy efficiency and operational intensity across large computing facilities. That same month, SatVu imagery revealed significant

heat leakage from one of the largest cryptocurrency mining centers in the US, highlighting how Earth Observation can expose real-world energy usage patterns that are otherwise opaque to investors,

regulators, and competitors.

Another rapidly growing enterprise applications of Earth Observation sit at the intersection of geophysics, AI, and resource discovery. Fleet Space's ExoSphere platform applies AI inversion models to satellite-connected geophysical sensors to map subsurface mineral structures. It can help uncover locations with underground lithium, a process that traditionally takes years of core sample drilling and only three per 1,000 potential deposits end up becoming commercially viable. In December, Fleet Space announced its contribution to a major lithium deposit discovery in Quebec, including analysis used to pinpoint drilling locations. These capabilities position Earth Observation as a front-end for critical minerals exploration rather than a niche geoscience tool. Fleet's technologies are now being developed for future off-world

resource mapping under Australia Space Agency's Moon-to-Mars program.

For energy enterprises, economics can matter just as much as ESG when it comes to Earth Observation value. For example, methane leaks represent direct revenue loss for energy firms, not just compliance risk.

GHGSat satellites monitor methane and CO2 emissions from orbit. In October, they signed a partnership with Petrobras, Brazil's largest energy company, to monitor methane across its onshore & offshore operations. That followed a similar deal in September with ExxonMobil to monitor and mitigate methane across onshore operations in America, Canada, and Asia. GHGSat also has deals with other global energy companies such as Saudi Aramco, Total and Chevron. To keep up with this growing demand, GHGSat is now adding additional satellites to its constellation.

In November, the California Air Resources Board announced that Planet's Tanager hyperspectral satellite had helped identify and resolve 10 major methane leaks across oil and gas facilities in the state since launching in May. The satellites find and track large plumes from methane leaks at facilities in the state.

The CARB program has enabled the state and facility operators to take action and make repairs more rapidly, already helped stop emissions equivalent to the removal of 18k cars from California's roads for a year.

Earth observation is no longer primarily about producing images, but about delivering operational intelligence. Enterprises are increasingly treating Earth Observation as a persistent sensing layer for the physical economy, one that feeds directly into asset management systems, compliance workflows, and strategic decision-making tools. What was once a specialized analytics market is becoming a core component of how businesses perceive, model, and optimize real-world systems.

Earth Observation addressing insurance gaps

As 2025 ended, there were growing examples of Earth Observation getting embedded directly into underwriting, policy renewal decisions, and disaster response workflows, effectively turning satellite data into a powerful resource for insurers around the world.

High-resolution imagery is increasingly being used for property underwriting and policy renewals. In 2025, insurers including Allstate and Travelers were reported to be using satellite imagery to assess roof conditions prior to renewing home insurance policies. In several high-profile cases, homeowners were notified that policies would be canceled or

premiums increased unless satellite-detected roof defects were repaired. These proactive "unsolicited inspections" highlight how Earth Observation is now functioning as a front-line underwriting tool, enabling insurers to continuously reassess risk across millions of properties at marginal cost.

In December, 2020, ICEYE supported rapid disaster response during Hurricane Melissa by delivering near-real-time radar imagery to insurers and reinsurers, enabling immediate mapping of flooded areas and infrastructure damage even under heavy cloud cover. ICEYE's Flood Rapid Impact product, announced earlier in the year and expanded through Q4 2025 property, uses SAR data combined with machine learning to automatically estimate property-level flood exposure within hours of an event. This allows insurers to triage claims, prioritize emergency payouts, and verify losses without waiting for field adjusters to access affected areas.

At the reinsurance layer, Earth Observation is increasingly being integrated directly into core risk intelligence platforms. In December, ICEYE and Munich Re expanded their partnership to embed satellite-derived flood and wildfire data into Munich Re's Location Risk Intelligence platform, giving underwriters continuous access to high-frequency hazard monitoring at a global scale. Rather than relying solely on historical catastrophe models, reinsurers are now incorporating live geospatial data streams to dynamically update exposure estimates and capital allocation decisions. ICEYE struck a similar data-sharing deal with Aon in 2024.

Earth Observation is also accelerating the growth of parametric insurance, where payouts are triggered automatically by measurable physical conditions rather than post-event loss assessments. Throughout 2025, insurers also highlighted Earth observation as a key enabler of parametric flood, wildfire, and drought products, using satellite data as the trusted, third-party source of truth for contract triggers. In this model, Earth Observation does not just inform insurance decisions; it directly governs financial transactions.

These developments are triggering a structural shift in how insurance leverage space assets. Earth observation is no longer just an external data source used for occasional analysis; it's becoming embedded infrastructure in the full insurance stack. From automated underwriting and continuous risk scoring to real-time disaster response and parametric payouts, Earth Observation is turning insurance from a backward-looking actuarial industry into a forward-looking, continuously sensing risk management system.

The Earth Observation-driven development of the Golden Dome remains one of the biggest drivers of US commercial space companies' doubling down on defense in 2025. It's intended to be comprised of an integrated layer of remote sensing satellite to spot and track threats and a constellation of

space-based interceptors to detect and intercept potential risks.

In October, SpaceX reportedly won \$2 billion to build missile and aircraft tracking satellites. In November, Space Force awarded its first round of contracts for Space-Based Interceptors (SBIs) but declined to disclose awardees. In December, the US Missile Defense Agency qualified over 1,000 more companies to compete for task orders under the \$151billion Golden Dome SHIELD contract. More than 2,100 companies are now qualified for the IDIQ. In October, Military leaders from France and Germany announced an initiative to create their own early warning capability. It will be called Joint Early Warning for a European Lookout and is planned to sync with NATO's Integrated Air and Missile Defense system.

In December, the US Space Development Agency awarded contract valued at over \$3.5 billion to Lockheed, \$1.1 billion, L3Harris \$843 million, Rocket Lab \$805 million and Northrop \$764 million to each build 18 satellites for the Tracking Layer of its Proliferated Warfighter Space Architecture constellation. The layer will be made to provide missile warning and tracking and significantly increase the coverage and accuracy needed to close kill chains against advanced adversary threats when integrated with Proliferated Warfighter Space Architecture's Transport Layer. In October, Sierra Space passed a critical design review to begin assembly of its own batch of 18 Transport Layer satellites.

The constellations are large networks of small, low-cost satellites, often with different capabilities, designed to work together as a single, resilient system. The US Space Development Agency's Proliferated Warfighter Space Architecture (PWSA) began deployment in 2025. However, in September and October 2025, 42 Transport Layer satellites were sent up in batches of 21 to begin building up the space-based backbone for a JADC2 network connecting sensors, shooters, and command systems across all services and domains. The Batch 1 was built by York Space as part of a \$382 million contract. Batch 2 by Lockheed Martin as part of a \$700 million contract signed in 2022. More Transport Layer satellites, including batches built by Northrop Grumman, are expected to launch later in 2026.

Secure communications

In October 2025, procurement documents showed Germany's plan to spend €14 billion on satellite programs to create multiple networked constellations aligned to its new €35 billion space safety and security strategy. It included €9.5 billion to develop a dedicated military and government secure communications constellation in LEO to ensure constant, jam-resistant connectivity for troops and command posts. This budget is expected to benefit German primes like OHB. Last December, the newly formed Defense Investment Agency (DIA) of the

Canadian government, struck a strategic partnership with Canadian space companies Telesat and MDA to build a state-of-the-art MILSATCOM architecture for Canada's Enhanced Satellite Communications Project –Polar.

In December 2025, a classified payload for the US National Reconnaissance Office was flown to orbit on a Falcon 9 rocket. It was SpaceX's 10th mission for the National Reconnaissance Office in 2025. Five of those carried up a combined 85 SpaceX Star shield satellites, which are government modified Starlink's with end-to-end encryption. Star shields are also often equipped to carry remote sensing payloads that can collect imagery and signals intelligence and feed it directly into military command-and-control networks.

Additionally, SpaceX was selected by Space Force to develop another new 480-satellite dedicated military communications constellation, called MILNET, that will operate as a high-capacity "backbone" layer alongside the Space Development Agency's Transport Layer, which focuses on low-latency tactical data inputs.

Intelligence, Surveillance, and Reconnaissance

ISR entails the collection of broad range of information and transforming it into strategic intelligence. Commercial space companies now operate constellations that originate some of its most mission critical raw data sources. Defense customers now have a wide variety of signal types they can source. And AI is making each more valuable individually and exponentially more valuable when combined.

In terms of imagery, Planet Labs operates the world's largest fleet of imaging satellites, which enables their customers to monitor entire regions of the Earth. Their solutions also integrate image recognition AI; they send users real-time alerts on things they need to action on rather than pictures they need to analyze themselves. This quarter, Planet won \$20 million in contracts for maritime intelligence and domain awareness to aid in vessel detection and monitoring for the US Navy10and National Geospatial-Intelligence Agency (NGA). Those were followed by an "8-figure contract renewal" with an undisclosed international defense and intelligence customer. Earlier in 2025, Planet expanded the scope of another DoD contract, secured a "seven-figure contract" with NATO for Maritime Domain Awareness support, and scored a €240M contract with Germany to deliver dedicated imaging capacity and direct downlink services over specific European regions.

While Planet's advantage is in scale of coverage, BlackSky's is in its Gen-3 very-high-resolution cameras' ability to autonomously detect and classify much smaller, more mobile objects like vessels, vehicles, and aircraft in near-real-time. Like Planet, they also use AI to provide a "real-time ISR" service layer that sends users

notifications to action on, not just snapshots from space. In November, BlackSky won a \$30million contract to "accelerate sovereign space-based intelligence capabilities" for "a strategic international defense customer."

ICEYE, founded in Finland, operates the world's largest constellation of Synthetic Aperture Radar SAR satellites, which produces detailed images regardless of clouds or darkness that aims to provide uninterrupted monitoring. In May, ICEYE entered a joint venture with Rheinmetall, Germany's largest arms manufacturer. In December, "Rheinmetall ICEYE Space Solutions" was awarded \$1.9 billion to build and operate a space-based surveillance constellation for Germany's armed forces. Two months prior, ICEYE had also partnered with one of Japan's top 3 defense contracts, IHI Corp, to build SAR satellites for security, civilian, and commercial use. Throughout 2025, they also signed deals and delivered SAR satellites for the Finnish Defense Forces in a deal estimated at €158M, Polish Armed Forces, and Portuguese Air Force.

Radio-Frequency RF Data

HawkEye360's satellites provide another unique set of space-derived intelligence radio-frequency (RF) data enabling defense customers to detect and geolocate electronic emitters like communications, radar, and jamming systems, even when targets are hidden, mobile, or intentionally trying to avoid optical or radar detection. Unlike imagery-based systems, RF sensing captures who is transmitting, on what frequencies, from where, and how often, revealing patterns of operational behavior, not just the physical presence of assets. In Q4 2025, the US Navy contract was renewed for the 4th consecutive year and was awarded dedicated funding from the NRO for the next 2 years.

Defense customers are awarding AI x space data contracts to more than just constellation operations: In Q4 2025, Airbus was awarded a €50 million contract to integrate AI into the weapons and information systems used by the French armed forces. Phase I will start with upgrading the Spationav maritime surveillance system with AI trained to process satellite-derived data. Voyager won a similar, \$21M AI-driven signals processing contract from the US Air Force. The NGA awarded the startup \$708M to train AI-enabled computer vision systems to process satellite imagery and identify targets of interest.

Over the last generation, the United States has steadily lost ground in an array of industries, from shipbuilding to machine tools to semiconductors. All of these industries have some relevance to national security. However, few are so clearly linked to intelligence gathering and military preparedness. If the United States cannot take effective steps to preserve its commercial geospatial intelligence sector, its prospects for remaining the world's sole superpower will be dim indeed.

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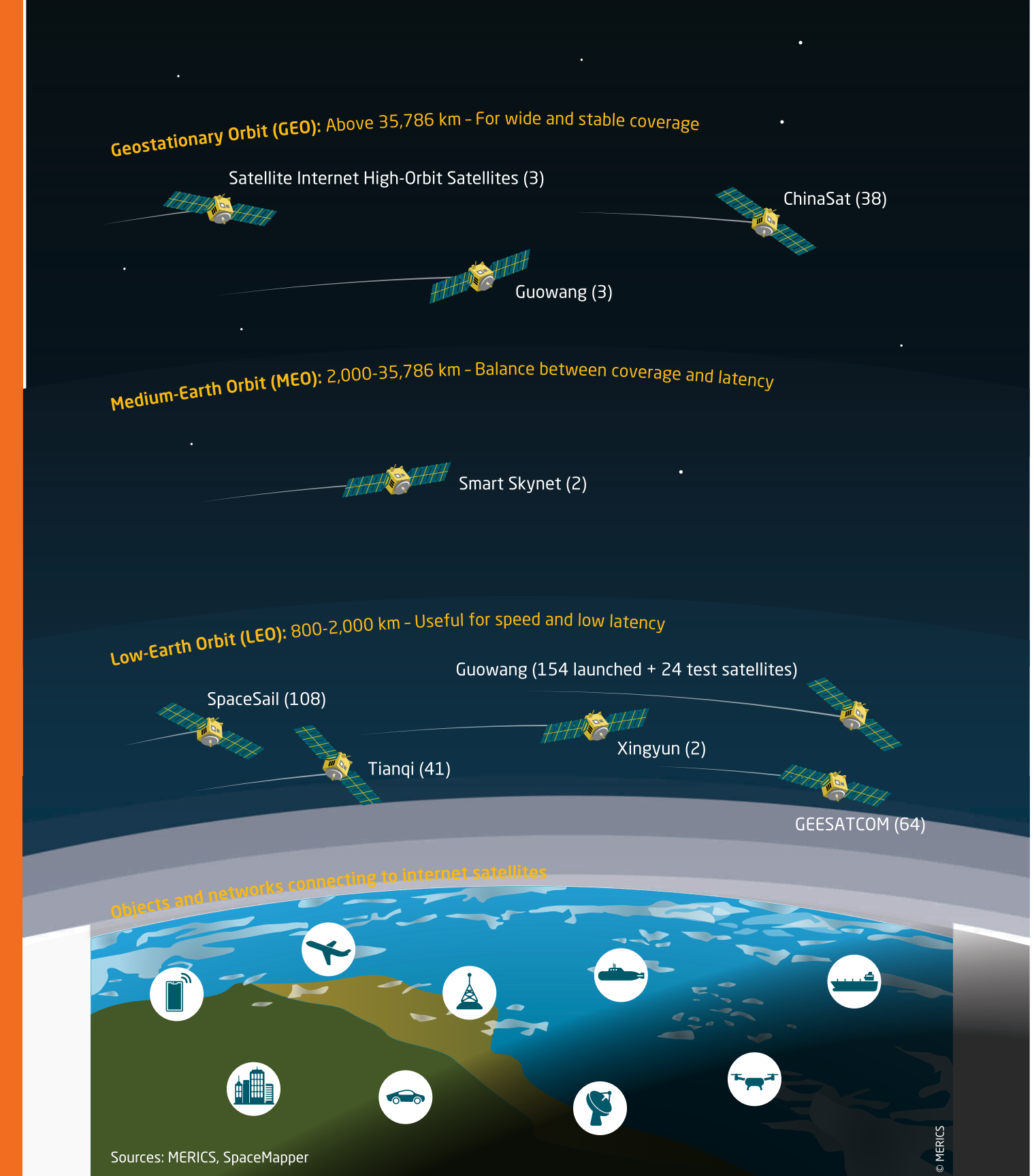
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China aims for an integrated and self-reliant space internet

Main constellations across LEO, MEO and GEO (number of satellites launched as of January 2026)



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How US cede Africa's space industry to China



On the outskirts of Cairo, a cutting-edge space lab was supposed to be the first in Africa to produce homegrown satellites. Step inside the plant, though, and the made-in-Africa image begins to fade

Satellite equipment and parts arrive in crates from Beijing. Chinese scientists scan space-tracking monitors and deliver instructions to Egyptian engineers. A Chinese flag hangs from one wall. The first satellite assembled at the factory, hailed as the first ever made by an African nation, was built mainly in China and launched from a spaceport there in December 2023.

The Egyptian satellite lab is the latest advancement in China's secretive overseas space program. Beijing is building space alliances in Africa to enhance its global surveillance network and advance its bid to become the world's dominant space power, Reuters has learned. China has publicly announced much of this space assistance to African countries, including its donations of satellites, space monitoring telescopes and ground stations. What it hasn't

discussed openly, and which Reuters is reporting for the first time, is that Beijing has access to data and images collected from this space technology, and that Chinese personnel maintain a long-term presence in facilities it builds in Africa.

The satellite plant, which began operating in 2023, is part of a suite of space technology that China has gifted to Egypt over the past two years. Transfers that have been disclosed publicly include a new space monitoring center, which features two of the world's most powerful telescopes, plus two Earth observation satellites launched in 2023 – the one that was assembled in Egypt, and another manufactured solely in China. In addition, China that year launched a third, Chinese-made satellite for Egypt, one capable of military-grade surveillance, according to two people with knowledge of the matter.

The satellite facility is the centerpiece of Space City, a complex being constructed about 30 kilometers east of Cairo near a new administrative capital being built by Egyptian President Abdel

Fattah El-Sisi's government.

Sisi has fostered closer ties with China in recent years, including inking infrastructure and energy projects under President Xi Jinping's Belt and Road Initiative. The Egyptian presidency did not respond to a request for comment.

Egypt, a major recipient of U.S. military aid, is not the only country in Africa being drawn into China's orbit. Beijing has 23 bilateral space partnerships in Africa, including funding for satellites and ground stations to collect satellite imagery and data, according to the United States Institute of Peace, a think tank. In the past year, Egypt, South Africa and Senegal agreed to collaborate with China on a future moon base, a project that rivals the United States' own lunar plans.

This is just the beginning. In a meeting with dozens of African leaders in Beijing in September, Xi said satellites, as well as lunar and deep-space exploration, would be among the priorities for \$50 billion in Chinese loans and investment earmarked

for Africa over the next three years. Xi's administration says publicly it is helping boost African space programs because China wants no country left behind as economies and militaries become increasingly reliant on space technology.

Privately, China is getting far more in return for its investment. This includes access to surveillance data collected by satellites and telescopes as well as a permanent presence in facilities it builds, according to six people with direct knowledge of China's space projects in Africa.

As China advances its relationships in Africa with technology incentives, the United States is pulling back. Billionaire Elon Musk, CEO of SpaceX and Tesla, is heading U.S. President Donald Trump's drive to shrink the federal government. One of his first targets has been the U.S. Agency for International Development, the aid agency that has spread American soft power around the world since its establishment by President John F. Kennedy in 1961.

The Pentagon says China's space projects in Africa and other parts of the developing world are a security

risk because Beijing can Hoover up sensitive data, enhance its military capabilities and coerce governments if they become locked into China's communications ecosystem.

The Pentagon and Eftimiades did not provide specific evidence that China has used space technology it has donated to Africa for intelligence or military purposes, and Reuters was unable to independently verify these claims.

Liu Pengyu, spokesman for the Chinese Embassy in Washington, did not respond directly to questions about whether China is using equipment in Africa for surveillance. He said the U.S. "is not in a position to smear or defame China" because of America's own record of spying. "The U.S. is the world's largest surveillance state," Liu said.

The space infrastructure and equipment that China is installing in Africa have common civilian uses such as transmitting data,

monitoring the impact of climate change and helping fly spacecraft. But they also have military applications.

Powerful telescopes are used for space situational awareness. They could predict when U.S. military satellites pass overhead and help coordinate the use of anti-satellite weapons (ASAT), according to a 2022 report by the U.S. Defense Intelligence Agency. During a conflict, for instance if China invaded democratically ruled Taiwan, knocking out an enemy's satellites could disrupt missile guidance systems and tangle communications between ground, air and naval troops. China and Russia have previously tested ASATs and are continuing to develop more advanced versions, the DIA report said.

Access to a broad range of Chinese-built, foreign-owned satellites gives Beijing the ability to better coordinate military operations. These satellites could also give China a clearer picture of U.S. military activities around the world. The Earth observation satellite assembled in Egypt, for instance, has the ability to take high-resolution images of areas where the U.S. and Egypt carry out joint military exercises.

China's overseas ground stations, like one it has built in Ethiopia and another it is planning with Namibia, can be used for coordinating military operations, tracking missile launches and monitoring other countries' space assets. They also add to a sprawling global network of data collection infrastructure, which includes undersea internet cables and 5G networks. U.S. allies have pulled back from terrestrial space partnerships with China. In 2020, Sweden declined to renew a contract with China that had allowed Beijing to use satellite ground stations in Sweden and Australia, citing the "geopolitical situation."

Sweden's state-owned space company declined to comment further on the contract. Australia's defense department did not respond to a request for comment.

To understand China's space push in Africa, Reuters interviewed more than 30 people with knowledge of Chinese projects on the continent, including diplomats, space engineers, consultants, and military and intelligence officials. Reuters also reviewed over 100 patents and papers published by Chinese government and military bodies leading Beijing's space program.

China's space web

China's rapid expansion of its space infrastructure on Earth is an example of a broader trend in which Beijing is catching up with the U.S. on everything from satellites to uncrewed moon landings to anti-satellite weapons, Stephen Whiting, commander of the Pentagon's U.S. Space Command, told Reuters.

China has accelerated the launch of low-earth orbit communications satellites over the last two years in an effort to compete with Musk's Starlink. The mogul's rocket launch company SpaceX owns Starlink, which provides commercial internet service, but is also building a network of hundreds of spy satellites for the National Reconnaissance Office, a U.S. intelligence agency that manages spy satellites.

"We see breathtaking advancements by China in space," Whiting said, adding that the Pentagon is "paying attention" to Beijing's partnerships with developing countries.

China Aerospace Science and Technology Corporation (CASC), a state-owned military and space contractor, has announced a goal to make the country the world's top space power by 2045. Plans include sending astronauts to the moon by 2030, building a moon base and developing nuclear-powered space shuttles.

The U.S. still has by far the biggest space program in the world, which is underpinned by SpaceX and a host of other private space companies.

China's space investments overseas also haven't always gone to plan. For instance, when a Chinese rocket carrying an Indonesian satellite exploded in 2020, it allowed SpaceX to swoop in and entrench itself as the Southeast Asian country's primary space contractor, Reuters reported.

Still, China's advances in space pose a challenge to Trump. During his first term, Trump created the U.S. Space Force, a new arm of the military that recognized the importance that space will play in future conflicts.

Trump's space team is unlikely to prioritize forging bilateral space relationships in the way Beijing has done in Africa, according to three space policy veterans who advised the former president's transition team.

They predict Trump is more likely to double down on America's military capacity in space and push ahead with a race to the moon and possibly Mars, bolstered by his friendship with Musk. NASA's Artemis program, supported by rocket launches by private companies like SpaceX, aims to get astronauts back on the moon by 2028.

NASA, in partnership with the United Arab Emirates, Canada, Japan and the European Space Agency, also plans to build a space station in the moon's orbit known as the Lunar Gateway. The White House did not respond to a request for comment.

Washington's efforts at space diplomacy have been unable to counter China's growing bonds in Africa, which are gaining significance as a new global space race takes off, according to interviews with U.S. and African space officials.

Around 90 countries now have space programs of their own, with many smaller nations aligning their national policies around frameworks set out by Washington or Beijing. By helping developing countries build space industries, China is nurturing crucial alliances.

The moon has emerged as a test of allegiance. The U.S. has signed up more than 50 countries to the Artemis Accords, a set of rules to influence space exploration and the use of the moon and Mars. China has described the U.S. rule book as a colonial-style land grab, proposing instead to build a collaborative International Lunar Research Station. China has gained the support of a dozen countries for its moon base, including Russia and Egypt.

Scott Pace, head of the National Space Council in the first Trump administration, described China as a fundamentally "self-interested actor" whose partnerships aim to cement China as the "center of power" in space.

China's main space agency, the China National Space Administration (CNSA), did not respond to a request for comment. In response to a question from a Reuters reporter at a media briefing in Beijing in October, Yang Xiaoyu, director of the agency's System Engineering Department, said China has data-sharing agreements with partner countries but "has never, and will never" use images and data to enhance its military surveillance capabilities.

Liu, the Chinese Embassy spokesman, said "African countries and their people have the wisdom and ability to choose partners that align with their own interests."

Egypt's space city

Recently, Egypt's Prime Minister Mostafa Madbouly met with Sherif Sedky, CEO of the Egyptian Space Agency, to review the agency's progress on several key projects.

During the meeting, Sedky briefed Madbouly on the agency's accomplishments and future plans. He outlined the status of the Space City, efforts to localise satellite technology, the establishment of a joint-stock company to manufacture satellite components, and the implementation of international agreements signed with various institutions and organisations.

He highlighted the successful launch of the "EgyptSat-2" satellite, which has enabled the complete mapping of Egypt, aided in urban planning, and assisted in monitoring national projects.

The satellite has also contributed to monitoring port activity, maritime navigation in the Suez Canal, and identifying strategic agricultural crops and their distribution. Sedky also discussed the launch of the experimental satellite "NEXT-SAT 1". The satellite has achieved a 40% localization of technology and, over the past six months, has successfully operated in orbit, undergoing over 400 tests and collecting over 1,400 images.

The agency has also developed an online platform allowing users to browse and purchase space images. The agency is working to establish more global partnerships to market satellite imagery and applications. It is also establishing a company to market its products.

The agency has collaborated with private sector institutions and international partners to provide satellite imagery for specific sectors. Egypt has won the presidency of the United Nations Committee on the Peaceful Uses of Outer Space, the first time an African country has held this position. Egypt has also been elected to head the Arab Group for Space Cooperation.

Sedky outlined the agency's key strategy to enhance its economic role, which includes continuing to contribute to the design, development, and manufacture of satellites, as well as assembling, integrating, and testing those satellites. The agency will play an active role in training and qualification programs in space sciences and technology. A technological zone within Space City will host

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companies. The agency has developed educational satellite models, with sales reaching EGP 5.8m, aiming for sales of EGP 15m.

In 2017, CNSA, the Chinese space agency, announced a partnership with Egypt's National Authority for Remote Sensing and Space Sciences to build a satellite facility in Cairo. The Chinese deal coincided with Cairo's creating the Egyptian Space Agency (EgSA) in January 2018 and laying out plans for the construction of a Space City on the outskirts of Cairo.

Between November 2017 and January 2018, Egyptian technicians and engineers went for training in China at space and military sites, two people with direct knowledge of the collaboration told Reuters.

When ground broke on the satellite plant, the Chinese ambassador to Egypt, Liao Liqiang, was on site. Liao, a career diplomat and vocal advocate for more Chinese-led space projects in Africa and the Middle East, would go on to closely oversee the development of the lab, according to the two people.

Dozens of construction workers and engineers from CASC, the Chinese space firm, moved into the Space City site. Some have never left.

The project was seen as a priority for China's space agency, and progress on it was fed back to CASC President Zhang Zhongyang, two sources said. CASC develops space tech to support China's military capabilities, according to a Reuters review of patents. This includes using satellites to coordinate missile strikes.

Zhang is a pivotal figure in China's space and military firmament. His background in missile design has made him a valuable player in efforts by the People's Liberation Army (PLA) to build up its space capabilities, according to statements posted on the official website of China's State Council. Zhang's role is highlighted by his membership in the military's Science and Technology Committee, a key part of the PLA's efforts to upgrade its technology and maintain war readiness. His high status in the Communist Party hierarchy is underscored by his inclusion in one of Xi's top decision-making bodies, the Central Committee.

In July last year, Zhang visited Egypt to inspect the satellite facility, official photos show. CASC, Zhang and Liao did not respond to requests for comment.

Egypt's satellite facility does not, however, add up to a full-fledged space program – it relies on China for almost every aspect of the project. Two of the three satellites emanating from the partnership so far were built solely in China, while the third was assembled in Egypt from Chinese components. All three were launched from China.

The first, dubbed Horus 1, was put into orbit in February 2023. That Earth observation satellite can help Egypt monitor agriculture productivity, predict natural disasters, and spot criminal activity such as narcotics cultivation, EgSA said at the time.

The second, Horus 2, was launched weeks later from the same spaceport in China, CASC announced, without disclosing the customer. Horus 2 is a military-grade surveillance satellite built for Egypt, two sources with knowledge of the satellite said. EgSA did not respond to questions about the purpose of Horus 2.

A Chinese Long March 2C rocket blasted off from the Jiuquan Satellite Launch Centre in China's northwestern Gobi Desert with the secretive payload. Egyptian Space Agency (EgSA) CEO Professor Sherif Sedky appeared before the media the following day.

The Egyptian official said that the Chinese-launched satellite is owned by the Egyptian state and that it is "capable of taking high-resolution images that benefit Egypt and Arab and African countries in their quest for sustainable development".

Sherif Sedky insisted that Horus-1 "is not a luxury, but a necessity for the country's growth". The new observation satellite is dual-purpose,

dedicated to military and civilian missions, among which the EgSA president highlights its dedication "to examine the soil of arable land, which will result in improving crop types, maximising profits and productivity"

Horus-1 will also monitor water sources, help anticipate natural disasters, monitor the occupation of state land and identify the location of illegal crops.

According to US Space Force analysts, Horus-1 is being manufactured by China's state-owned DFH Aerospace, with the participation of Egyptian engineers.

It has a mass of about 300 kilograms and has been positioned at an altitude of approximately 496 kilometres above the Earth.

Egypt's third satellite, MisrSat-2, went aloft in December 2023. It was the first to come out of the Cairo plant.

Most of the construction of MisrSat-2 was done by CASC in China; parts were shipped to Cairo, assembled and tested by CASC and Egyptian engineers, then shipped back to China for launch, two people with direct knowledge told Reuters. While the \$72 million satellite technically belongs to Egypt, CASC still monitors the data and images it collects, the people said.

Sherif Sedky, CEO of EgSA, told Reuters that the assembly facility and MisrSat-2 were "donations" from China and nothing was expected in return. Sedky said data from Egypt's satellites belongs to and is controlled by Cairo. EgSA did not respond to questions about whether China also has access to the satellite data.

MisrSat-2 will help Egypt tackle climate change, enhance farming output and improve urban planning, EgSA says.

Sedky said Egypt is not picking sides in the space race by partnering with China. Cairo has received more than \$80 billion in U.S. military and economic assistance since the late 1970s, according to the State Department website. "We are neutral, we deal with everybody," Sedky said in an interview in his office in Egypt's Space City, a gated complex that also hosts a new African Space Agency created by the African Union. "If we get an offer, we take it."

A Reuters journalist saw Chinese engineers buzzing in and out of the Space City complex. Asked about their presence, Sedky said they were there to install equipment and train Egyptian staff. He said these Chinese workers would leave eventually.

Egypt's satellite plant may soon have a new tenant with Chinese connections. In August, USPACE Technology Group, a Hong Kong-listed private space tech firm, said it had signed a strategic partnership with EgSA to develop satellite technology at Egypt's Space City.

U.S. missteps

In many ways, China's space diplomacy mirrors a strategy the U.S. has been implementing for decades. NASA, the U.S. Space Force and U.S. private companies maintain networks of global ground stations for tracking and communicating with satellites, mostly hosted in U.S. overseas territories or allied countries. These sites are used for monitoring space and downloading data and for conducting secretive military operations in space.

Space Command's Whiting said the U.S. programs aren't comparable to China's. "We publicly talk about where they are, what they do," Whiting said of U.S. military ground stations. "With China, we don't see that same level of openness, and that does create doubt as to what's



happening."

Whiting said the U.S. Space Command does not have any space-tracking assets in countries where China is setting up similar capabilities.

If the Trump administration is serious about executing its "America First in Africa" policy and transforming American engagement on the continent, it needs to focus on sectors where it still holds a decisive advantage. Africa's emerging space industry may be the most promising.

China's expanding space presence in Africa stands in sharp relief to America's absence. NASA last year began construction on a ground station in South Africa – its first on the continent – to communicate with spacecraft in the U.S. moon program. Its partnerships consist mainly of a network of 36 shoebox-sized atmospheric sensors scattered across 14 African countries, according to NASA international agreements reviewed by Reuters. It has also enlisted three African countries such as Angola, Nigeria and Rwanda – to the Artemis Accords.

Recognizing the inherent weakness of Washington's "aid-forward" approach to Africa, China has, over the last two and a half decades, established inroads into the continent by pursuing an aggressive economic-driven strategy that

focuses on trade and investment. Kickstarted by the 2001 "Going Out" policy and later catalyzed by the Belt and Road Initiative, which were both designed to incentivize the expansion of domestic businesses into new markets, Chinese FDI into Africa has risen dramatically in recent years. Unsurprisingly, this sustained Chinese attention throughout the continent has resulted in shifting alliances, with many African countries willing to adopt a more Chinese-oriented worldview.

Some African governments have grown weary of Washington's security warnings about China and are more interested in which country is going to provide money and space technology, said Temidayo Oniosun, managing director at Space in Africa, a Nigeria-based consultancy.

"The U.S. had decades to help Africa develop their space programs, but they never did," Oniosun said. "These countries are realizing that the U.S. doesn't exactly have their best interests at heart."

Pace, the former top space official under Trump, said the U.S. should have done more to build relationships in Africa and elsewhere. A big part of the problem is that NASA, the State Department and the U.S. development agencies often don't coordinate their efforts as closely as Chinese arms of government do, he said.

Liu, the Chinese embassy spokesman, did not comment on China's specific motives for investing in Egypt's space program. He said "supporting Africa's development is a shared responsibility of the international community."

Ethiopia is another recipient of space aid from Beijing.

Since 2019, China has launched two Earth observation satellites for the East African country and funded construction of a ground station there. China also funds data collection to help Ethiopia monitor floods and droughts, said the country's top space official, Abdissa Yilma, the general director of the Ethiopian Space Science and Geospatial Institute. He said his nation is neutral and wouldn't get drawn into the U.S.-China rivalry. But he said the contest could help supercharge technological development, just as East-West competition did in the Cold War. "It seems that the race has started again," Yilma said.

Egypt's "strategic" cooperation with China

China's assistance in establishing Egypt's satellite assembly center as well as building a remote sensing satellite helps the country become Africa's pioneer in the space field, said Egypt's space agency chief in a recent interview with Xinhua. Sherif Sedky, CEO of the Egyptian Space Agency (EgSA), described Egypt's cooperation with China in the field of space technologies as "strategic" and "fruitful."

"Egypt's cooperation with China in the field of space is long-standing, the most important part of which is the establishment of the Satellite Assembly, Integration and Test Center (AITC), the largest of its kind in the Middle East and Africa, in addition to the design and manufacture of the MisrSat II satellite," said the EgSA CEO. In June, two China-funded prototype satellites of the MisrSat II satellite project were delivered to the Egyptian side, making Egypt the first African country with the capacity to assemble, integrate, and test satellites.

Sedky pointed out that the AITC and the MisrSat II satellite were established via a full grant from China. MisrSat II, the first satellite Egypt owns through a partnership with China, has been tested in the Arab country by Egyptian and Chinese engineers and will be sent later to China for launch, according to the head of EgSA.

"There are seven basic tests, including those related to the space environment, the simulation of the launching process itself, the electromagnetic coverage, and the payload, all of which have been fully and successfully completed," he told Xinhua, adding that the satellite is currently ready for launch in December.

"The space technology is a large and significant area of cooperation with China, and it has proven very successful," Sedky said.

He explained that MisrSat II is a low-orbit imaging satellite that is meant to serve Egypt's sustainable development goals by photographing agricultural areas, urban development, changes in beaches, water resources, and existing mineral wealth.

The Egyptian-Chinese cooperation in the space field is "very promising," and it has proven successful over the past years, said the Egyptian official.

"We are very happy with our strategic cooperation with China, and we're looking forward to deepening it," Sedky added.

Egyptian Minister of International Cooperation Rania Al-Mashat thanked China for supporting and cooperating with the agency, and being a "strategic partner and friend" of Egypt.

She noted that the China-funded MisrSat II satellite and satellite assembly, integration and test (AIT) center has greatly boosted Egypt's capacities in satellite research, development, measurement and control, making Egypt a leading African country in the aerospace field.

"The advanced devices and effective technology we saw today are important for Egypt as they open a gateway for cooperation with Africa in this field," she said.

Describing the MisrSat II satellite project as another landmark outcome of jointly building the Belt and Road Initiative between China and Egypt, Chinese Ambassador to Egypt Liao Liqiang said the project has laid a solid foundation for Egypt's space industry and will promote the development of space technology on the African continent.

According to the Chinese ambassador, it is the first time that China has completed a large-scale overseas test on an entire satellite and delivered a satellite cooperation project overseas.

"Egypt is the first African country to have complete satellite assembly, integration and testing capabilities," Liao said. Sherif Sedky, chief executive officer of the Egyptian Space Agency, said over the past three months, Egyptian and Chinese engineers and experts have joined hands to run every stage of the tests on the three models of the MisrSat II satellite, comprising two prototype models and one flight model.

He noted that these tests inaugurated the largest satellite AIT center in Africa and the Middle East, which was fully equipped through a grant from China. "The center is the first of its kind to localize the satellite industry in Egypt. It also gives Egypt a leading role in transferring this technology to Africa," Sedky said.

With an image resolution of up to 2 meters, the MisrSat II satellite will make an effective contribution to the Egypt Vision 2030 for sustainable development by maximizing the use of national resources, including determining the types of crops and their distribution in Egypt according to the nature of the atmosphere and soil, exploration of mineral resources, urban planning, and monitoring coastal changes, according to Sedky.

After the delivery of two prototype satellites in Cairo, an in-orbit delivery of the flight model of the MisrSat II satellite has also been scheduled.

Additional report by Joey Roulette, Eduardo Baptista, Sarah El Safty and Joe Brock

STARTUP SPOTLIGHT



SATELLOGIC: A venture takes shape towards a 60-satellite constellation



Kurt Billick was in a comfortable place in his life. He had built a wide-ranging and successful career in finance, beginning as an agricultural commodities trader and finally owning his own hedge fund. After receiving his MBA from UC Berkeley Haas in 1994, Kurt worked as a sell-side research analyst covering the mining industry. Hespent the next 15 years at both investment banks like UBS and specialized hedge funds, managing global commodity portfolios with assets of hundreds of millions of dollars.

In 2010, Kurt founded Bocage Capital, an asset management firm where he successfully raised over \$1.5B in institutional assets from a variety of investors. As Chief Investment Officer at Bocage, he leveraged his expertise in energy, power, metals and agriculture to invest in futures, equities, currencies, and corporate debt securities. In early 2017, Kurt was ready for a new challenge.

At a networking event, he reconnected with a friend from Haas who worked at Google Ventures. Their discussion veered towards the rise of new private-sector companies in the satellite space industry and their implications for diverse sectors like energy, commodities and agriculture. Kurt had been following these developments as a keen observer of new technological developments in these areas, including past experience around commodities, and agricultural securities, and he had strong views on the industry.

"The cost issues are too significant," he professed, implying he had reservations about the potential of the technology to have broad impact. Aware that Kurt was looking for his next act, his friend had a sudden realization. "I know the guy you need to meet," he said to Kurt.

The satellite industry

In 1954, the U.S. Air Force began developing satellites for military intelligence. The goal of these early programs was to take photographs from space and relay them back to earth. These early satellites were equipped with a panoramic camera intended to photograph the Soviet Union. The exposed film would be de-orbited for mid-air or ocean recovery. In case the aircraft missed, the capsule would float for two days, during which time Navy boats attempted to recover it.

The first of these satellites, developed by a joint Air Force and CIA project named Corona, was launched in February 1959, and the program had 38 public launches before the ending in 1972. While people outside of the government for example, the Polaroid Corporation were instrumental in the creation of the Corona satellites, the program itself was funded and managed by the U.S. government. The mission of the program, which cost an estimated \$850 million at the time, was to collect data and monitor foreign

military sites to help American leaders make national security decisions. During this time period, other government agencies were working on creating communications and weather satellites designed for civilian, rather than military, use.

Beginning in the 1960s, AT&T and Bell Telephone Laboratories launched commercial satellites that could transmit television and telephone signals. However, it was not until the 1990s that the commercial satellite market began to grow, in part due to the Land Remote Sensing Policy Act of 1992 that allowed private companies to enter the satellite imaging business.

WorldView Imaging Corporation, which was later renamed DigitalGlobe, was one of the pioneers in this field and commercialized satellite images and data analysis.

DigitalGlobe launched a number of satellites that cost hundreds of millions of dollars to build and launch and provided very high resolution imagery as compared to Landsat. DigitalGlobe's latest satellite, Worldview-4, built at a cost of \$835 million, was launched in November 2016 and provides images at a resolution 0.3m4 with a temporal resolution of four to five days. Motivated by the high costs of traditional satellites, in 1999, Jordi Puig-Suari of California Polytechnic State University and Bob Twiggs of Stanford University helped to develop specifications for a small satellite that weighed less than 2 kilograms and could be launched as a secondary payload, a small payload on a launch vehicle that was already sending a larger satellite to space.

They called these small satellites CubeSats, and their initial intention was to enable grad students to design, build, and operate these small satellites. These satellites were much cheaper to launch and the materials to create a CubeSat were themselves relatively low-cost, with a total price tag of \$50,000.

Until 2013, most CubeSat launches were done by academics and institutions, but starting in 2013, most newly deployed CubeSats were for commercial projects. A number of companies were created, most notably Planet Labs, which was founded in 2010 to exploit the commercial potential of the CubeSat technology. By 2018, Planet had launched over 175 of these small satellites called "doves" which can image the earth at a 3m resolution, and collectively, aim to provide an image of every point on the planet's surface every day.

Building an affordable satellite

Emiliano Kargieman, a.k.a. EK, an Argentinean tech entrepreneur, got the idea for creating a satellite company when he was attending a Singularity University program at NASA Ames Research Center in 2010. Singularity University was a Silicon Valley think tank that offered programs for executives and managers on emerging technologies and fields of study like human enhancement and AI.

Emiliano came to Singularity University after leaving his role as a Managing Director and co-founder of Aconcagua Ventures, the tech venture capital firm he had founded in Argentina. He had spent four years building the company and investing in early-stage software, internet, and medical device companies in Latin America.

He was still involved in an advisory role with the first company he founded almost 15 year prior, an information security software provider based in Boston. He had no prior experience with space technology, and his hope was to learn more about the sector, as well as to talk with entrepreneurs from other fields. Emiliano was surprised to learn that the pace of innovation in information technology had far outstripped the development of space technology.

At the time, it took ten years to build a functioning satellite from start to finish. Satellites were subject to physical limitations: the quality of the photos they took were reliant on the amount of power the satellite had, and the size of a satellite determined how much data it could store. It seemed that satellites either had to be large and expensive and thus have poor ground coverage because of the cost and difficulty of launch, or be

small and cheap and provide low-quality data and images.

SATELLOGIC: A venture takes shape

It occurred to Emiliano that it must be possible to find some middle ground between time-intensive, high-cost satellites and low-cost but low-value satellites. He imagined that the data and images collected by these satellites could provide real-time information on infrastructure, natural resources, and even social conflicts.

He drew a blueprint for a satellite made of inexpensive individual components that could be easily replaced while the satellite system remained reliable, and he envisioned launching 300 satellites into space to provide imaging around the globe. Later in 2010, Emiliano founded Satellogic, a company focused on executing this mission. He had connections in the tech community in Argentina, and felt he could better recruit engineers and raise capital there. Emiliano's first priority was building a strong technical team at Satellogic. He began by hiring five software and electrical engineers, three of whom he knew well from his prior work. He was also able to raise some capital from the Argentine space agency as well as some local angel investors.

Notably, many of the first engineers that Emiliano hired were not from the satellite industry, but were instead general technologists. Because there were restrictions on importing the required parts in Argentina, the satellites were manufactured in Uruguay. Satellogic was also incorporated in Uruguay, which allowed it to avoid U.S. regulations on satellites. The company didn't have to comply with the U.S. International Traffic in Arms Regulations ITAR restrictions because it didn't use any American technology, and as a result it was able to launch satellites from restricted countries, like China, which U.S.-based companies could not do. The North American Aerospace Defense Command monitored objects in space, including satellites, and issued collision warnings, and the company was subject to international communications regulations.

With its new team and manufacturing facilities, Satellogic launched its first satellite using a Chinese rocket in April of 2013, and then launched another in Russia later that year. In September of 2013, the company announced its seed funding round and raised \$2 million, all from Latin American investors.

In the following three years, the company raised two more rounds of funding, and its 2015 Series A was led by Chinese internet giant Tencent. Throughout this time, Satellogic maintained a low profile and did little external marketing and PR, unlike some of its competitors. The company then followed up with more launches, launching their sixth micro-satellite into orbit on June 15, aboard a Long March-4B rocket that took off from Jiuquan Satellite Launch Center in China. It also announced that it had raised \$27 million in a Series B round, again led by Tencent along with a few other investors at in the summer of 2017.

In addition to the technical team working on the satellites themselves, Emiliano hired other employees who would help the company make the most use of and develop monetization

strategies for their unique data. Because similar talent was not available in Argentina, Emiliano developed a team in Tel Aviv, Israel through personal connections with a researcher in the image recognition and computer vision space. He also enlisted Marco Bressan, a well-known Argentine data scientist who lived and worked in Barcelona, Spain and built a team of data scientists in Barcelona. By the end of 2017, Satellogic had 100 employees across its three offices in Argentina, Tel Aviv and Barcelona, as well as a small office in San Francisco.

Satellogic's technology

Satellogic's technology was in many respects superior and significantly cheaper as compared to its competition. The company's satellites had 1m ground resolution, while Planet, its most visible competitor, had images were 3-5m in resolution, and the resolution of images from this distance was too low to distinguish between individual objects, like cars and trees. Satellogic satellites also were the only ones in the small-satellite space that offered hyperspectral imaging at a 30m resolution. Hyperspectral imaging allowed Satellogic to capture data beyond the visible spectrum, allowing for the detection of specific minerals which reflect light at a certain wavelength or assess the state of vegetation.

The implications of hyperspectral data for agricultural markets was particularly exciting as this information could be used to monitor crop and soil health and ecological monitoring among a variety of other applications. The arrival of hyperspectral remote sensing to the civilian market through the Landsat program had revolutionized mineral and oil discovery, and Satellogic's technology had the potential to provide such information at a significantly greater spatial and temporal resolution and at a cheaper cost than before.

Satellogic's goal to launch a constellation of 300 satellites would enable them to achieve average revisit times of around five minutes anywhere on the planet for one meter resolution multi-spectral imaging, a feat that was impossible with any other competing platform. Further, these satellites were also capable of capturing 720p-4K video across its different spectral bands.

Satellogic's competitive edge also came from the low price of its satellites, which cost roughly one tenth of what the same product from Planet did and well under 1% what a DigitalGlobe satellite cost. This low price was possible because of the satellites' small sizes and lower launch costs. Being headquartered in and manufacturing in South America also helped Satellogic lower its development costs and achieve cost leadership in the small satellite industry. Additionally, Satellogic used commercial technology and relied less on each individual satellite and more on the network of satellites, which allowed the company to use lower cost components that could be replaced in each satellite.

Evaluating the satellite market

When Kurt's MBA classmate introduced him to Emiliano, Kurt was interested in the company, but he had no experience in technology. Despite this fact, Emiliano wanted Kurt to come onboard. Kurt's main focus would be to develop a strategy for Satellogic's emerging data pipeline, find applications for the imagery and develop a solid

commercialization strategy that would help transform the technological promise of the company into real value for its customers and stakeholders. Satellogic was small, with fewer than 100 employees, most of whom were in technical roles.

Kurt told Emiliano, "I'm interested, but I'm not qualified. This isn't a job I've ever done before. I've never sold anything, other than my hedge fund. But I think I understand your markets. And I'd like to try."

During the company's first few years, Emiliano and his team prioritized developing their satellite technology and hiring the right engineers to do so. The established market for satellite imaging was primarily foreign governments and agricultural, energy, and mining asset monitoring. Kurt commented, "The approach with regards to customers was very much 'If we build it, they will come.' We could all see there's a path, so it felt more like a blocking and tackling job. There's an existing market, and our costs are so low, we should be able to penetrate the existing market."

However, translating this promise of "build it and they will come" was proving to be more challenging than they originally thought. Satellogic's existing clients mostly resulted from inbound inquiries about the company, and most of them were in the agriculture and commodities industries.

The company had spent very little time actively thinking about a strategic focus and in targeting new customer segments that might be interested in the technology. To demonstrate the value that satellite imaging could provide for a new client, the company would deploy a pilot over a small area for a few customers. Along with the satellite images, Satellogic also provided data analysis generated by machine learning algorithms that overlaid these photos. Satellogic's leadership was selective in choosing which clients to take on, and focused on providing data to answer problems with a broad audience.

Satellogic's first goal was to get to a constellation of about 60 satellites by 2019, which would allow it to provide high resolution multispectral imagery and medium resolution hyperspectral imagery of the surface of the earth at a frequency of about 2 hours for any given location.

As is common in the satellite industry, the team was facing a few technical challenges in order to achieve this objective. Solving these challenges was key to delivering images at the required quality as well as volume required for practical and commercial application. The team felt confident about its ability to deliver on this technical promise.

On the commercial side, a major impediment to Satellogic's plans to complete the constellation was raising enough capital at an attractive valuation to enable Satellogic to manufacture and launch 60 satellites. They believed that if they were the first company to launch a complete fleet of 60 satellites providing high resolution multispectral images, then "there is a natural monopoly here," and that they could leverage their first-mover advantage to protect such a monopoly.



INDUSTRY REPORT

Chinese startup landscape brighthens as SPACETY sets new records

All eyes have been on China's successful satellite imagery business with over 200 small satellites launch into orbit in the last few years. The pace of growth, racing ahead of key western nations, surprised most international analysts and commentators, even as Europe lags behind the Chinese space adventure. Again, spacecraft and the rocket that launched all the satellites, like most of the technology for China's national space missions, was made by China Aerospace Science and Technology Corporation (CASC), 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.

Today, the commercial space sector in China 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.

Globally, commercial space companies including China propose placing more than twenty thousand satellites in orbit in the next ten years. Up until 2020, approximately eleven thousand payloads had been placed in orbit in the entire history of the space age. As of 2024, there are more than 13,000 satellites in orbit, with 7,084 operational and 3,305 inactive. From 2021 to 2024, the number of active satellites has already increased by 27.9 percent. If just half of those commercial space proposals are successful, the space traffic created would more than double the number of satellites deployed over the last sixty years, and create more than six times the number of active satellites. Small satellites represent 75 percent of spacecraft launched from 2011 to 2020, and 94 percent of spacecraft launched in 2020.

The global commercial space market is valued annually at \$349 billion. In 2018, Morgan Stanley predicted that the space industry would triple in size by 2040. Morgan Stanley's research identified ninety private companies as being on "the forefront of space disruption."19 Launch and satellite-manufacturing companies make up 39 percent of Morgan Stanley's list of the private space economy, by far the largest segment. In another study, Bank of America and Merrill Lynch projected that the global space industry would

reach a value of at least \$2.7 trillion in the next three decades.

Given state backing, some Chinese space startups are able to offer products at a steep discount, such as Expace's Kuaizhou-11 launch system financed via the State Owned Enterprise China Aerospace Science and Industry Corporation CASIC which sells for only a fifth of the market rate. Such predatory pricing could be critical to gaining a greater chunk of global market share, especially given the high price point of American products which currently occupy a majority of the market.

Additionally, the domestic Chinese market and a chunk of BRI countries is providing some elbow room for Chinese space startups to find their footing away from the US, which is more averse to these markets due to aforementioned security concerns. So, while these firms face challenges in China's "brand image" problem and its associated supply chain risks, as well as a newfound emphasis on performance metrics, low prices and relatively untapped markets leave plenty of room for growth.

Six Satellites in One Launch!

Spacety, a world leader in cubesats and smallsats, has developed, launched, and operates 30 satellites for science and technology demonstration missions, providing satellite-based services globally. 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, supporting space missions support science experiments or observation, and in-orbit demonstrations and validations of space technologies and products, or space systems.

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. 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.

Recently, six commercial satellites developed by SPACETY have been successfully launched aboard a Zhuque-2A (ZQ-2A) modified carrier rocket from the Dongfeng Commercial Aerospace Innovation Test Zone. These satellites cover multiple application fields, including **one commercial SAR** remote sensing satellite TY42 also called Shenqi-2, **two optical** remote sensing satellites TY29, the DIZHI-1 and TY35, and **three space science** experimental

satellites TY34, TY45, and TY46. After precise orbital insertion, according to reports, all telemetry parameters were normal, with solar panels and antennas deploying smoothly, marking the complete success of the mission.

The TY42 (Shenqi-2), the mission's centerpiece, is a lightweight, low-cost, high-performance C-band SAR satellite jointly developed by SPACETY and Zhangye Constellation Space Technology Co., Ltd. Equipped with SPACETY's next-generation Synthetic Aperture Radar payload, it achieves internationally advanced technical specifications, enabling all-day, all-weather Earth observation and stable acquisition of high-resolution imagery under complex meteorological conditions.

The TY42 satellite also features operational Interferometric SAR also called InSAR) capabilities, enabling millimeter-level surface deformation monitoring. With broad application value in natural resource management, water conservancy, power grids, infrastructure monitoring, marine and coastal surveillance, and disaster emergency response, it provides global users with regular, high-quality, and independently controllable commercial SAR data services. Upon orbital deployment, TY42 will collaborate with Shenqi-1 and Fucheng-1 to perform repeat-pass interferometric imaging, delivering global operational InSAR services with a 3-4 day revisit cycle.

Another satellite, the TY29, led by China University of Geosciences located in Wuhan, is a hyperspectral geological remote sensing intelligent small satellite. Its spectral bands between 410nm-2480nm are meticulously optimized for geological applications, forming specialized spectral coverage for the industry.

Furthermore, TY29 simply DIZHI-1 has overcome multiple critical technical challenges, including high-reliability integrated optomechanical system design, high-reliability infrared focal plane filter spectral splitting technology, and Time-Delay Integration (TDI) multi-spectral visible light detection technology for the camera. These breakthroughs provide robust technical foundations for the efficient application of satellite data in geological and environmental remote sensing. The TY29 satellite also called DIZHI-1 is capable of delivering high-precision remote sensing data and professional analytical services for geological and environmental exploration, monitoring, identification, interpretation, and analysis. Its applications

span mineral composition detection, rock type identification, alteration information extraction, soil quality assessment, and water pollution monitoring. Through these high-quality datasets and services, DIZHI-1 will empower scientists to more accurately decipher Earth's geological structures, offering strong scientific evidence and technical support for resource exploitation, environmental protection, and disaster prevention.

TY35 popularly called NCHU-1, was developed under the leadership of Nanchang Hangkong University, is an intelligent multispectral ecological environment monitoring satellite. Its platform demonstrates significant advantages in autonomous operation and intelligent control. The onboard multispectral camera employs an advanced off-axis three-mirror optical system, with optical parameters such as focal length, field of view, F-number, aperture, spectral range, and band selection meticulously optimized to enhance imaging performance and quality.

Equipped with a high-quantum-efficiency, low-noise CMOS detector, TY35 supports real-time monitoring and rapid response, particularly excelling in water pollution detection, water quality analysis, and algal bloom monitoring. Additionally, it is applicable to terrestrial environmental remote sensing, including soil and vegetation monitoring, providing comprehensive data support for regional sustainable development goals.

SPACETY will collaborate with Shenqi-02 from the Zhangye SAR Constellation and the two optical satellites above to validate optical-SAR synergistic technologies in orbit, enabling enable high-efficiency fusion and precise utilization of dual-mode remote sensing data, improving the completeness, accuracy, and timeliness of Earth observation data in complex environments. These advancements will strengthen support for disaster emergency monitoring, environmental surveillance, and dynamic resource assessment.

This mission is SPACETY's first six-satellite launch and its 20th space mission, completing the systematic deployment of 37 satellites. This achievement signifies a transformative leap from single-satellite technology verification to batch production, while establishing the world's first full-cycle industrial ecosystem for C-band commercial SAR satellites, encompassing satellite design, constellation operation and maintenance, and data services.

Meanwhile, the launch also demonstrated SPACETY's full-range satellite platforms spanning 20kg to 300kg-class, marking a new phase in small satellite technology development and the beginning of satellite industrialization. SPACETY remains committed to innovating remote sensing and scientific satellite platforms,

continuously advancing core technologies in cost reduction, modular design, and intelligent operations, while driving iterative upgrades in commercial small satellite systems.

In the future, SPACETY will focus on providing end-to-end technical support for large-scale SAR constellation operations, building a high-reliability, high-performance SAR service system. This initiative will fully empower space technology innovation and industrial ecosystem development, contributing to China's vision of becoming a global leader in science and technology.

The U.S sanctions

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.

On January 26, 2023, the U.S. Department of the Treasury added Spacety Co., Ltd., into the Specially Designated Nationals List. Spacety Luxembourg S.A., as the holding subsidiary of Spacety Co., Ltd., was implicatively added into the SDN List. The company said, it deeply regrets this. "As one of the pioneers in the global commercialization of miniaturized SAR remote sensing satellite, we 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.

The U.S. said, it 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 STPI, 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.

Accordingly, the report said, Chinese satellite imagery companies posed the risk of providing imagery of U.S. and partner forces to those seeking to harm U.S. interests. A prime example is Spacety China, a commercial company sanctioned by the U.S. Treasury Department in early 2023 for selling imagery collected over Ukraine to enable Wagner Group combat operations.

Whereas the new civil-military fusion policy has been a boon for the domestic space sector, it poses



some challenges to foreign capital and trade in the space sector, particularly with advanced Western nations home to the most sophisticated capital centers that are perpetually skeptical of China's intentions.

Specifically, the coziness of China's "dual-use" commercial space sector with the military via CASC and GGFs subjects these nominally private companies to the vicissitudes of geopolitics.

Sensitive to the incidental funding of its rival military, the current US Administration has banned US investment in Chinese military-affiliated companies, a potential dragnet that already includes CASC and the China Academy of Launch Vehicle Technology.

As the climate remains hawkish on Chinese dual-use firms, Chinese space start-ups may need to focus more on domestic and emerging-market BRI countries capital.

Another high point in SAPCETY's corporate life was a partnership between the French propulsion startup ThrustMe and the Chinese micro- and

nano-satellite maker Spacety. In 2020, Spacety, officially Changsha Tianyi Space Science and Technology Research Institute, launched the world's first iodine-propelled satellite. Iodine is cheaper and easier to use compared to other propellants like xenon.

Though the collaboration focused on applications in airplane tracking and remote sensing, electric ion thrusters can make small satellites more maneuverable, thus limiting collisions that would produce even more space debris in the already crowded LEO.

Despite the potential benefits, ThrustMe's collaboration with Spacety also raised clear national security concerns. Spacety, was hit by US and EU sanctions for providing satellite imagery of locations in Ukraine to assist the mercenary Wagner Group in Russia's invasion of Ukraine. It is unclear whether Beijing, which has been supporting Russia's war in Ukraine, was aware of those activities. Spacety is also known for its work on air defense radar.

As the strategic relevance of space is growing, and more European countries increasingly view China as a security challenge, scrutiny of such collaborations

has fortunately increased. In Germany, the government in recent years barred a laser tech company from operating in China and blocked the takeover of another satellite communications firm by the Chinese state.

Given China's strategic and geopolitical ambitions, any collaboration should be vetted thoroughly, provide clear benefits to European stakeholders, and include safeguards to ensure that no technology or know-how is compromised in ways that could jeopardize economic or national security.

The company hereby affirm that it has been strictly abiding by the laws and regulations of relevant countries and regions in course of business development, and fully comply with the international sanctions imposed on Russia by the United States and the European Union, and never have any ties with Russia at all after international sanctions were imposed.

In the future, "We will continue to strictly abide by the laws and regulations of relevant countries in our R&D and operations activities, and to provide the most advanced technology, the most reliable products, and the best services to build a better future for human life", said the CEO.

INDUSTRY REPORT

Integrating commercial remote sensing satellites into defense and intelligence architectures



Once in space usually defined as the Kármán line 100 kilometers above the surface, satellites typically enter one of a few types of orbits: low earth LEO, medium earth MEO, or geostationary GEO. LEO is the most common orbit, anywhere from 180 to 2,000 kilometers above the surface of Earth. Satellites in LEO complete an orbit around Earth every 90 minutes. The proximity to the surface is the main benefit, as this results in a higher resolution of data captured from remote sensing satellites.

While a GEO satellite orbits Earth, it does so at the same speed as the Earth itself rotates on its axis, once every 23 hours and 56 minutes, creating the illusion that the satellite is stationary above a specific location. Due to this, only three GEO satellites are needed to observe the entire planet at once, but they must orbit at 35,786 kilometers above the surface to maintain this position. The last orbit is MEO, which is anywhere between LEO and GEO, and is useful for larger resolution (1 kilometer or larger) remote sensing.

The information from these satellites, when used in a national security or military context, is referred to as intelligence, assesses

"threats to nation, its people, property, or interests; development, proliferation, or use of Weapons of mass destruction; and any other matter bearing on national security."

The commercial remote sensing sector is dominated by a few major players, Vantour Technologies, BlackSky Technology, Airbus Space & Defense, Planet Labs, and Capella Space. There is a set of smaller emergent players that includes, but not limited to: Satellogic, Umbra, Albedo Space, and Earth Daily.

Vantour Technologies currently operates electro-optical satellites at 30cm resolution, the first firm to offer remote sensing data at that resolution, and are in the process of deploying their new WorldView Legion constellation to increase their 30cm capability.

BlackSky Technologies currently operates a constellation of high resolution satellites and markets their products through their geospatial platform to governments around the world. The current Gen-3 constellation offer 30cm resolution imagery. They have also received a NRO contract for \$1.0 billion over 10 years for access to their capability. Airbus Space & Defense, the only non-U.S. firm in this list, currently operates 30cm,

50cm, and 1.5m constellation satellites. They remain under European operating license and are not under a NOAA license, however are in the process of obtaining a NOAA license through their U.S.-based subsidiary. Airbus is also the parent firm for Spot Image, which operate the Spot and Pléiade constellations, which are the earliest existing commercial remote sensing satellites.

Planet Labs focuses on launching miniature satellites, colloquially known as small sats, currently operating a large constellation of satellite at 3m, 50cm, and 50cm resolution. The firm reclassified itself as a public benefit corporation, a firm with a focus on a specific policy interest. Capella Space specializes in synthetic aperture radar SAR imagery and operates a constellation SAR earth observation small sats at 50cm resolution. As the commercial remote sensing sector has developed, so too has the debate over the sectors influence, collaboration with the government, and perceived benefits.

In the early years of the Landsat program, the US government was unable to prop up a robust satellite remote sensing industry as costs remained too high. However, while the U.S. failed at maintaining this effort, the French space agency, CNES, helped fund the first successful commercial

space firm, Spot Image in 1986, proving the potential for commercial space with some government support. The capability provided by Spot Image's satellites, SPOT 1 Satellite Pour l'Observation de la Terre, Earth Observation Satellite and SPOT 2, proved lucrative to U.S. military efforts in the 1990s.

Engaging in their first purchase of commercial remote sensing capability during the 1990-1991 Gulf War, capabilities from these two commercial satellites proved pivotal, providing wide-area coverage of the battlefield to U.S. and coalition forces. With a resolution of 10-20 meters, coalition leaders used this capability to focus on larger-scale surveillance that high-resolution reconnaissance satellites were unable to do.

However, arguments over commercial capabilities existing solely to increase government capabilities do not represent the entire picture, as even when national security systems have real-time coverage, commercial systems remain in demand. This suggests that additional motivations exist beyond traditional gap-filling. One of the most important versions of this is intelligence sharing. With national security satellite systems being classified, this complicates the sharing of information taken from these satellites with allies and partners. While agreements such as Five Eyes, AUKUS, and other intelligence sharing agreements exist, they do not cover more ad hoc information sharing, such as between the U.S. and its partners during the anti-ISIS coalition in the early 2010s.

Sharing classified data requires screening of the recipient, while also potentially leaking vital information about U.S. national security satellite systems and their capabilities. Commercial remote sensing satellites, on the other hand, are unclassified by nature, placing little barriers barring a contract's terms and conditions to sharing information with partners, non-governmental organizations, and the international community at large.

This helps in the spread of critical information without sacrificing national security interests. When faced with sharing information with partners that lack a more formalized relationship with the U.S. commercial data proved pivotal to bridging this gap. This has been most famously utilized during Russia's full-scale invasion of Ukraine, where government released copious amounts of unclassified commercial information to showcase Russia's military buildup and demonstrate its failures, while share intelligence with Ukraine. Releasing data from a commercial satellite, which usually has detailed information of the satellite public for commercial purposes, allows the publication of vital information without compromising national security systems.

SatVu, the firm which owns the first commercial high resolution infrared remote sensing satellite stating that they can provide the military and intelligent community with "a dataset they can share and that is much more useful" to them than their traditional classified national security satellites precisely because of its unclassified nature.

In a world dominated by multilateral military and intelligence operations, the need for better information sharing has become crucial, and integral to this has been the use of commercial remote sensing data to bridge the information gap with little resistance.

The rise of commercial space sector

One of the fundamental questions posed in the industry today is why the private satellite remote sensing sector is developing at this pace. From an initial perspective, this is a chicken and egg problem. A key driver of the use of commercial space capabilities is the need to fill gaps in existing U.S. national security satellite apparatus. This was first seen in the Gulf War, to act as a temporary enhancer of existing capabilities during a time of acute need.

Today, the modern battlefield needs high resolution images quickly, with short delay between request and receiving images. This demand manifests in two forms: more existing capability to choose from, and new capability the government does not currently have.

Starting with the first form, the existence of commercial capabilities gives the military and intelligent community an additional pool of data from which to take information when achieving their various missions. Instead of waiting for government systems to provide actionable information, commercial partnerships allow individuals in the military and intelligent community to see if a timelier alternative exists on the open market.

While attempts to privatize remote sensing, initially lacked success, France, through its space agency CNES and the European Space Agency ESA, spearheaded the creation of an independent firm, Spot Image, to oversee and run its SPOT remote sensing satellite program in 1982. Such a decision arose out of the desire of the socialist French Prime Minister Pierre Mauroy in 1981, who sought the long term stability of the SPOT program through selling SPOT data on the open market.

Seeing a lack of market demand, except for scientific uses, the government decided to create the private firm to develop the market while operating the SPOT satellite program, launching its first satellite in 1986. In doing so, domestic, and greater European, efforts pushed the desire to create their alternative to existing American remote sensing operations while cementing Europe as a major player in the remote sensing space.

Acting as a market innovator, Spot Image was able to break the ice for the commercial sector, laying the groundwork necessary for future firms to exist, precisely the goal of the initial program. SPOT quickly expanded to three major markets, North America, Australia, Oceania, and South Asia, seeing much of its success in North American and South Asia. It would soon dominate the market, outcompeting Landsat programs and gaining a 60-70% market share within a decade.

As time progressed, they found success specifically within the forestry, environmental monitoring, agriculture, urban planning, and mapping sectors, opening commercial demand for on-demand image purchasing and beating out traditional aerial photography.

In US, there was no need for a commercial sector during this period, as the government did not engage in largescale operations that would require immense amounts of timely remote sensing and imagery data, nor was there the commensurate commercial demand. Instead, operations within the intelligence and military sectors were able to be fulfilled using existing national security systems alongside the images from Landsat.

All this changed during the Gulf War, as the buildup in Operation Desert Shield shook the existing U.S. space apparatus, highlighting gaps in remote sensing and satellite communications capabilities that the military and intelligent community quickly needed to fix. Turning to the commercial sector, the government found an alternative with Spot Image, helping temporarily fill gaps in coalition capabilities.

When the dust settled following the Gulf War, the government saw the event as a watershed moment for space systems, with space playing a decisive role in what they would perceive to be the future of modern conflict.

This lead to intense government review of its space architecture, especially as this period saw the end to the Cold War which significantly altered security considerations. Integral to recommendations was the government fostering commercial industry to reduce costs, augment capabilities, and foster international cooperation in space.

Simultaneously, there were difficulties in fully integrating SPOT and Landsat capabilities into the current U.S. military and IC space apparatus, alongside gaps in capability specifically on smallscale mission planning. This resulted in the beginning of new partnerships between the government and industry, which saw the government reshape its imaging efforts to directly cooperate with commercial firms.

Innovators within the government would play a pivotal role in spreading awareness of commercial imagery and provide downlink connections to commercial satellites to increase accessibility, in turn increasing demand for commercial imagery.

This would lead to a relative boom in the industry with three major firms coming on top by the start of the new millennia, Space Imaging, Maxar now Vantour Technologies, and Orbimage. Government funding and backing allowed them to fuel growth both domestically and internationally, competing with firms like Spot Image later renamed to EADS Astrium and purchased by Airbus Space & Defense internationally. However, the turnaround from government demand to commercial satellite was

difficult, with the first commercial satellite, Orbview-1 from Orbimage with a 10 km resolution launching in 1995. Most commercial firms would see their debut in 1997-1998, with Digital Globe, Space Imaging, and others launching their high resolution satellites.

In the meantime, other nations, notably India, Japan, and Canada, each began to market their government remote sensing and earth observation satellites to the global marketplace, seeing the growth in demand for such services. Significant change to the sector would only emerge in the early 2000s, with the launch of DigitalGlobe's QuickBird-2, which had a 61cm resolution, allowing for detailed intelligent community and military use, near comparable to classified systems.

From then on, the sector quickly established itself, with the government taking note of its importance, and policy surrounding the sector was developed, beginning the path to the modern remote sensing sector as seen today. \

With 357 currently operational remote sensing satellites, most of which are operated by commercial firms based in the US or Europe, this offers a wide array of potential data for the intelligent community and military.

The key problem is that U.S. national security satellites cannot be everywhere all at once, limiting the collected data. In lieu of this, commercial remote sensing satellites offer globally circulating constellations of data to fill in gaps when needed. Integrating government and commercial capabilities offers commanders and analysts 'fused' information that covers the entire electromagnetic spectrum, resolution, and time of day to a degree unobtainable simply through using government satellite systems.

This greatly enhances the force capabilities of the U.S. while requiring little upfront costs, as purchasing data or capabilities is far less costly than designing, building, testing, and launching a new satellite. Therefore, this enhances capabilities in underdeveloped sectors of the national security apparatus, leading to better overall attainment of national security outcomes by the military and intelligent community.

At the same time, certain capabilities are only within the commercial sector. In this case, it makes more sense for the government, especially one running under a "buy before you build" mentality, to purchase this capability from commercial sources rather than build its own version.

Commercial experimentation into very low earth orbit (VLEO) satellites and artificial intelligence (AI) processing of data has also seen moderate success. Commercial firms have the benefit of being traditionally more innovative than the government, as commercial and free market pressures are driving forces of market innovation, push factors that do not exist within the government.

AI and machine learning have seen significant

strides in identifying, documenting, and monitoring changes within zones of interest using commercial remote sensing data, a large asset for the intelligent and military. Example use cases can be detecting the building of new missile silos in China or the tracking of any changes to pre-existing silos, tasks that would require legions of intelligence analysts, or a single AI program. Therefore, partnering with commercial AI firms, the commercial sector has integrated AI into their satellites and data centers, allowing for more targeted and actionable information to be sent to the end-user.

Already this year we have seen the successful launch of the first satellite with integrated AI chips, Planet Labs Pelican-2, which integrated NVIDIA's Jetson AI chips into their on-orbit computing, seeing relative success in integrating AI into remote sensing.

Like everything in the U.S., the commercial remote sensing sector is also influenced by the parochial nature of domestic politics, with politicians vying for increased government spending in their own districts and companies vying for more government contracts. At the same time the U.S., like any government, also strives towards maintaining its domestic industrial capacity, keeping skilled workers in the country and stimulating the economy through purchasing components from American, rather than foreign, firms.

In Congress, firms like Planet Labs, Maxar Technologies, BlackSky Technology, and their respective lobbying groups, putting millions into Congress each year to lobby in their favor, with a notable uptick in recent years coinciding around times of recent policy shifts.

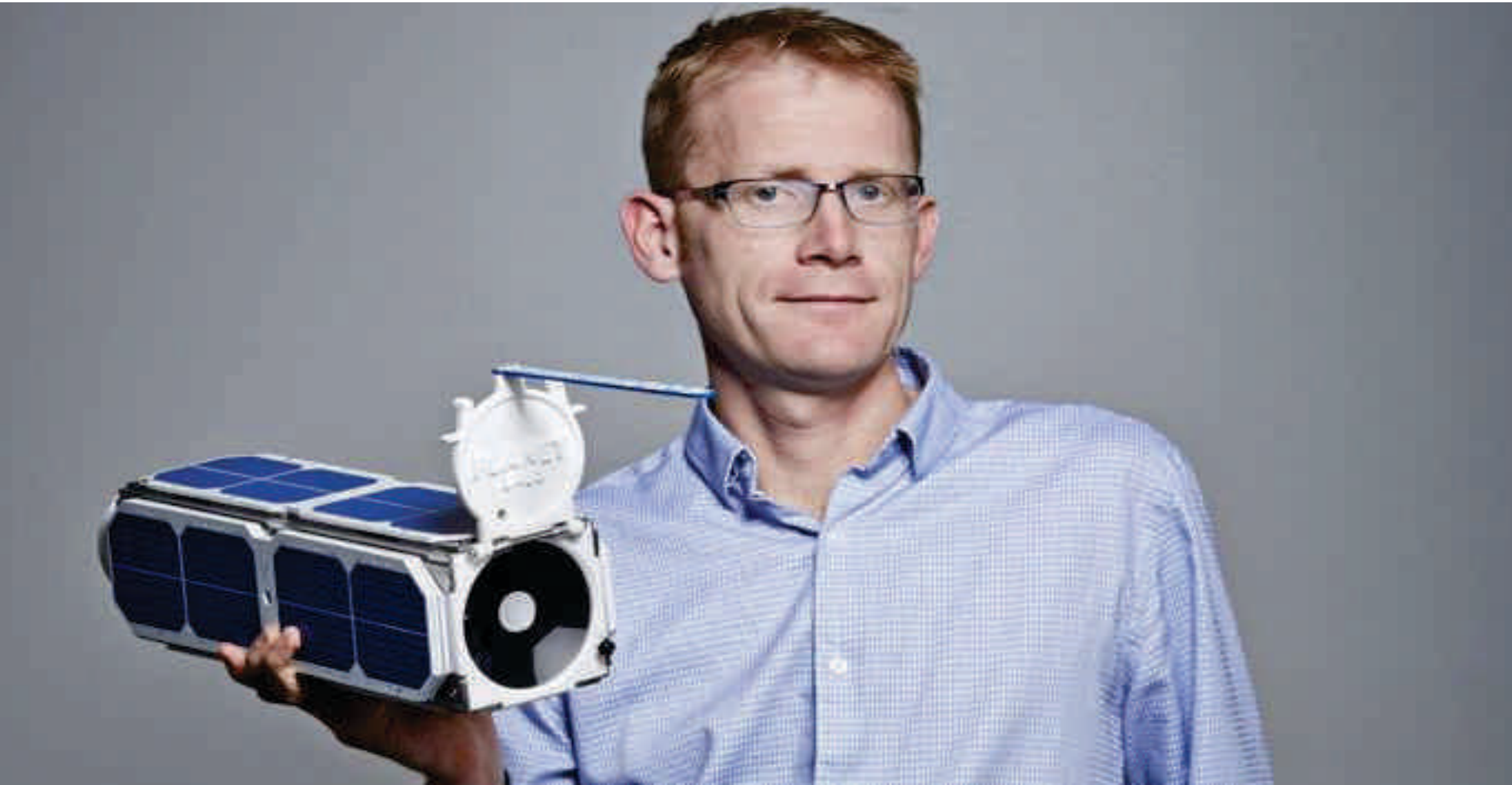
On a more general level, the U.S. government is committed to protecting domestic industries, with this sentiment shared by policymakers and making its way to high-level policy documents. Doing so helps ensure talent remains in the U.S. in a key industry, while developing and patenting new technologies to ensure long-term industry success. At the same time, the U.S. can take advantage of commercial innovation, as firms have a larger incentive to develop better satellites through profit generated from government contracts that could lead to further innovations that the U.S. government can take advantage of.

Unlike government research which is more narrowly focused, and oftentimes slower, commercial research is often motivated by a 'move fast and break things' mentality that leans itself to innovation in the field compared to a slower, more methodical government development. As a result, there is an implicit desire to promote commercial industry by the government from its desire to preserve talent, continue domestic industrial development, spur additional innovation, and protect U.S. manufacturing and engineering jobs.

While firms are subservient to their shareholders, the IC and military are beholden to their respective missions and congressional direction. Government activity is inherently unprofitable by nature instead, serving as a public service while commercial firms focus on maintaining profitability and increasing their stock price. This creates a divergence of thinking that is difficult to overcome, even for the most patriotic firms or cognizant officer or analyst.

SPECIAL REPORT

Why convergence of imagery intelligence and the media will improve transparency



In February 2017 Botswanan journalists with a non-profit, donor-funded news organisation, the INK Centre for Investigative Journalism, pursued a lead that the President of Botswana Ian Khama, was improperly using Botswana Defence Force labour and government funds to secretly construct an elaborate multi-million-dollar private compound and airstrip at a prime tourist destination. For four years, the President's office had dismissed journalists' questions over the allegations and refused media access.

Three INK journalists, Joel Konopo, Ntibinyane and Kaombona Kanani drove 500 kilometres from Botswana's capital Gaborone to the President's remote compound, at Mosu in the isolated north east of the country. They were just 5 kilometres from the site when they were detained at gunpoint by security agents. The INK team's camera equipment and phones were temporarily confiscated, and the three

were allegedly warned they would be shot dead if they ever returned to the location.

Obtaining visual evidence was critical to the success of the investigative assignment, so after returning to the capital, INK managing partners Joel Konopo and Ntibinyane, assessed the options. A search of Google Earth revealed old imagery dating back to 2012. Ntibinyane says this has been a common problem across Africa, where large areas of the continent that receive little online traffic from Google Earth viewers are not regularly updated or "refreshed"; "at the moment Google Earth wasn't helpful to us because it isn't showing that there were major developments taking place. We didn't see any vehicles or any earthmovers. So, we said, No, we can't rely on something that was last updated 6 years ago. We wanted a current thing, and

that's why we're in the business of news. We want something new" says Ntibinyane.

A proposal to deploy a small remotely-piloted drone mounted with a camera was discounted. While consumer-grade drones have been successfully deployed on many hazardous newsgathering tasks in recent years, the INK team concluded that the risks on this assignment were too great. The drone pilot would have been required to launch and control the craft from an exposed location within a few kilometres from the President's compound increasing the risk of detection by patrolling security forces.

Hiring a helicopter was also ruled out as too expensive, costed by INK at \$5,000 USD, and too hazardous; "again you don't want to risk going there. Those are military guys. They can just shoot it down" explains Ntibinyane. The INK team then explored the option of obtaining

imagery from an Earth observation satellite. The team was aware of the basic capabilities, as the local mining industry frequently tasked satellites for survey work. A Botswana-based imagery broker initially agreed to assist by contacting major US-based company DigitalGlobe, operator of the world's highest resolution commercially-available satellites, except two days later, the broker abruptly cancelled the agreement, claiming the location of the President's compound was defined as a "protected area". "We only learned later that they were put under pressure by the security services", says Ntibinyane. INK finally secured the services of a remote sensing and mapping company in neighbouring South Africa that had no concerns in co-ordinating the task with DigitalGlobe. A topography expert concluded that satellite imagery resolution of 30cm, the highest available

commercially would be ideal for distinguishing details of the scale of construction in the compound.

Ntibinyane says INK was quoted a commercial rate of \$8,000 USD for the task, using 30cm imagery, nonetheless this was too expensive for the small non-profit, non-governmental organisation largely funded by private international donors. A compromise was reached; DigitalGlobe would provide imagery at a lower resolution of 50cm, with the cost reduced to \$5,000USD. While this arrangement was not ideal, Ntibinyane concludes it would provide just enough visual data to work with and the INK partners took significant pay cuts for three months to fund the satellite gamble:

"It was a lot of money, but we weighed up the idea of public interest. We said to ourselves this has a big public interest implication." For three days in May 2017, DigitalGlobe's efforts to collect new imagery of the compound were defeated by cloud cover. Most Earth imaging satellites are mounted with electro-optical sensors that can only record imagery in daylight and with mostly clear skies. Faced with frustrating delays, high costs and fear of government retribution, the INK journalists worried that their significant investment would not pay off. "Initially, we thought, well, this might not be much, maybe we are just troubling the guy, maybe he's not building an airstrip or maybe there's no military maybe we are going to be disappointed" concedes Ntibinyane.

Ntibinyane's doubts were swept away when a single, very high-resolution image was finally emailed to the INK office. "When I opened it, I was so surprised, I was like, "Wow, this is just bigger than I thought". It was the smoking gun; Incontrovertible visual evidence of the size of the project. The scale of construction was confirmed when the new imagery was compared with Google Earth's archive from 2006, 2010 and 2012.

The DigitalGlobe image revealed a 15-hectare construction site, complete with earth-moving equipment, trucks, barracks accommodation for a significant number of soldiers labouring on the project, and a solar-panel power plant. INK had the story, and the President's office knew it, but they attempted one last legal obstruction; "Before we published, we met with our lawyer. Because in Botswana, there's a law called Protected Areas and Places Act, so initially the government was saying the President's compound is protected by law" says Ntibinyane.

The challenge was dismissed, when it became clear that Botswanan law doesn't preclude satellite coverage. INK ran with the story, framed around the extraordinary amount of detail extracted from the single image; "Completing the picture of a luxury eco-retreat outback is 79 square metre helpaid and a tower jutting out of a sprawling housing complex of 22 buildings linked to a 45 hectares airstrip with a 1.6 kilometres runway".

The investigation was published in Botswana's Sunday Standard, South Africa's Mail and Guardian, with a subsequent interactive edition on INK's website.

"They were caught. From there, we started receiving messages from senior government officials, including cabinet ministers and

government administrators saying, "Guys, you did a good job. We know it won't do anything. The President won't be held accountable, but we are happy that the story came out", said, government representatives.

As predicted, the INK expose did not bring down President Ian Khama, and he retired as originally planned, in April 2018. INK reported that a subsequent Ombudsman's investigation of the alleged misuse of public funds in constructing the luxury compound found the President to be "above the law" and "protected by the Constitution against being probed".

Despite a chronic lack of resources and ongoing threats and intimidation, the INK team demonstrated how satellite technology could be successfully applied in a well-planned and executed investigative story. Ntibinyane notes that the team learned some critical lessons from the satellite investigation; the importance of specialist expertise, an appreciation of the cost and logistical complexity of commissioning satellite imagery and the issues of responsibility that come with using this powerful platform.

Requirement for expert analysis

Satellite imagery analysis requires a specialist skill set to interpret the data and it is extremely easy for journalists lacking these skills to misinterpret data and get the story wrong. DigitalGlobe provided a standard 21km x 19km very high resolution (0.8m) image. The President's compound and airstrip were located within the red box.\\

The INK team accessed the Google Earth Pro program with software for determining precise distant measurements needed to analyse the precise scale of construction, however they lacked the skills to effectively run the program. They consulted a local topographer with satellite imagery expertise, to examine the data, a decision that Ntibinyane believes prevented a disastrous misinterpretation that would have undermined the credibility of the investigation.

"There were times when we thought, 'Okay, this should be an earth mover.' But when the topographer came and said, 'No, no, an earth mover wouldn't measure like that, it was something like a tower. Yeah, for us, we got it wrong. I'm sure if we'd gone with what we thought... we would have messed the whole thing up".

INK is a small non-profit investigative and advocacy organisation, largely dependent on international donors for funding, and the journalists struggled to raise the commercial rate of \$5,000 USD for the imagery. This contrasts with DigitalGlobe's ongoing agreements with major media corporations to provide very high-resolution imagery free of charge, in return for company attribution, usually on the captions of the published images. It's a standard news attribution protocol, but for satellite companies jostling for business, this brand recognition is marketing gold.

Turner Brinton, manager of DigitalGlobe's Maxar News Bureau, says he was unaware of the Botswana investigation, nonetheless he explains that INK's exclusion from a media deal would have been in keeping with company policy.

"As much as we would like to support every organization that's doing good work, and there are so many of them, the news bureau is restricted to accredited media organizations. Even if it was a Non-Government Organisation. We do work with a lot of NGOs, but it's typically under commercial arrangement" says Brinton during an interview.

There was no commercial incentive for DigitalGlobe to support the investigation, pro bono, a decision that frustrates Ntibinyane: "It is quite astonishing that some big media organizations are getting images for free while non-profit organizations with an important mandate of holding power and the powerful to account are required to pay more to obtain the image.

" What happened to social responsibility? Companies like DigitalGlobe with footprints all over the world including in Africa should support initiatives to support good governance by ensuring that non-profit organizations like my organization are supported to keep power in check". Ntibinyane predicts that observational satellites will become an increasingly valuable tool for journalists working across the vast, logistically-challenging spaces of Africa, but believes this capability comes with a social responsibility. Ntibinyane notes that neither the South African company that brokered INK's request, nor DigitalGlobe, formally requested identification. This casual approach greatly assisted in gaining quick access to imagery central to the story, although upon reflection, he worries about the broader security implications: "They never asked us anything about what we want to use the imagery for. Nothing. They were just saying, "OK, you want the image? Pay. You will get it".

"They just said "OK we want to help", which I think now with some hindsight...they should do more background checks, because imagine if we are like ISIS or warlords trying to get this image to only bomb the President's Palace" he adds.

"I think the whole thing should be regulated and you should really do background checks before selling these images. It's an issue that will need individual countries to address it, and maybe at the UN level, because leaving it as it is. For now, it's OK, it hasn't really produced anything disastrous, but with time, I can tell you people are going to use this technology to do other things that are bad".

'Burned to the Ground'

Satellite imagery has also become a compelling centrepiece for visual storytelling, the key element that anchors layered, multi-media reports. Thomson Reuters has published several outstanding examples of this genre.

Thomson Reuters is the largest news agency in the world with more than 2,500 journalists in 190 countries. Nonetheless there are still places the organisation struggles to access. The agency graphics team publishes up to a dozen news information graphics or data visualisations a day. Singapore-based

Deputy Head of Graphics Simon Scarr says satellite imagery plays an increasingly important role in providing a window into remote or restricted locations. The agency has agreements with both DigitalGlobe and Planet, and Scarr says both companies have proved capable of meeting difficult requests and tight news deadlines.

"We usually get a response within the next 24 hours and this can usually include the imagery we are looking for. Sometimes it needs a little more work on their side and could take a day or two. The speed in which our requests are dealt with is fantastic".

In December 2017, Thomson Reuters published 'Burned to the Ground', a special report utilising satellite imagery and data to document the persecution of the Rohingya Muslim minority living in Burma's Rakhine state. Multi-layered projects combining graphics and satellite imagery are highly labour intensive, and this project took nearly 3 weeks to complete, amid competing daily news demands. The story team comprised Simon Scarr and graphics journalist Weiyei Cai as main authors, with additional editing and fact checking from the Thomson Reuters Myanmar bureau and a Singapore-based news editor.\\

The team also accessed data from MODIS and VIIRS sensors on NASA's Terra and Aqua satellites that scan the Earth surface for fires each day. The older MODIS sensor has a 1,000m resolution, while the newer VIIRS has 375 metre resolution. And while they may not be suitable for close up imagery, the systems are ideal for detecting fires. For the Burned to the Ground project, the data was processed by the UN Operational Satellite Applications Program.

"We've used data from these sensors to visualise active fire hotspots. This was valuable when first reporting on this story back in late August and September. Fires and thermal anomalies are just one of many subsets of data available from these valuable instruments," notes Scarr.

Simon Scarr says layering up the data and satellite imagery was actually the easier part of the project. The most difficult element was determining the sequence of events that took place on the ground and attributing that information correctly.

Tracking expansion in the South China Sea

Building on the success of projects such as Burned to the Ground, Simon Scarr felt future satellite-based stories could be further enhanced by involving industry experts highly skilled in the analysis of visual data.

One of the most difficult stories to access and report is China's military build-up in the South China Sea, an extensive complex of military bases being constructed on a chain of man-made islands, well away from the prying eyes of journalists. Therefore, Scarr engaged the services of US-based Earthrise Media, an independent non-profit group supporting independent media to obtain and analyse imagery from commercial satellite companies.

Utilising satellite imagery for journalism can be a deceptively complex task. In response to a growing demand, a number of expert non-profit groups, including Earthrise, have emerged that are prepared to assist journalists with accessing the right satellite

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images for a story and the technically challenging job of analysing the visual data.

With US military officials saying China's extensive project was nearly complete, Scarr asked Earthrise to analyse the scale of construction by counting buildings on China's seven bases on the reefs and reclaimed land of the Spratly and Paracel Islands.

Earthrise spent six weeks "digitally scrutinising hundreds of images dating back to 2014 when China started rapidly building up those islands. Reuters journalists checked the data with a range of military and academic contacts".

On a spreadsheet confirming extensive construction across the area, Reuters reported that one location stood out, the Subi Reef, where nearly 400 buildings had been erected, far more than expected, and double the scale of construction on other islands

"It was great data to have and it really helped us build-up the webpage with imagery and information from other sources too" Scarr notes. The satellite imagery, sourced from both Planet and DigitalGlobe, and Earthrise data analysis anchored the final Concrete and Coral package that was researched produced by Reuters journalists in Hong Kong, Beijing and Sydney.

The story provided a compelling challenge to Beijing's narrative that construction was "mostly civilian". The type and scale of new building on Subi and two other main islands matched military bases in China, and included "emplacement for missiles, 3km runways, extensive storage facilities and a range of installations that can track satellites, foreign military activity and communications".

Making sense of it all

Maxar already faces modest but growing competition from the disrupters for the lucrative intelligence market. In 2017 Planet was awarded a \$14M one-year contract with the NGA, following a successful 7 months \$20M pilot program. And as Mark Brender notes, Maxar's key multi-billion-dollar contract is up for renewal within two years: "and it's going to be very interesting to see what happens once that mega contract is over, and if the NGA initiates multiple smaller contracts with companies like Planet". So why does the vast US intelligence establishment, with the world's most sophisticated spy satellites, do business with a Californian start-up operating a fleet of shoe-box sized 'Doves'?

The answer, according to Planet's Head of Data Visualisation Robert Simmon, is frequency: "They get basically what the strength of Planet is, and that is that frequency - that every single day. So presumably the US military has a relatively small number, say 5 to 10 very high-resolution satellites. They can only look in one place at a time and so that's a really big limit on what they can observe, and with Planet Labs you get this much coarser view, but you're going to get it everywhere, every day". NGA Director Robert Cardillo enthusiastically endorsed Planet: "Planet's advantage,

in our view, and the reason why we've contracted with them to begin to explore what we could learn, is the fact that they repeat their sensing of the planet in a way that no-one else does today, at least not at that magnitude. I have to tell you, for somebody in my profession that's very exciting".

Utilising satellite imagery for journalism can be a deceptively complex task. The volume of data, while not comparable to the "rising tide" now immersing America's satellite spies, can still be overwhelming. Imagery has to be acquired by satellites, the raw data transmitted to ground stations for processing, analysed, then distributed to clients.

In response to growing demand from journalists, non-profit satellite industry organisations, Google, scientists and journalism educators are intensifying efforts to run media workshops on understanding the technology and skills required to exploit visual data. These workshops range from introductory sessions, through to more complex training that frames satellite journalism as a subset of the burgeoning 'data journalism' field.

In the United States, Columbia University's Tow Centre for Digital Journalism, the Center for Investigative Reporting, and the Global Investigative Journalism Network have all actively educated journalists on the technology and its applications.

Non-profit organisations are also prepared to assist. US-based SkyTruth, an environmental group that utilises satellite imagery to monitor threats to natural resources, supported the Associated Press Pulitzer Prize-winning investigation 'Seafood Slaves' (SkyTruth, 2018).

Another American non-profit, Earthrise Media, partners several media groups including Thomson Reuters, NBC and the San Francisco Chronicle. Earthrise asks why commercial satellite imagery use should be dominated by the defence industry and commodity traders. The group's philosophy is to leverage "the half-trillion-dollar investment in Earth observation satellites to surface environmental stories that are otherwise left untold and unseen". Earthrise estimates that globally, there are between 100-200 stories each day that can be materially enhanced with satellite imagery.

Radiant.Earth is a Washington DC-based non-profit, whose funders include The Bill and Melinda Gates Foundation and the UK Space Agency. Specialising in applying satellite expertise to global development issues, Radiant.Earth also supports media projects.

Google no longer directly operates satellites, since selling its Skybox constellation to Planet in 2017 in a partnership deal that gives Google access to Planet's imagery. Nonetheless Google 'developer advocate' Christiaan Adams extensively supports journalists through the Google News Initiative and Google Earth Outreach programs; "I help provide timely imagery for major disasters and news events. This includes working closely with the Google News Initiative to provide geo, imagery and online mapping expertise to journalists around the world".

Adams says the most important free imaging tool for journalists is the Google Earth Engine, which is often

also used by scientists and researchers; "Earth Engine includes a cloud-based repository of public satellite data including Landsat, MODIS, Sentinel, and other Earth observation data, co-located with massive computing power in our data-centres, and a browser-based API where anyone can perform very powerful and fast remote sensing analysis, machine learning image processing, and other types of analyses".

In October 2016, Amnesty International called for 'digital volunteers' to join the 'Decode Darfur' project to map remote and vulnerable villages in Darfur. According to Amnesty, people had been shot while fleeing, raped, even subjected to chemical weapons attack. 28,600 volunteers from 147 countries examined 326,066 square kilometres to provide data for a second Amnesty Decoders crowdsourcing project to identify home and schools in Darfur that were being destroyed.

Keith Hiatt, Director of the Human Rights and Technology Program at UC Berkeley told the Columbia Journalism Review: "There's little doubt that the use of new data is growing as part of reporting conflicts and human rights abuses. For journalists reporting during a humanitarian crisis, these sources provide relief by verifying facts and gathering information quickly and, more often than not, reliably. In the face of new and exciting ways to uncover human rights stories, however, there are also new challenges. As human rights reporting has changed drastically in a digital age from old-fashioned street reporting to work far more reliant on sophisticated data, there is a struggle to use these technologies in a smart, safe way".

While acknowledging the capabilities of these extraordinary new newsgathering tools, Hiatt notes that there is no real substitute for 'ground truth'. For one, the increasing reliance on open-source materials means that journalists do not always use witness testimony or boots on the ground, especially in high-conflict areas like Syria and Ukraine. Instead, the use of compelling evidence compiled by human rights organizations and citizen evidence on the internet is often seen as enough".

Convergence of imagery intelligence and the media

The US National Geospatial Intelligence Agency NGA has long pursued Public-Private Partnerships with industry, not only to bolster intelligence gathering capabilities, but to also boost aid to civil society capabilities in scientific research, mapping and navigation.

In 2018 the agency extends these civil partnerships to Non-Governmental Organisations NGOs specialising in investigation of human rights abuses. Organisations such as Amnesty International sift through a wide range of commercial and government supplied imagery seeking tell-tale signs of war crimes such as burned-out villages or freshly dug mass graves, which provide valuable evidence to war crimes investigators at the International Criminal Court. Amnesty also encourages public participation in crowd-sourcing of imagery.

'Democratisation of technology' and 'radical transparency' are the declared principles of a new generation of Earth observation start-ups, although these declarations need to be balanced with one important factor: government control. The recent increase in third-party provision of imagery has, to date, proved highly successful for both satellite companies and major media outlets.

Both Planet and ICEYE will decline media requests for imagery, if they are deemed to be in breach of licensing agreements under US law as Robert Simmon, Planet's head of data visualisation, elaborated; "We're only allowed to sell to the people that the US Government grants us a licence to. So, there are some obvious countries that are not allowed to buy the data, if you have ties to a terrorist organisation you'd be on the forbidden list. So we actually count on the US Government to identify the bad actors and then we will abide by those rules one hundred per cent", he said.

Turner Brinton, head of Maxar News Bureau, says his company has refused to support media requests determined to be counter to US national security interests or "frivolous" and cites two examples; A request to monitor the development of a new US military installation and military operation, and; A request to look at the many properties owned by a celebrity for a "frivolous purpose". "We try to support projects that are meaningful. We don't want to be the paparazzi from space," says Brinton, declining to provide further details.

This limited form of editorial control over the supply of third party content appears to be a workable compromise, particularly when coverage of major international events in hotspots such as North Korea, Syria, Ukraine, the South China Sea and Myanmar is generally favourable to US Government interests. Nonetheless as Eliot Higgins, founder of citizen journalism investigative group Bellingcat asks, what will happen when the international news agenda turns to issues that significantly embarrass Washington, or are deemed counter to US national interests? "And it's going to be interesting when we start seeing if that focus is on Israel and Palestine and Yemen and other countries, where the West and its allies might not want so much close attention paid to it"

Until this time, the media publication or broadcast of imagery largely relied on declassified, often blurred or obscured spy satellite pictures, usually released by Washington or Moscow to underscore developments in a major military conflict or diplomatic dispute.

Brender quickly realised the potential of commercial Earth observation satellites for journalism, and he proposed to launch a satellite dedicated to news-gathering, but the project was grounded by a lack of funding; "I created a company in 1984 called MediaSat International Inc. and I felt one day there'd be a media consortium or a media company that would want a competitive edge. They'd get access to satellite imagery over areas of breaking news on Earth and get it first. But I'm not an Elon Musk or a Bill Gates or a Steve Jobs that will just go and fund a satellite, so there never was a MediaSat".

With Brender's project grounded, it was left to a French company SPOT, to launch the world's first commercial imagery satellite in 1986, with a

resolution of just 10 metres, capable of "clearly photographing a sports stadium".

"It was through SPOT that international media first began to make significant use of remote sensing. In April 1986, news agencies around the world used SPOT and Landsat images of the Chernobyl nuclear disaster region to show television viewers out-of-control fires and spreading radiation in an area sealed off for a 100-mile radius". SPOT's images were expensive, and logistically complex to co-ordinate. In his paper "Satellite imagery, the ethics of a new technology" Adam Powell notes that Brender, working as an ABC news producer, quickly capitalised on the opportunities created by SPOT; "ABC World News Tonight began showing pictures of secret military installations in North Korea, weapons plants deep inside Iran and mysterious laboratories in the Russian heartland".

Following the end of the Cold War, the US relaxed controls on commercial satellites and embarked on an 'Open-Skies' policy. The passing of the 1992 US Land Remote Sensing Policy Act enabled American companies, for the first time, to commercially operate Earth observation satellites.

Tim Brown, a US researcher told World Politics Review this policy change was primarily a strategic move to maintain control of the emerging civil sector said: "The law was meant to encourage firms from the US space industry that built the reconnaissance satellites of the Cold War to enter and saturate the market, thereby deterring foreign firms from doing so. That way, the US would not face significant foreign competition or threats to its security. The logic was, 'If we build it first, they won't come'".

Satellite-based news reporting is a good idea that's been a long time coming, according to Mark Brender, who has enthusiastically advocated satellite news-gathering for more than three decades. The former US Navy Public Affairs Officer worked for the US ABC network for 18 years as an assignment editor, producer and radio correspondent, before joining satellite company Space Imaging in 1999, where he rose to become Vice President.

As a former journalist and satellite imaging corporate consultant, Brender is uniquely placed to provide historical context to the politics and tensions between the US intelligence community, satellite companies and media groups now shaping the nascent satellite journalism world.

Concerned that preparations for Operation Enduring Freedom would be compromised, the Pentagon's National Imagery and Mapping Agency (NIMA) approached Space Imaging, operator of the one-metre resolution Ikonos, the only commercial satellite capable of detailing troop movements, to buy up exclusive rights to all imagery of Afghanistan and Pakistan for three months.

By this time, Mark Brender had left ABC and was an executive for Space Imaging: "And the Government called then-Space Imaging and said, "We want to buy all of your satellite imagery



over Afghanistan and buy imagery collected from every orbital pass. We're not going to impose shutter control, but we're going to buy all of your product all the time". So, they did that, for about three months and spent about \$8 million (USD), and finally someone said, "Hey, this is crazy". And so, all that imagery was then available for sale to the public".

By this stage, US-led forces had secured all the initial objectives in Afghanistan and the value of the imagery as news material had passed. Writing at the time in the UK Guardian newspaper, Duncan Campbell, a journalist specialising in intelligence issues, argued that the deal provided no military value beyond media censorship: "The US military does not need the pictures for its own purposes because it already has six imaging satellites in orbit, augmented by a seventh launched last weekend. Four of the satellites, called Keyholes, take photographic images estimated to be six to 10 times better than the 1 metre resolution available from Ikonos".

Barbara Cochrane then-President of the US Radio-Television News Directors Association lodged a protest over the government action denying media access to the imagery; "No news organization would risk the disgrace that would come from putting out information that costs the lives of American fighting men and women. No journalist worthy of the name would give away troop movements or strategic plans. Just as in previous military conflicts, journalists have already shown in this one [Enduring Freedom] that they will keep sensitive information secret

until it can be safely disclosed."

And what Washington couldn't buy, it sought to control by diplomatic means. The US reportedly pressured France to withhold the release of high resolution commercial satellite imagery, with "President Bush, convincing the French Defense Ministry to ban sales of SPOT images over Afghanistan in 2001".

However, by early 2003, as US-led forces massed to go to war against Iraq for a second time, the Pentagon's space censorship efforts were overwhelmed, as Israel, France, Japan and India had all launched a new generation of high-resolution satellites in quick succession. At the time Mark Brender noted the futility of continuing the 'buy-to-deny' approach; "It would be difficult for the U.S. Government to enter into enough contracts to keep all that imagery off the shelf and with 600 embedded journalists, why shutter control a commercial imaging satellite that's overhead every three days?".

The Pentagon abandoned chequebook shutter control, and instead embraced the new capability. In a memo to the Pentagon satellite imagery agency NIMA, then CIA Director George Tenet said: "It is now the policy of the Intelligence Community to use US commercial space imagery to the greatest extent possible". America's spies wanted to harness the burgeoning commercial satellite sector, but

according to Brender, there were tensions; "The concept of outsourcing overhead imagery has been an anathema to the intelligence community for a long time. "There are still those in the federal government who feel that commercial remote sensing is competitive to the capabilities of the spy satellites, though presumably the spy satellites have much better ground resolution. They're much more agile; they can pivot on an axis to shoot at angles and they can be lowered up and down to get higher resolution imagery. They weigh tons. They cost billions of dollars. But there are those in the government, the cold warriors, that still see so much value in spy satellite technologies, that they look at commercial satellite imagery as a stepchild".

But the nascent satellite imaging industry was a well-remunerated stepchild. In 2003-4 contracts totalling \$1B USD were awarded to the DigitalGlobe and GeoEye companies to develop the next generation of commercial imagery satellites. This freed up the National Reconnaissance Office's powerful spy satellites for more urgent tasks.

While Brender states that the US satellite imagery industry is getting better at selling imagery to commercial clients, he notes that none of the companies would be economically viable without government contracts, primarily with intelligence and defence agencies. And this makes them vulnerable to another method of government censorship beyond 'shutter control' and 'buy to deny'.

How commercial satellite imagery makes nuclear secrecy very difficult

Additional report by Igor Moric

Emerging capabilities of commercial satellite imagery are enabling high-resolution observation of objects and activity over large areas or territories of entire earth with capabilities to image many strategic locations on earth up to 15 times per day, many traditional earth observation companies image twice per day.

The widespread availability of commercial high-resolution satellite imagery will for the first time reveal to many people and organizations information to which they never before had access. Some have celebrated this new development, calling it the emerging era of global transparency. But transparency has both positive and negative consequences. In the field of international relations, greater transparency is allaying suspicion and tensions among international agencies tasked with monitoring and verification of nuclear plants and herald a new era of peaceful coexistence.

As one observer stated, once international organisations know what nuclear states are doing, they are less likely to increase world tensions through their activities. And nations that know that international organisations are observing them, they are far less likely to indulge in actions that will subvert treaties and agreements. According to this view, if everyone is constantly watching everyone else, rules will become unbroken and aggressive actions unrewarding. This premise may often be true, but not always.

In 1858 the French photographer Gaspard-Felix Tournachon popularly known as Nadar pioneered the field of remote sensing when he took the world's first aerial photograph of Paris from his gas balloon, Le G. ant, 250 feet above the ground. Two years later Nadar found himself taking aerial pictures of enemy troop movements during the 1870 Franco-Prussian war. What had started as one man's desire to capture the imagination of the world through the lens of a camera suddenly found novel applications in the bloody field of interstate warfare.

Since those early days, many more applications have been discovered for remote sensing data. Although the age of easy access to timely high-resolution satellite imagery is just now dawning, for several decades imagery has been available from aircraft and even at lower resolutions from government operated satellites.

Today, satellite imagery are providing near-instant insight into more of the Earth. Without the need for mobile resources, government and non-governmental organisations can regularly and affordably gain insights about

regions that are challenging to access using in situ surveys. Satellite data, captured from optical or radar imagery, is being collected every day. It can be generated extremely quickly compared to traditional methods, and therefore can consistently provide more up-to-date insight.

Transparency could also complicate decision making by introducing new participants into the policy process. Widespread availability of high-resolution satellite imagery has allowed private citizens, nongovernmental organizations, and particularly the media to take a more active role in policy making.

These groups are independently using satellite imagery to monitor state compliance with international agreements, expose environmental degradation, and publicize large-scale humanitarian emergencies. In some situations, civil society groups and the media might be able to compel states to take action, even when government officials would much prefer to do nothing. Here again, there are no guarantees that greater transparency will produce better outcomes. Nongovernmental organizations and the media rarely have the resources, analytical skills, or technical expertise that are more readily available to state governments. It is inevitable that organizations will make mistakes as they begin to increasingly rely on satellite imagery. The media have already made such errors on at least four occasions.

In recent years, the number of satellites launched each day has been increasing at an exponential rate. According to NOVASPACE, over 2,800 satellites are expected to be launched annually between 2023 and 2032, averaging about eight satellites per day.

During the 1986 Chernobyl accident, in an attempt to be the first with breaking news, a number of media organizations misinterpreted imagery and erroneously reported that two nuclear reactors had melted down. Just a few weeks later, a number of networks in the United States cited SPOT imagery of a Soviet nuclear proving grounds at Semipalatinsk as evidence of Moscow's decision to resume nuclear testing. Further analysis revealed that the networks had completely misinterpreted the imagery, falsely presenting routine activities in a far more pernicious light.

Another error occurred in 1992 when a newspaper called the European published SPOT images of what it labeled an Algerian nuclear research complex. Subsequent analysis of the image revealed that the feature in the photo was not a nuclear research facility but a military airbase. To make matters worse, the European had published the image upside down and backwards.

Over the next five years, more private companies around the world will be launching news commercial remote sensing satellites with the ability to detect objects as small as less than one meter across. That level of detail will be as good as that of current government-controlled spy satellites, which by most accounts has been achieving a resolution of just a few centimeters.

One key difference renders the commercial satellites far more interesting and possibly far more destabilizing than the state-owned spy satellites: the operators of these systems are not going to hide the imagery in the bowels of intelligence agencies, but are going to sell it to anyone able and willing to pay. The new commercial satellites will make it possible for the buyers of satellite imagery to, among other things, tell the difference between trucks and tanks, expose movements of large groups such as troops or refugees, and determine the probable location of natural resources.

Whether this increased access to imagery amounts to a positive or negative development depends on who chooses to use it and how. On the plus side, governments, international organizations, and nongovernmental groups may find it easier to respond quickly to sudden movements of refugees, document and publicize largescale humanitarian atrocities, monitor environmental degradation, or manage international disputes before they escalate to full-scale interstate wars.

Once a country signs the treaty, the world's nuclear watchdog, the International Atomic Agency, provides continuous and technical proof that the country's nuclear program is peaceful.

The IAEA ensures that countries operate their programs within the limits of nonproliferation agreements: low enrichment and no reactor misuse. Part of the agreement allows the IAEA to inspect nuclear related sites, including unannounced surprise visits.

These are not just log reviews. Inspectors know what should and should not be there. When the IAEA is not on site, cameras, tamper-revealing seals on equipment and real-time radiation monitors are working full-time to gather or verify inside information about the program's activities.

Countries seek a nuclear weapon capability for a variety of reasons, primarily prestige, influence and security. Security issues may be global as with the United States and former Soviet Union during the Cold War, or regional. For instance, Pakistani Prime Minister Zulfikar Ali Bhutto is reported to have said after the disastrous Pakistan defeat at the hand of India in 1971, that his country would build nuclear weapon even if the people had to eat grass, Israel nuclear program appears to have been driven entirely by

security motivations, the possession of nuclear weapon seemed necessary to ensure its survival. Some countries believe they will be perceived as the dominant state in their region just by possessing nuclear weapons. After the May 1998 Indian nuclear test, Prime Minister Vajpayee announced, "We have a big bomb now. India is a nuclear weapon state.

In August 1987, for example, the German foreign intelligence service, the Bundesnachrichten Dienst, used 10-meter resolution SPOT imagery to publicize the construction of a chemical warfare production facility near Rabta, Libya. Space-based reconnaissance is particularly well suited for this type of intelligence collection because it is sanctioned under international law and is considerably less intrusive than either aerial or on-ground surveillance.

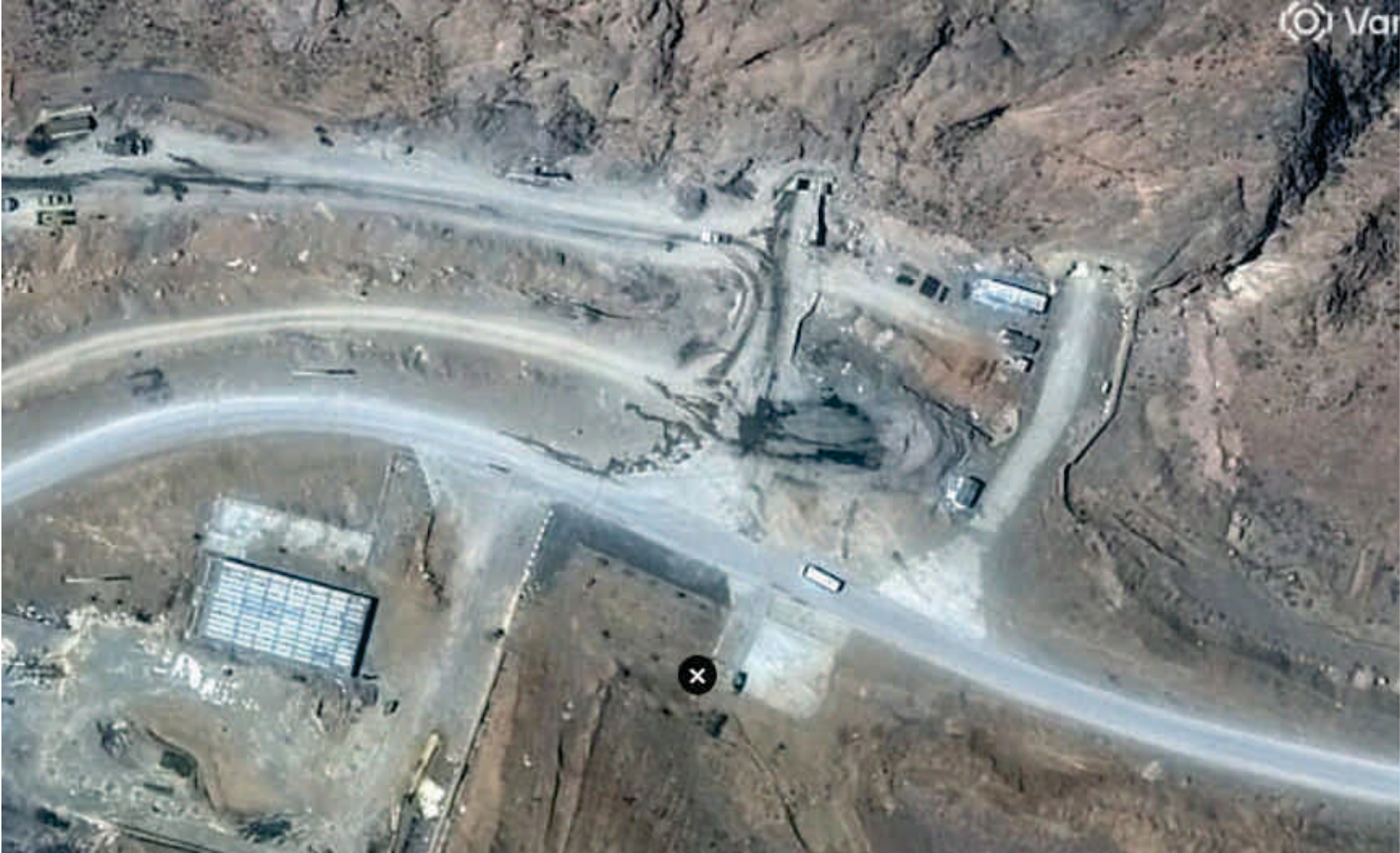
An added advantage of commercial satellite imagery is that it can be shared. Whereas government officials closely guard spy satellite images to conceal the technical capabilities of national reconnaissance systems, commercial imagery can easily be shared with foreign governments and international organizations, a considerable advantage in multilateral operations such as those in Iraq, Bosnia, or Kosovo.

In addition to intelligence collection, high-resolution commercial satellite imagery can help identify enemy vulnerabilities, plan military operations, assess strike effectiveness, and prioritize targets for follow-up missions. There is some evidence that the Iraqi military may have used 10-meter resolution SPOT satellite photographs for attack planning and post-attack assessments both during the eight-year Iran-Iraq war and prior to the invasion of Kuwait in August 1990. SPOT and Landsat imagery later helped the allied forces expel the Iraqi troops from Kuwait.

Similarly, the political economy of space activities is changing, and the space sector is growing rapidly. At present, private companies, such as Airbus, BlackSky, Spire and Planet, produce satellites that are launched by private launch providers, such as SpaceX, providing real-time, space-based intelligence that delivers on-demand, high frequency imagery, analytics, and high-frequency monitoring of the most critical and strategic locations, economic assets, and events around the world.

The operation of nuclear facilities is associated with some specific activities or features on the earth surface, such as vehicles in parking spaces, delivery traffic and equipment. While these types of surface objects and their movements can easily be monitored using very high-resolution satellite imagery, the existence of thermal emissions could give the essential indication that a facility is in operation.

The absence of these activities and features on the surface can be used to confirm the non-operational status of nuclear facilities, and, depending on the type of facility, thermal infrared imagery can play an important role in this context.



The International Atomic Energy Agency is applying commercial high resolution satellite imagery for monitoring state compliance with international arms control agreements. But there is no way to guarantee benevolent uses. Governments, corporations, and even small groups of individuals could use commercial satellite imagery to collect intelligence, conduct industrial espionage, plan terrorist attacks, or mount offensive military operations. Even when intentions are good, it can be remarkably difficult to derive accurate and useful information from the heaps of transmitted data.

Following analysis comes the problem of identification; is the observed event a violation. At this stage it is common for information from other sources to be brought to bear on the problem, since it is rare that a violation can be unambiguously identified from a single source. For instance, if a satellite sensor detects what appears to be the light flash from a nuclear weapon test in the atmosphere, it is possible to study various meteorological, seismological and radiological data to attempt to gain confirmatory or contradictory evidence.

On April 26, 1986, two explosions destroyed Unit 4 of the Chernobyl nuclear power plant in Ukraine and released 100 million curies of radionuclides into the environment. Hoping to keep the incident secret, the Soviet government immediately sealed off a 100-mile radius around the stricken reactor and banned all foreign travel to Kiev, the largest city nearest the site of the accident.

Two days later, as radioactive clouds began setting off radiation alarms throughout Europe, the Soviet news agency Tass confirmed Western suspicions by disclosing that one of its atomic reactors had indeed been damaged. Within hours

of the announcement the United States top-secret spy satellite, Keyhole, began collecting imagery of the Chernobyl power station.

By April 29, Keyhole photos were in the hands of U.S. policy makers in Washington, D.C. But this time government official did not have exclusive access to satellite imagery. Less than twenty-four hours after Keyhole images reached the White House, the American Broadcasting Company (ABC) aired medium-resolution Landsat images of the blazing nuclear reactor. Shortly thereafter, a number of media organizations began broadcasting higher resolution SPOT images of the Chernobyl power plant. In the

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decade and a half since the Chernobyl accident, the use of satellite photos by news organizations has increased significantly.

Survey of emerging nuclear states

A US intelligence assessment in the later part of the 1960s and early 1970s concluded that India could rather easily and quickly move from a peaceful nuclear program to a military one. Shortly, before the 1974 Indian test, US intelligence concluded that over the next several years the chances that India would conduct a test were about even. However, the drilling in the spring of 1974 at Pokhran, the designated test site, was incorrectly thought to be related to search for water or perhaps oil. The primary reason for this failure was the low priority for the use of technical collection assets allocated for this monitoring task along with the paucity of inside information.

However, there was a different and more favorable outcome in May 1982. In response to a proposal from Indian nuclear scientists, Prime Minister Ghandi authorized two nuclear tests, however, India's foreign secretary, Maharaja Krishna has been in Washington and learned that the United States had information on preparations for the planned tests. When Ragostra returned to India, he told Gandhi that there would be trouble if India conducted a nuclear test, she abruptly cancelled the two tests.

In the spring of 1995, Prime Minister Rao authorized the preparation of test shafts at the Pokhran nuclear test site. During the months that followed, these preparations were closely followed by US intelligence. On 15 December 1995, the U.S Ambassador called on the private secretary of Prime Minister Rao and indicated that a test by India could bring sanctions from the United States. President

Clinton phones the Prime Minister soon after. And for the second time good intelligence had helped prevent an Indian nuclear test.

Om 1998, however, the outcome was different despite enhanced intelligence effort to monitor India's nuclear weapon activities. On MAY 11, India unexpectedly carried out three tests at Pokhran, and then conducted two more tests on May 13. While the actual number and yields of the tests would remain controversial for years, there was no doubt that India had carried out nuclear tests, and the US intelligence had not given policy makers advance warning.

Many asserts that US had satellite imagery in early May showing unusual activity at the test site, by imagery analysts were slow to study the images and give advance warning. If true, then the US intelligence community was clearly guilty of missing a chance to provide tactical warning. India had engaged in extensive concealment activities at the test site that included burying the

cables, placing camouflage netting over the test area, and conducting as many operations as possible at night or when reconnaissance satellites were not overhead.

The Indian took advantage of May sandstorms and vehicles used for activities at night were always back in the same assigned places for the day so as to not disclose increased vehicle movement.

The Indian Intelligence Bureau ran a vigorous counter intelligence program; the CIA was apparently unable to recruit a single person who knew anything about the tests. And the US National Security Agency also could come up with no relevant intercepts because India's nuclear weapon establishment communicated via encrypted digital messages relayed through satellites.

After the Indian test of May 1988, US intelligence analysts strongly believes that Pakistan would soon respond in kind. Director

Tenet informed the congressional committee that preparations for an underground test by Pakistan in the Chagai Hills region has been detected. The tests, six in all, took place on May 28 and May 30 and came as no surprise. Six months prior, department of energy experts confirmed that Pakistan was making significant progress in developing nuclear weaponry.

the intelligence record with regard to Israel also seems to have been mixed. Israel has never acknowledged that it possesses nuclear weapons, preferring to adhere to a policy of ambiguity, but it has never been a party to the nonproliferation treaty and is regarded as a de facto nuclear weapons state. The only uncertainty appears to have been the precise size of its arsenal, use doctrine, targeting and alert status.

US intelligence became interested in the Israel program early on and by the late 1950s became convinced that Israel was engaged in a secret nuclear weapon program. The CIA learned of the Norwegian heavy water sale to Israel, and by 1960, Dimona was considered to be a probable nuclear weapon development site.

After taking office in January 1961, President Kennedy pressed for inspections to resolve ambiguities in US understanding, but the Israelis refused and were successful in limiting the frequency and duration of US inspection, thereby concealing the true purpose of Dimona. While the US government agencies believe that Israel had the capability to build a nuclear weapon quickly if it chose, there were differences of views as to whether it had actually done so.

By 1974, however, a national intelligence estimate concluded that Israel had already produced nuclear weapons, between ten to twenty. By the 1980, estimate had increased to between twenty to thirty. However, an interview by Mordechai Vanunu, a former employee at Dimona published by the London Times on 5 October 1986 revealed that nuclear weapon program in Israel was much larger, one hundred to two hundred weapons, and disclose an Israel capability to build thermonuclear weapons. While policy makers provided early warning of an Israel nuclear weapon program in the late 1950s, the size and capabilities of the program ultimately were underestimated.

The rise of New Space start-ups

New Space start-ups playing a growing role in the development of space exploration, the landscape of space programs has been permanently altered. While governments remain interested and invested in space programs, they are no longer the only stakeholders.

Since the launch of its first satellite in 1986 Airbus has built up an extensive archive of satellite imagery. With unique access to both optical and radar imagery, Airbus has a comprehensive portfolio of satellite imagery, data, and related services.

The detailed nature of Airbus imagery makes it a valuable resource for Coastal applications, vegetation monitoring, and construction planning. Airbus now offers 30cm resolution imagery (commercially available est Q4 2021 which can provide high-level insight for development planning, environmental consultants and civil engineers.

U.S based Planet Labs provides an easily analysed optical solution for identifying change detection. Due to an increasing number of satellites in orbit, Planet's satellite constellation now provides the highest frequency of repeatable imagery capture on the

market. Their satellite revisit period provides near-global images of the same location on a daily basis, making it invaluable for change detection.

Planet's quick revisit periods and repeatability allows customers to consistently monitor the same location and detect change. This can be used to understand the impacts of disaster quickly with before-and-after imagery allowing the deployment of the right resources in the right locations and to anticipate market effects and investment impact caused by disasters using imagery as evidence. The use of change detection imagery can also help the construction industry plan infrastructure, oversee project development, and understand the potential environmental impact of developments.

Planet's satellites are not tasked with searching for images; their Mission 1 is to scan the whole Earth every day. Customers can then search for the images they want using GPS coordinates. A spatial resolution of 1–5 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.

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 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.

Also, Capella offers flexible solutions that can capture change in all weather, 24/7, allowing consistent guaranteed data collection on a daily basis, which is ideal for detecting change. Capella's rapid Very High Resolution SAR imagery allows organisations to quickly visualize and alert team members, enabling fast critical thinking and problem-solving when you need it most.

The nature of Capellas VHR SAR imagery makes it ideally suited for detecting and distinguishing between objects, nuclear plants, ships, planes and vehicles and capturing large, small and barely perceptible changes that occur every day in your Areas of Interest. The ability to acquire images through clouds, day and night, is particularly useful for monitoring and planning emergency or natural disaster situations. Imagery can be rapidly delivered to provide visibility during events such as volcanic eruptions or hurricanes

Today, the market is shifting away from static, low frequency satellite imagery and geospatial mapping solutions toward dynamic and on-demand, high frequency imagery and advanced analytics that together deliver real time space based intelligence. The commercial sensors on orbit expand from a handful of large, expensive commercial satellites to now hundreds and soon to thousands of space based sensors that are changing the way we see and understand our world.

The need for real time space based intelligence is now more important than ever. Recent global events like the ongoing conflicts in Iran, Israel, Sudan and Ukraine and the Earthquakes in Turkey and Syria have reinforce the value of real time, space based intelligence. BlackSky is

changing the way space is used to deliver vital, actionable intelligence through our two key strategic assets, our high-revisit observation smallsat constellation and our AI enabled software platform.

To capitalize on this paradigm shift, BlackSky deployed a propriety satellite constellation providing high-frequency, high resolution imagery and built a fully operational software platform capable of integrating our proprietary data with the data from this proliferation of sensors and other third party information, such as synthetic aperture radar SAR data and radio frequency data from partners, millions of GPS enabled terrestrial data sources and Internet of Things connected devices.

BlackSky helps customers improve their decision making processes by incorporating on-demand imagery and AI-driven analytics into their daily operations through our modern, easy to use, software as a service customer experience.

BlackSky Gen-2 constellation provides unique value with the ability to collect imagery and analytics from dawn-until-dusk at a higher cadence and at lower cost than traditional providers. US and allied militaries rely on this services for high revisit monitoring of airfields, vehicle depots, troop movements, and other high value locations to detect change in pattern of life. BlackSky can distinguish landscape features such as roads and buildings, and gauge commercial activities and patterns such as movements from ships in ports, progress at construction sites and changes in production by estimating the number of cars in a parking lots.

Satellites operated by private companies located in more than 30 countries now provide imagery that once was accessible only to a handful of governments. One must look no further than the daily coverage of the Russian invasion of Ukraine; satellite images captured the massing of Russian forces on the Ukrainian border, columns of military units, destroyed buildings, burning vehicles, and bodies scattered over streets.

These images of war are now on our screens with unprecedented speed and detail. They are shared over social media by open-source investigators and combined with ground imagery of geo-located events captured by civilians with camera phones and soldiers with drones, a framework often referred to as open-source intelligence or OSINT.

Beyond conflicts, commercially available satellite images also provide an unobtrusive and cost-effective way to monitor the activity of civilian or military nuclear programs, as shown by the many recent analyses of sites in Iran and North Korea. Imagery is part of the International Atomic Energy Agency's toolkit, with the agency's inspectors combining commercial imagery with open-source information to look for direct and indirect signs of nuclear activities.

In 1974, during the SALT I1 negotiations, satellite imagery could verify the proposed limitation on changes in silo diameter to a maximum of 10- 15 per cent, implying a ground resolution of at least 0.5-0.75 m was available in 1974. Current resolution capabilities of about 0.1 m could detect even smaller changes in silo design as well as a great many other details of missile site layout; equipment such as radars, communications facilities, vehicles, storage buildings, and so on, can now also be seen and described in considerable detail.

The emergence of China

A Chinese company that specialises in generating geospatial intelligence is actively tracking American military aircraft and ships involved in ongoing operations against Iran, highlighting the vulnerability of conventional armed forces to observation from satellites in low Earth orbit.

Shanghai-headquartered MizarVision has been posting satellite photos of US military activity to social media, including the movement of naval vessels and the location of both combat and support aircraft. A number of the facilities and assets posted by MizarVision were subsequently targeted by Iran in missile and drone strikes, which were launched after the US and Israel initiated Operation Epic Fury.

Among the US assets catalogued by MizarVision in recent days and posted to the social media site X are Lockheed Martin F-22 stealth fighters parked on the ramp at Israel's Ovdal air base and a range of critical platforms staged at Saudi Arabia's Prince Sultan air base, including seven Boeing E-3 airborne warning and control system (AWACS) jets and two Bombardier E-11 communications aircraft.

"Satellite imagery shows the US military continuously transporting supplies to Ovdal air force base via Boeing C-17s," MizarVision said. "During the same period, seven F-22s were parked on the tarmac, and four F-22s were spotted on the runway." Operation Epic Fury launched roughly 24h after that observation, which was accompanied by imagery, was posted to X.

Other key facilities have also been observed, including the al-Udeid air base in Qatar, which was targeted by Iran in a drone and missile attack. Naval assets, including Washington's two aircraft carriers in the region, were also located and tracked by MizarVision on their approach to the Middle East. The company says satellites "continuously tracked" the USS *Gerald R Ford*, the US Navy's newest and largest flattop, following the carrier's departure from Souda Bay naval base in Crete. Images of the *Ford* posted on X show Boeing F/A-18E/F Super Hornets and Northrop Grumman E-2D airborne early warning and control aircraft staged on the flight deck.

The same day, MizarVision posted photos of the USS *Abraham Lincoln*, the other aircraft carrier in the region, appearing to rendezvous with a resupply vessel in the Arabian Sea off the coast of Oman. Separate analysis posted on 28 February shows how other open source tools can be combined with commercial satellite imagery to track carriers at sea.

Using imagery and flight tracking software, MizarVision followed a US Navy Boeing P-8A maritime patrol jet from Isa air base in Bahrain to an area in the Arabian Sea, where the *Lincoln* is known to be operating. "The aircraft is suspected of providing protection and defence for the *Lincoln*," MizarVision concludes. Intelligence coming from the Chinese firm has not only been limited to the Middle East area of operations.

On the same day it was tracking the *Ford* in the Mediterranean, MizarVision's satellites photographed Diego Garcia, the Indian Ocean atoll where Washington leases an air base from the UK. Photos of Diego Garcia's runway posted

on X show US Lockheed F-16 fighters, Boeing KC-135 tankers and a number of heavy-lift transport aircraft, including C-17s and a Lockheed C-5 Galaxy.

MizarVision tracked the path of the aircraft carrier USS *Gerald R Ford* as it departed Crete for the Eastern Mediterranean. The company was simultaneously tracking the USS *Abraham Lincoln* carrier strike group in the Arabian Sea and activity around the air base on Deigo Garcia. It is unclear if the Chinese imagery of American troop movements was used by Tehran to support its missile and drone strikes across the Middle East, but the deluge of material shows how difficult it has become to hide military assets from adversarial observers.

While attempting to avoid observation from orbiting reconnaissance has been a common practise since the Cold War, 20th Century spy satellites were large and relatively few in number, with limited ability to reposition.

The proliferated low-Earth orbit constellations of the 21st Century use a greater number of small, cheaper satellites that can provide global coverage at a fraction of the cost Cold War-era imagery required. That substantially reduced price has allowed commercial operators to launch their own private satellite imaging and analysis services. The major players in the space are American firms Vantor, formerly Maxar Intelligence and Planet Labs alongside Airbus Defence and Space in Europe.

MizarVision does not itself operate any satellites, but uses artificial intelligence and other remote sensing tools to rapidly scan and analyse commercially available imagery. However, the exact source of that imagery remains a matter of ongoing debate, one which the company does not disclose. One option is China's indigenously developed Jilin-1 constellation, although there is some scepticism that the Chinese satellites can provide the quality of resolution seen in MizarVision's images.

Applications in nuclear verification and monitoring.

According to the Union of Concerned Scientists' database, as of January 1, 2022, there were 4,852 satellites in orbit, 72 percent of which being commercial systems. The civilian space industry is experiencing extraordinary growth made possible by advancements in technology, increased governmental and public demand for services, and cheaper space launches. Following this growth and relaxation of distribution restrictions, providers of commercial satellite imagery are launching new constellations and encouraging the development of novel applications of overhead imagery.

Satellites can view ground objects only if they are larger than the sensor's resolution, nothing is obstructing their view, and they are visible within the sensor's observation bandwidth. In addition, the capacity to view the activity as it occurs or map out trends depends on the revisit time, that is the time interval between subsequent observations of the site. The quality of ground

coverage during a given period of observation, therefore, mainly depends on spatial resolution the sensor can achieve from the altitude of the satellite, spectral information the sensor can acquire during the observation interval, and frequency of repeated observation.

Current commercial systems can acquire data with a 30-centimeter and 31-cm resolution in the panchromatic black and white, respectively. By comparison, US government-owned spy satellites can produce imagery with a top resolution at the level of 10 cm; as evidenced by former President Trump's tweet showing a failed Iranian missile launch in 2019.

Rather than trying to reach the highest level of image quality, commercial providers deploy instead multiple satellites built with cheaper, off-the-shelf components which they can easily replace if they malfunction or technology advances. In addition, using multiple sensors observing from different angles and orbits results in a higher persistency of coverage. For example, the US company Planet operates more than 150 Dove satellites with up to 3.7-meter resolution. The constellation is being constantly expanded and upgraded, and the data is combined to get a more comprehensive view of the surface.

Sensors with a wider spectral range make it possible to see details beyond the capabilities of the human eye, classify observed material and distinguish human-made from natural objects. Some sensors can also image in the infrared spectrum, allowing them to detect thermal sources on the surface, especially useful for tracking activity inside facilities. But most optical systems won't see the Earth's surface during the night or in conditions of poor illumination. Clouds cover most of the land surface at any moment in time, and some locations remain permanently hidden. This makes it difficult to observe any location on demand.

Synthetic-aperture radar SAR systems can fill the observation gaps. Here, the image is produced by the radar antenna which transmits microwave pulses that bounce from ground targets and are then bounced back to the satellite. By measuring the phase and the intensity of the returned signal, the system can construct an image of the surface and accurately derive distances between objects, after a relatively extensive image conversion process. Atmospheric and illumination conditions will not affect the quality of the image. SAR systems are always watching.

If all commercial satellites currently in operation were to be combined into one super-constellation, they would provide global coverage of the Earth's surface with a frequency of only a few hours. Recent work has simulated what type of coverage can be provided by a super-constellation formed by 300 systems, 265 optical imaging satellites and 35 SAR-equipped satellites.

These systems were selected under the condition that they offer some form of public access to their data and have an imaging ground resolution of five meters or less, at which it becomes possible to identify many objects from space even though lower-resolution imagery can

and was regularly used for nuclear verification and monitoring.

The simulation calculates the ground coverage of the constellation over territories of states with active nuclear programs for a duration of 14 days. A successful pass was not defined simply as a ground track revisit but as a successful observation of some site considering orbit and sensor properties. For optical systems, it considers the effect of statistical cloud coverage and sun illumination, while for SAR it assumes this has no effect on observation quality.

Coverage was calculated for different ground resolution intervals, equivalent to levels of detectability of ground objects. Optical and SAR systems were simulated separately because observations in different bands are not equivalent and do not provide the same type of information for a given resolution, even though data from different bands can be merged to provide more than the sum of its parts. Results from the simulations show that with combined commercial systems, it would be possible to observe most locations on the planet every 15 hours on average in the optical and under five hours with SAR, with a sub-meter resolution.

The current fleet of commercial imagery satellites allows inspectors to detect, identify and monitor most objects relevant to nuclear arms control and nuclear proliferation analysis. They also allow identifying signatures of activities associated with the development, acquisition, and maintenance of operational nuclear weapons capabilities. Commercial imagery satellites can also reveal the absence of items that are necessary for the normal operation of a site that was declared to have some other non-nuclear uses.

High resolution and high frequency of observation are not necessary for the detection of new structures and most immobile objects. Commissioning of nuclear facilities takes years and can easily be detected even with low-resolution sensors. For example, in 2006, imagery taken at a monthly rate was used to detect the construction of a nuclear reactor in Pakistan and later produce a three-dimensional model of the facility and estimate its plutonium production capacity. Even before construction begins, a future site of a nuclear facility can be recognized by tight security, the stockpiling of equipment and increased traffic at a remote location, or proximity to other sites of similar characteristics.

Satellite observations of a site at a weekly frequency provide more information on the facility operation and surrounding activity. Multispectral monitoring of thermal and vapor plume emissions and steam discharges enables monitoring of the operational state of a nuclear facility and can even help estimate the existing stockpile. Satellites can also be used as a tool to track the nuclear fuel cycle.

For example, civilian inspectors were able to monitor the operation of North Korea's nuclear reactor and Yongbyon radiochemistry laboratory. Established durations of activity match IAEA's estimated time required to reprocess irradiated fuel and produce plutonium.

Even more frequent observation allows for more confident mapping of trends and an increased probability of detection of attempts at deceiving the observer. Using imagery taken daily, researchers from Stanford's Center for International Security and Cooperation were able to count trucks at a border crossing between China and North Korea, and in that way track trends in trade activity between the two countries.

With the enormous amount of data being downlinked to ground stations each day, AI algorithms are increasingly used for the processing of raw imagery, object classification, and identification of correlations and irregular behavior. For example, the retail industry uses such algorithms to count cars on parking lots and help companies evaluate commercial activity, whereas analysts use them to count the number of new oil well pads to predict global supply. Similar AI-powered detection capabilities can be used for nuclear verification and monitoring.

With the help of AI algorithms, researchers from open-source defense intelligence agency Janes and Stanford's used imagery taken at a monthly rate between mid-2020 and early 2021 to automatically count vehicles on a parking lot of a nuclear facility in Iran. From this information, they inferred site personnel fluctuations and then the progress in the construction of a possible underground centrifuge assembly facility—despite the facility not being directly visible from space. Higher persistency of coverage could permit detection and tracking of individual vehicles entering and leaving nuclear facilities with much higher confidence. This can reflect staffing and material demand, allowing remote inspectors to evaluate the production status without the need to visit the site or place intrusive electronic sensors.

Monitoring of state nuclear activities can be performed even without satellites. Citizens can often see what is happening in their area and share information over the Internet. For example, Nukewatch, a volunteer-based civilian organization—tracks British nuclear warhead convoys. Then, crossing the observed level of activity and movement of trucks with official reports and publications, Nukewatch can analyze UK's nuclear modernization and estimate the armament of their nuclear-capable submarines. But this kind of information gathering by concerned citizens is not possible in all countries. Even otherwise democratic societies often work hard to keep their nuclear programs far from the public eye.

Another simulation was performed with a satellite super-constellation by focusing the coverage on the territories of China and North Korea. Chinese and Russian providers that might have objected to imaging of sensitive areas were removed from the sample of available systems. A similar analysis can be performed for other territories, such as the United States and Russia, by removing satellites operated by companies located in those countries. The results showed that on average all locations for every ground resolution in China and North Korea can be imaged at least once every 24 hours. If using the SAR technology, the entire territory of China can be imaged every few hours. This would, for example, allow detection of missile uploading at all known Chinese missile silo locations.



Example of coverage achieved through satellite super-constellation imagery at locations of known missile silo sites in China. Observation resolutions were selected to allow detection of new construction (5-m optical), vehicles (3-m SAR), and missile uploading (1.4m optical).

Even though confidence in what is observed typically scales with sensor advancements and the increased number of satellites, there are inherent limitations to what a sensor can observe from the Earth's orbit. Hosts can attempt to obfuscate their activities, camouflage objects, or otherwise deceive the observer. But hiding will become increasingly difficult as more data is collected, and persistency of coverage is improved.

Advanced satellite imagery allows counting objects of sufficient size, but cannot reveal sensitive information about their structure,

chemical composition, or other confidential characteristics. This technical limitation could act as an advantage in nuclear inspection, as the host does not need to worry about the unintended disclosure of information.

Within the next few decades, swarms of commercial surveillance satellites could make real-time multispectral satellite imagery available to everyone.

Aided by AI, this could be exploited to create an automated system that monitors sites and detects the appearance or removal of objects relevant to civilian and military nuclear programs, for all atmospheric conditions and during the night. Satellites may be able to track all vehicles entering or leaving nuclear sites anywhere in the world, be they uranium mines, enrichment plants, nuclear reactors, or weapons assembly, deployment, maintenance, storage, and dismantlement sites. Establishing secret nuclear programs, both for

energy and weapons and maintaining secrecy around existing ones could soon become extremely difficult, if not impossible

AQ Khan network

Abduk Qadeer Khan was once described by CIA Director Tenet as "at least as dangerous as Osama Bin Laden. After completing his university studies in Pakistan, he went to work for a subcontractor of UTNECO in the Netherlands, where he had access to sensitive information relating to uranium enrichment and nuclear fuel cycle. Traumatize by his country's defeat in the 1971 war with India, Khan secretly transferred centrifuge plans and other sensitive information to which he had access to UTENCO to Pakistan agents.

Toward the end of his stay in the Netherlands, Khan's activities were discovered by the Dutch security service. The Dutch government was prepared to move against him, however, CIA reportedly urged that this not happen so that the US could learn more about his activities and

associates. In less than a year, Khan was able to establish the Engineering Research Laboratories and begin playing a significant role in the Pakistan nuclear weapons program. By 1979, experts realized that Khan had assembled everything he needed to construct his own centrifuge plant. US intelligence closely monitored Khan's work, but what wasn't known for over a decade was that Khan had emerged, after the maturity of the program in Pakistan, as a worldwide middleman of nuclear proliferation. In the 1980, the intelligent report learned that Khan had obtained a design for the Chinese nuclear weapon tested in 1966, which he later supplied to the Libyan and possibly the Iranians.

In short, the emerging global transparency resulting from high-resolution commercial remote sensing satellites promises both benefits and costs. The challenge is to devise policies that harness the benefits of growing international transparency while minimizing its many potential negative consequences.



APPOINTMENTS

Former USGS Leader Kevin Gallagher Joins Woolpert as Senior Geospatial Advisor

Kevin Gallagher has joined Woolpert as a senior geospatial advisor. A former U.S. Geological Survey (USGS) associate director for Core Science Systems, Gallagher brings nearly 40 years of federal service and executive leadership experience spanning geospatial strategy, science informatics, technology modernization, and national mapping efforts. As senior geospatial advisor, Gallagher will provide strategic counsel supporting the firm's long-term growth across federal and international geospatial markets.

"Kevin's experience operating at the intersection of science, technology, policy, and global collaboration is exceptionally aligned with where Woolpert is headed," said Woolpert Executive Vice President and Global Head of Technology and Innovation Amar Nayegandhi. "As governments and organizations around the world increasingly rely on trusted geospatial intelligence to support resilience, infrastructure, security, and resource management, Kevin brings a unique perspective that will help strengthen our international relationships, sharpen our strategic positioning, and elevate how we engage at the executive level globally."

At USGS, Gallagher served as chief information officer and chief technology officer where he led enterprise IT and telecommunications operations, including overseeing the Geologic Mapping, Geospatial Mapping, and Science Informatics programs and managing the world's largest Earth science library.

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Former NASA Deputy Administrator Pamela Melroy Joins Gilmour Space Board of Directors

Australian aerospace company Gilmour Space has appointed former NASA Deputy Administrator, astronaut, and retired US Air Force Colonel Pamela Melroy to its Board of Directors.

Col. (Ret.) Melroy brings more than three decades of leadership across civil, defence, and commercial aerospace. Most recently, she served as Deputy Administrator of NASA, helping guide the agency through a period of significant growth and innovation. She is also a former astronaut and one of only two women to have commanded a Space Shuttle mission.

Her appointment follows the addition of international business leader Paco Ybarra to the Board last year and further

strengthens Gilmour's leadership as the company scales its launch, satellite, and spaceport capabilities for global markets.

Adam Gilmour, CEO and Co-founder of Gilmour Space, said: "Pam is one of the most respected leaders in the global aerospace industry. Her experience across government, defence, and commercial space will be invaluable as we continue building sovereign capability in Australia and expanding our presence internationally. We are proud to welcome her to the Board and look forward to her guidance as we enter our next phase of growth."

Col. (Ret.) Melroy said: "I'm excited to join Gilmour Space at such an important stage of its journey. The team is building a genuinely critical sovereign capability for Australia, with ambitions that extend well beyond launch.

"It's been impressive to see the company's willingness to tackle some of the most challenging aspects of the space sector, from launch vehicles and satellites to the infrastructure needed to support them. Building these capabilities takes patience, technical excellence, and long-term commitment. As access to space becomes increasingly important for economic growth, technological leadership, and national security, I believe Gilmour Space is well positioned to play a meaningful role in Australia's future and the global space economy."

PLD Space strengthens its Board of Directors with the appointment of Hilario Albarracín

PLD Space, an international space transportation company, continues to strengthen its corporate governance with the appointment of Hilario Albarracín, former Chairman and CEO of KPMG in Spain, as a new independent director. This appointment, which comes just days after the incorporation of space industry pioneer Candace Johnson, underscores PLD Space's ambition to build a Board composed of strategic profiles with international prestige. Albarracín's arrival is key in the current phase of preparation for the commercial operations of the MIURA 5 launcher, bringing first-class experience in finance, risk management and corporate strategy.

"Continuing to strengthen our Board with a profile like Hilario's is essential on our path toward leadership in space transportation in Europe," said Ezequiel Sánchez, Executive President of PLD Space. "His deep expertise in corporate governance prepares us for the challenges and opportunities of large-scale commercialization."

For his part, **Hilario Albarracín** stated that *"being part of this successful project is both*

a challenge and an opportunity in my professional career. PLD Space represents an innovative Spanish and European private initiative that can become a key player in the aerospace sector. It is currently in a strong phase, with a clear and advanced industrial project, and an exciting future ahead. Without a doubt, the launch of MIURA 5 represents a major milestone."

PLD Space appoints space industry pioneer Candace Johnson as independent board member

PLD Space, an international space transportation company, has appointed Candace Johnson, one of the most prominent and influential figures in the global space industry, as a new independent board member.

Johnson's arrival represents a strategic milestone for the company, strengthening its corporate governance and global vision during a decisive phase of growth. This phase is marked by the first test flight of MIURA 5 and the company's consolidation as a key player in ensuring independent and global access to space. Her appointment also brings matchless experience and an unparalleled network of contacts within the global space and telecommunications ecosystem.

"It is a true honor to welcome Candace to our Board of Directors," commented Ezequiel Sánchez, Executive President of PLD Space. "Her career and deep knowledge of the industry are invaluable. Having her strategic perspective will be a key asset as we advance our mission to become a global leader in space transportation. Her decision to join us is the greatest possible validation that our technology, our team, and our business vision are heading in the right direction."

On the other side, **Candace Johnson** added, *"access to space is one of the most critical issues facing the trillion-dollar space economy, and I am delighted to have been chosen for the Board of Directors of PLD Space, one of a select group of private companies globally developing complete launch systems, enabling global access to space supported by a strategic network of locations worldwide."*

Wolfgang Schmidt, Former Head of German Chancellery, Joins Planet's European Advisory Board

Planet Labs Germany, a leading provider of daily data and insights about change on Earth, announced the appointment of Wolfgang Schmidt, former German Federal Minister for Special Affairs and Head of the Federal Chancellery, to its European Advisory Board. He joins the board at a pivotal moment as Planet expands its presence in Europe and advances plans for a new satellite manufacturing facility in Berlin, reinforcing Germany's growing role in

Europe's New Space ecosystem and Planet's long-term commitment to the region. The Berlin facility will serve as Planet's European center for advanced satellite manufacturing.

Wolfgang Schmidt's extensive knowledge of the German, European and international political landscape, as well as his long tenure in leadership positions, will support Planet as it expands across the continent. In addition to his role as head of the Chancellery, Wolfgang also oversaw the intelligence services of the Federal level in Germany. "We are privileged to welcome Wolfgang Schmidt to our European Advisory Board during a period of significant operational momentum for Planet in Europe," said Will Marshall, Co-Founder and CEO of Planet. "Wolfgang's direct help facilitating our partnership with Ukraine supported by Germany, his experience leading the Germany Chancellery, and his deep expertise in European policymaking and international affairs will be invaluable particularly as we expand our manufacturing in Germany, underscoring our deep commitment to Germany and Europe."

Karman Space & Defense Names Jon Rambeau as Chief Executive Officer to Lead Company's Next Phase of Growth

Karman Space & Defense, a leader in the rapid design, development and production of critical, next-generation system solutions that align with the U.S. Department of War's core mission priorities and the nation's accelerating demand for access to space, announced a transition in leadership to drive its next phase of growth, with Chief Executive Officer Tony Koblinski retiring after a successful 40-year career in leadership and Jon Rambeau assuming the CEO position effective March 23, 2026.

Rambeau is a 30-year, proven defense leader with a track record of driving results through innovation and technology – pushing the boundaries of what's possible to solve complex problems for our nation and allies around the globe. He has held C-suite and senior executive roles with two of the world's top defense contractors, most recently as president of the \$8 billion Communications & Spectrum Dominance segment for L3Harris Technologies, a disruptive innovator in the global defense ecosystem. In this role, he led an extensive portfolio that included electronic warfare, advanced communications, threat sensing and targeting, and integrated vision systems. He served previously as the president for the \$7 billion Integrated Mission Systems segment.

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."

Doug Laurendeau Joins Karman Space & Defense as Chief Growth Officer

Karman Space & Defense announced that Doug Laurendeau, former vice president of Enterprise Strategy Integration at Lockheed Martin Corporation, has joined Karman's senior leadership team as chief growth officer, and current chief growth officer Stephanie Sawhill has assumed the role of chief technologist. With more than four decades of experience at Lockheed Martin, Laurendeau led development of the growth strategy for the successful \$70 billion business portfolio, relying on close relationships with the C-suite, business units, and functional organizations.

Laurendeau previously served as vice president of Strategy and Business Development for the Rotary and Mission Systems business segment. In that role, he drove growth for the \$16 billion organization through his approach to customer relations, market assessment, competitive intelligence, strategy and business capture activities. Under Laurendeau's business development leadership, the company notably delivered significant domestic and international growth in critical markets, including joint all-domain command and control, air and missile defense, undersea, and aviation.

"As our new chief growth officer, Doug brings valuable experience to Karman at a time



when market dynamics and customer demand position us for continued, profitable growth," said Jon Rambeau, chief executive officer of Karman Space & Defense. "Karman will benefit from Doug's strategic orientation, his decades of experience, and his relentless focus on rapid innovation and strong customer partnerships."

Former Merck and NASA Leaders Bring Strategic Expertise to SpaceMD Amid Rising Demand for its In-Space Pharmaceutical Development Capabilities

Redwire Corporation, a global leader in aerospace and defense technology solutions, announced it has appointed pioneering industry leaders Paul Reichert, former Principal Investigator at Merck Research Laboratories, and Niki Werkheiser, former Director of Technology Maturation at NASA's Space Technology Mission Directorate, to serve in strategic advisory roles at Space Microgravity Development LLC (SpaceMD), Redwire's venture company focused on leveraging the microgravity environment to create new innovations in biotech and other fields. Specifically, Reichert and Werkheiser will expand SpaceMD's leadership in space-enabled research and pharmaceutical innovation as it accelerates work with a

growing number of pharmaceutical customers and partners.

As Scientific Advisor, Reichert will shape SpaceMD's scientific and commercial roadmap by identifying promising drug candidates and supporting the development of an orbital research and manufacturing pipeline. In her role as SpaceMD's Strategic Advisor, Werkheiser will work closely with the SpaceMD team and biotech partners to develop new therapeutic concepts and establish new opportunities to apply SpaceMD technologies to pharmaceutical research on the International Space Station (ISS) and emerging commercial platforms.

"SpaceMD's mission is to unlock new pharmaceutical drugs through cutting-edge, space-based research. Bringing Paul and Niki onto our advisory team significantly advances that mission," said John Vellinger, CEO of SpaceMD. "Their unparalleled expertise in drug development and go-to-market strategy, biopharmaceutical research, and space technology will bolster the momentum already underway as SpaceMD continues to lead the industry in in-space pharmaceutical research."

While at Merck, Reichert played a key role in advancing the company's research pipeline. Notably, he contributed to the early formulation and crystallization

research of pembrolizumab—the active ingredient in Keytruda, a breakthrough immunotherapy used to treat multiple cancers. Reichert's work at Merck and Schering-Plough has helped shape the pharmaceutical industry's understanding of molecular behavior, formulation challenges, and drug development pathways.

Spire Global Appoints Eric Mellinger as Chief Commercial Officer

Spire Global, a global provider of space-based data, analytics and space services, has appointed Eric ("Mell") Mellinger as its Chief Commercial Officer, effective August 3, 2026.

As Chief Commercial Officer, Mr. Mellinger will lead Spire's global commercial organization, overseeing the Company's go-to-market strategy, business development, sales, strategic partnerships, and customer growth initiatives. He will focus on expanding Spire's presence across government and commercial markets while driving the execution of the Company's long-term commercial strategy.

Mr. Mellinger joins Spire from Mantech International Corporation ("MANTECH"), where he served as Vice President for

Business Development & Growth Leader, Defense & Space Sector. In that role, he led a team that grew an annual business pipeline exceeding \$4 billion across U.S. defense markets, driving strategic account planning and market development that contributed to over \$2.5 billion in contract awards and double-digit year-over-year revenue growth. He also played a key role in evolving MANTECH's go-to-market strategy through partnerships with leading technology companies including Anduril, AWS, Google, IBM, Microsoft, Oracle, Palantir, and SpaceX. In addition to leading domestic growth, Mr. Mellinger helped expand MANTECH's support for U.S. government missions across the Indo-Pacific, Europe, the Middle East, and Central and South America.

"As demand for space-based intelligence continues to grow across government and commercial markets, we're focused on expanding our reach while deepening the value we deliver to customers," said Theresa Condor, Chief Executive Officer of Spire Global. "Mell has an exceptional track record of turning strategy into execution, building strong customer relationships, entering new markets, and leading organizations that consistently deliver growth. His leadership will be instrumental as we continue to scale Spire's commercial business and execute on our long-term vision."



STARTUP SPOTLIGHT

Why U.S. is falling behind China in commercial earth observation sector



The year was 2015, and New York University professor Debra Laefer sat at her desk in Brooklyn reviewing yet another stack of research papers on remote sensing. As she scanned the authors' affiliations, she paused, the same journals that once overflowed with names from American universities and Nasa labs had begun to publish discoveries from Beijing, Wuhan and Shanghai. Over the next few years, the drips became a wave and then a tsunami. Back in the 1990s, the United States dominated remote sensing just as Silicon Valley dominates software today producing nearly 90 per cent of all research in the field, while papers from China were virtually nonexistent.

But by 2023, China accounted for close to half of all remote sensing papers published globally, while the US share had shrunk to under 10 per cent. The shift represents one of the most significant recent changes in global technological leadership, according to Laefer, a professor at the New York University Tandon School of Engineering and a faculty member at the university's Centre for Urban Science + Progress. She published her findings in the journal Geomatics. Remote sensing technology is the science of collecting information remotely through techniques such as laser scanning, imaging and hyperspectral

imaging from ground, aerial, and even space platforms. It supports a range of critical applications, from autonomous driving to climate monitoring and national security. While it might be too far a stretch to say that the Intelligence Community is now embracing foreign-owned commercial remote sensing providers, there definitely is a shift underway in the willingness to acquire and use imagery produced by non-US satellite operators. A study done by the National Geospatial Intelligence Agency NSA in its Olympic Games for remote sensing providers, twiggd leaders

Today, US Congress is weighing reductions to the National Reconnaissance Office's budget for acquiring commercial satellite imagery, a move that could ultimately give China an edge in the influence domain and on the battlefield. The cut could slow growth and innovation at U.S. remote-sensing companies, at a time when China's own burgeoning satellite-imagery industry is aggressively seeking clients. Though European countries are unlikely to become reliant on Chinese imagery, the same cannot be said for governments in Africa, Asia, and Latin America. If Chinese companies can offer comparable imagery at lower cost, the profits could fuel innovation at a pace that U.S. firms struggle to match.

If the Beijing-3 is equipped with artificial intelligence, it can potentially observe up to 500 areas around the world with up to 100 revisits a day, they added, a US media reported. Still, the quality of the Beijing-3's imagery isn't sharp enough to rival American-developed satellites, such as the Worldview-4, which was built by Lockheed Martin and could capture images at a resolution of 12 inches per pixel. Beijing-3 can snap images with a resolution of 20 inches per pixel at best. But its researchers said the Chinese satellite's response time is around two to three times faster than that of Worldview-4 which was retired in 2019, less than three years after its 2016 launch, because of a failure in its stabilizing system. In just 42 seconds, the small Chinese satellite captured images of a large area around a US city that would be sharp enough to identify a military vehicle on the street and tell what type of weapon it might be carrying, say scientists reporting on the breakthrough. Most Earth observation satellites must be stable when taking images because attitude control mechanisms can produce vibrations that blur the images. But in this experiment on June 16, the Beijing-3 rolled and yawed wildly, the dramatic motion changing the angle of its camera's line of sight to the ground when flying over North America. The movement allowed it to capture a larger area than satellites have managed until now. 01:30

China's nimble Beijing-3 satellite does unprecedented rapid scan of San Francisco. The image, taken from an altitude of 500 kilometres (310 miles), had a resolution of 50 centimetres per pixel. The performance test over North America and other areas showed that the satellite could take images while its body was twisting at up to 10 degrees per second, a speed not seen on a satellite before. "As a community, we've begun to realize that there's a better way," Dave Gauthier, director of the National Geospatial-Intelligence Agency's (NGA) Commercial and Business Operations unit, told Breaking Defense recently. Speaking after his presentation to the annual GEOINT Symposium here in St. Louis, he noted that this happening across the membership if the IC's Commercial Space Council including the National Reconnaissance Office. "China started relatively late on agile satellite technology, but achieved a large number of breakthroughs in a short period of time," said project lead scientist Yang Fang and her colleagues of the DFH Satellite Company writing in a paper published in the domestic peer-reviewed journal Spacecraft Engineering this month. "The level of our technology has reached a world leading

position." Despite its small size and relatively low cost, Beijing-3 was deemed as the most nimble satellite and could be one of the most powerful Earth observation satellites ever built, according to Yang. A satellite in the lower orbit could usually observe a straight, narrow strip of area underneath it. It must circle the Earth multiple times or work with other satellites to cover a region of interest.

The report on Beijing-3 comes amid rising concerns in the US that China's space technology is growing at a breakneck pace. Gen. David Thompson, the vice chief of space operations in the US Space Force, said earlier this month that China could overtake the US in space capabilities by 2030. "The fact, that in essence, on average, they are building and fielding and updating their space capabilities at twice the rate we are means that very soon, if we don't start accelerating our development and delivery capabilities, they will exceed us," Thompson said, according to report.

That could leave U.S. adversaries in control of how the world perceives developing conflicts, warned Kari Bingen, director of the Aerospace Security Project at the Center for Strategic and International Studies and former deputy defense undersecretary for intelligence.

"If Chinese companies end up leading in this area, they would be positioned to become the partner of choice, to undercut US companies in the global marketplace, and ultimately could control the narrative of what happens on Earth," Bingen said.

AUS response to threats? "On February 23, 2022, instead of Western companies publicly releasing imagery of the buildup of Russian forces along the Ukrainian border and marrying that with intelligence on what we anticipated imagine if those images and that narrative had come from China?"

The Trump administration is weighing a proposal to reduce funding for NRO's electro-optical commercial later program from \$300 million a year to \$200 million, news media has reported first reported. And NRO requested no funding for its commercial radar program in 2026, despite expectations that it would ask for about \$30 million, according to industry and congressional sources.

NRO usually doesn't prioritize requests for commercial because officials know Congress will add money there through the appropriations process, according to one congressional staffer.

So it's likely but not certain that lawmakers will add back the funding this year. But the staffer warned that this year's budget will be "really, really tough," and likely involve major cuts, since the administration is banking on

the passage of the reconciliation bill to fund the Defense Department.

The EOCL contract is a 10-year program worth almost \$4 billion, with Maxar holding the largest share, and BlackSky and Planet Labs holding pie of the share of the deal. If the proposed 30 percent cut is spread equally between all vendors, it could be "catastrophic" for Maxar, because the company heavily relies on NRO for revenue, the staffer said. But if NRO opts to fully fund Maxar, BlackSky and Planet would bear the brunt of the reduction.

The proposed EOCL cut was first brought up publicly by Rep. Seth Moulton, D-Mass., during a May 14 hearing at which he cited a "rumor" that NRO had slashed commercial imagery funding lines in the 2026 budget, at the direction of OMB.

NRO director Chris Scolese didn't confirm or deny the rumor during the hearing, but said, "We very much value the commercial capabilities, and intend to keep on using those." Asked about Scolese's remarks, a spokesperson for NRO declined to comment and said the specifics of the NRO budget are protected.

One industry executive described the proposed cuts as not only "reprehensible," but also unexpected, since President Trump released an executive order directing the Defense Department to use commercial solutions wherever possible.

Other executives argued that the move further proves the government isn't a reliable partner to industry, especially since companies have been scaling up their offerings in response to previous government encouragement to expand commercial. The cut likely wouldn't be fatal, the executive said, but companies are relying on Congress to "do the right thing" and add the money back to the budget.

The future narrative of conflict China's Jilin-1 satellite constellation, operated by Chang Guang Satellite Technology Co., has emerged as a central instrument for observing the evolving U.S.–Iran conflict, enabling near-continuous surveillance of military operations across the Middle East through a network designed specifically for high-frequency Earth observation.

The constellation's scale allows Chinese analysts to conduct persistent stare monitoring, meaning satellite passes occur frequently enough to reconstruct operational timelines that capture changes in American force posture, aircraft activity, and logistics movements during active military campaigns.

Satellite imagery released by Chinese firms and related analytic platforms has revealed detailed views of U.S. F-22 fighter deployments at airbases such as Ovda in Israel and Al Udeid in Qatar, providing visual confirmation of the distribution of advanced stealth aircraft during the opening phases of the conflict.

Additional imagery has also captured the movements of major U.S. naval assets including the aircraft carrier USS Gerald R. Ford, demonstrating the ability of the Jilin-1 network to

monitor maritime force projection in real time as carrier strike groups reposition within the region.

'The escalation of the U.S.–Iran conflict following coordinated American and Israeli strikes under Operation Epic Fury has unexpectedly transformed the Middle East battlefield into a strategic intelligence laboratory for Beijing, as China's expansive Jilin-1 Earth-observation satellite constellation systematically records U.S. operational behaviour, creating a data archive that analysts believe could influence People's Liberation Army (PLA) doctrine for decades.

Evidence emerging from recent imagery releases and analytical reports indicates that the Jilin-1 constellation operated by Chang Guang Satellite Technology Co. CGST has been observing key elements of the conflict including strike patterns, aircraft deployments, missile trajectories, and logistics cycles turning the unfolding confrontation between Washington and Tehran into a near-real-time dataset of American warfighting tactics.

The strategic stakes of this surveillance effort intensified after U.S. officials, including Deputy National Security Adviser Jon Finer, publicly accused China of enabling Iranian attacks by providing intelligence derived from commercial satellite monitoring, allegations Beijing rejects by arguing that the imagery collected by Chinese firms represents commercial Earth-observation activity rather than military cooperation.

High-resolution commercial satellite imagery released by China's MizarVision has revealed the operational deployment of MIM-104F Patriot PAC-3 surface-to-air missile systems alongside F-16 multirole fighters at Shaikh Isa Air Base in Bahrain.

Despite those denials, the density and responsiveness of the Jilin-1 satellite network have created unprecedented observation coverage of U.S. military activity across the Middle East, allowing analysts to reconstruct operational timelines that reveal how American airpower, missile defense, and logistical networks function during high-intensity regional warfare.

This evolving situation has also highlighted a structural shift in global intelligence competition, as the availability of commercial high-resolution satellite imagery allows both state actors and non-state observers to monitor sensitive military deployments once concealed by classified reconnaissance platforms. For China's strategic planners, the ongoing U.S.–Iran confrontation therefore offers a rare opportunity to observe American operational tempo, force posture, and logistics architecture, generating insights that could shape future anti-access, area-denial strategies in potential Indo-Pacific conflict scenarios.

The fact that Ukraine remains a sovereign nation is due in part to the release of commercial satellite images showing Russian forces massing on its borders in February 2022. The decision to share those images helped the United States persuade allies and much of the world to disregard Moscow's claims that it had no intention of invading, and contributed to a coordinated response from allied governments, which quickly

SPECIAL REPORT

mobilized military aid and imposed economic sanctions against Russia, said David Gauthier, who led commercial operations at the National Geospatial-Intelligence Agency at the time.

The NGA worked alongside the NRO to ensure that imagery and related data were available: The NRO procured the images, while Gauthier oversaw the acquisition of analysis and other data. "We actually worked pretty well together to instill long-term vision in industry that the government would be a good customer in this effort," Gauthier said.

Newer space-based capabilities like synthetic aperture radar, or SAR also helped Ukraine monitor Russian forces, providing intelligence despite cloud cover and concealment, such as what Russia used during 2021 military exercises. "The Ukrainians could use that radar imagery to understand convoy movements at night and track Russian tanks under clouds," Gauthier said. "They could use that to defend themselves better and maybe pre-position their forces to be better at defending their homeland from this invasion."

U.S. military leaders, along with partner militaries, are asking for such capabilities more and more frequently, said Dan Smoot, CEO of Maxar, during a panel at the Special Competitive Studies Project's AI forum on Tuesday. "There is an increased demand. Unfortunately, the world has got geopolitical challenges right now," Smoot said. Asked about potential budget changes, Smoot pointed to rising demand from European governments that could help fill the gap. "We've seen a lot more countries lean in really driving their own capabilities," he said. "We're seeing the European Union really step into wanting to have their own intel and defense capabilities at this point."

That push is driving new partnerships, such as one announced recently between Maxar and Saab aimed at enabling satellite imagery collection even under conditions where GPS is jammed or denied. Still, Gauthier cautioned that European enthusiasm won't immediately replace the U.S. government's central role. "The U.S. government is the single largest customer for this data in the world," he said. "So you can never discount the fact that the biggest customer plays the biggest role in the fate of these companies." And while NATO member states are eager to build sovereign satellite imagery capabilities, their budgets remain limited, said Tomáš Hrozensky, a senior researcher at the European Space Policy Institute. "Europe is investing 0.07% of its GDP or about €14 billion per year in space activities, almost exclusively in the civil domain," Hrozensky told **Defense One**. "The U.S. is investing 0.24% of its GDP, via NASA and the defense sector on comparable levels."

Bingen said U.S. export controls especially International Traffic in Arms Regulations make American companies less competitive globally. "While international markets are a growth area providing commercial space capabilities to allies and partners, our companies are hampered by restrictions, especially SAR and radio frequency providers, that reduce their competitiveness," Bingen said. "So it's a double whammy to our commercial companies."

A European defense official speaking on background

said NATO member nations are urgently discussing how to build a more autonomous commercial imagery sector. That discussion is expected to feature prominently at the upcoming NATO summit later this month. But for now, Europe remains reliant on U.S.-based commercial satellite imagery providers.

And a March decision by the White House to temporarily paused intelligence sharing with Ukraine and prevent NATO allies from redistributing data purchased from U.S. commercial firms has eroded trust, the official said. "All of these relationships between all these nations are built on trust, and we cannot deny that there has been a breach of that trust," they said.

Commercial Satellite Olympics

"The stakes are high. Should any one country dominate the commercial remote sensing market, not only could it gain economic advantages, but it would also control the information narrative about the entire planet, from the environment to natural resources to human conflict," the report concluded.

Most notable in the Earth Observation categories is China's rise to gold in EO imaging capability, with its SuperView Neo-1 system, launched in 2022, offering a commercial product that combines high-resolution imagery with the largest constellation collection capacity.

On February 27, 2025, the SuperView Neo-1 03 and 04 satellites were successfully launched with two satellite aboard a Long March 2C rocket from the Jiuquan Satellite Launch Center. Becoming the highest-resolution and most geometrically precise commercial optical satellites in China, the successful launch of SuperView Neo-1 03 and 04 signifies a significant breakthrough in the country's commercial high-resolution remote sensing sector.

Operating at an altitude of 500 kilometers in a sun-synchronous orbit, SuperView Neo-1 03 and 04 feature ultra-high-resolution imaging, ultra-agile control, and exceptional positioning accuracy, achieving performance levels that meet international standards for commercial satellites. For ultra-high-resolution imaging, the satellites employ a unique "dynamic-static separation" dual-ultra technology developed by SAST, utilizing a large-aperture optical camera magnetically suspended above the satellite platform.

A new assessment of global commercial remote sensing satellite systems shows that Chinese firms are edging out US commercial firms in capabilities across a broad range of sensor technologies.

The study produced a "Top 3" ranking of the world's best commercial space-based remote sensing systems in 2024 framed as a mock Olympic Games. China grabbed the "gold medal" in five areas; the US in four. One company each from Finland and South Korea also nabbed gold.

China now leads the world in five out of 11 satellite remote sensing performance categories, with the US leading in four. The study is a follow-up to research published in 2021 by the US National Geospatial-Intelligence Agency (NGA), which became known as the 'Commercial Imaging Olympics'. In that research, the NGA revealed that the US and China each won

'gold' in three of nine performance categories.

"While the United States has long been the global leader in space, the 2024 medal winners spotlight the continued advancement of China's remote sensing capabilities and the expansion of its commercial space sector," the report found. "Those China flags matter," said Robert Cardillo, former director of the National Geospatial-Intelligence Agency (NGA), during a CSIS seminar to debut the report. "We're in a competition. It's not a secret, okay? It's an open competition, and as any world competition, state competitors are going to use everything at their wherewithal to create their advantage. So we should take it also as a warning that this game is afoot."

China's dominance in some fields, like long-wave infrared and C-Band SAR, reflects the existence of existing civil systems in the US that likely precluded commercial efforts. Future US LWIR providers Albedo Space and Muon Space are expected to launch new spacecraft in 2025.

The authors used 11 performance categories and open source information to assess company capabilities across the remote sensing technology landscape, including electro-optical (EO), synthetic aperture radar (SAR), and infrared (IR) sensors, the report explained. The assessment also included parameters relevant to each of those sensor categories, such as "spatial resolution, spectral resolution, number of imaging bands, and the number of operational satellites (or persistence of imaging), among others."

China's Jilin-1 EO systems hold the top spot in EO revisit, owing to its large constellation of over 180 operational satellites in orbit. In the EO video category, the latest generation U.S. SkySat system earns gold when accounting for its enhanced product offerings tied to frame rate, dwell time, and spatial resolution. While not on the podium due to its products not being available on the commercial market, Japan's CE-SAT-1E system, operated by Canon Electronics, receives an honorable mention for its high frame rate performance and innovative design.

Jilin-1 is China's first, self-developed, commercial remote sensing satellite system and is operated by the Chang Guang Satellite Technology Corporation (CGSTC). The Jilin-1 satellite constellation is the core project and will eventually be composed of 138 remote sensing satellites covering high resolution, large swath width, video, and multi-spectrum, and a high revisit commercial service. As of the beginning of 2020, CGSTC has successfully launched 73 Jilin-1 satellites into space. The completed Jilin-1 constellation will be able to visit any place in the world 15 to 17 times per day, with the ability to update a global map every year and a national map five times per year. It can provide "high-quality remote sensing information and product services for agricultural and forestry production, environmental monitoring, smart city, geographical mapping, land planning and other fields".

A noteworthy trend is a growing group of EO constellations offering sub 1-meter imagery at

higher revisit rates. One such example is the U.S. BlackSky Global constellation that, while not on this year's podium, will be one to watch as it and other constellations optimize different performance parameters to increase the value of remote sensing to end users.

However, the multispectral and hyperspectral podiums tell two different stories. In multispectral, China's SuperView Neo-3 received the gold medal, but the competition in this category was tight. All three podium winners appear to offer similar capabilities, with China's Siwei and the second-place finisher, U.S./Uruguay Satellogic, both launching their top performers in the last two years.

Hyperspectral capability was a category that, in NGA's 2021 assessment, showed no competitive U.S. system. In 2024, a U.S. system is now atop the podium with GHOSat satellites developed and operated by the U.S. company Orbital Sidekick.

And an Indian system, Pixxel, is in receipt of the silver medal. Performance parameters for hyperspectral systems can often be in tension, making direct comparisons challenging. Some systems are designed for higher spatial resolution to aid in discovering smaller targets while others are optimized for finer spectral resolution to characterize specific materials and hydrocarbons and find them over larger areas. In future iterations of this analysis, it will likely be appropriate to separate hyperspectral systems into two unique categories.

Across the infra-red remote sensing categories, short-wave infrared appears largely unchanged from NGA's 2021 rankings. WorldView-3 remains the leader, driven by its resolution performance, as many U.S. companies have shied away from SWIR offerings due to long-standing regulatory restrictions. While not reflected on the podium, several countries have or are developing commercial short-wave infrared systems that could alter these results within the year.

In contrast, fewer companies are pursuing mid-wave infrared remote sensing systems. The South Korean KOMPSAT-3A, a system launched in 2015 was then and still sits now atop the podium. Chinese systems launched in 2018 and 2019 took silver and bronze, respectively, with lower resolution offerings than KOMPSAT-3A. Despite a smaller competitive pool at present, there are mid waves infra red efforts by British, German, and U.S. companies worth watching.

In the category of long-wave infrared, Chinese commercial systems are dominant. Much of the utility of long-wave infrared remote sensing is in applications such as climate change, agriculture, and wildfire monitoring. Changes to U.S. regulatory restrictions on infrared imaging will enable U.S. companies to test this commercial market, with two U.S. companies planning to launch systems in 2025 capable of imaging in the LWIR spectral range: Albedo Space and Muon Space. Both could be future medal contenders.

Meanwhile, Chinese companies moved up the podium in Earth Observation imaging and



multispectral capabilities, and they hold dominant positions in LWIR and C-band SAR. The authors cannot definitively explain China's dominance and the absence of U.S. or other Western commercial entrants.

However, space-based remote sensing using C-band SAR and LWIR instruments for environmental and scientific applications has long been a core competency of Western civil space agencies, such as NOAA's Geostationary Operational Environmental Satellite weather satellites and the European Commission-European Space Agency Copernicus initiative, with fewer commercial market opportunities. However, key development during the event is the progress by U.S. companies like Albedo Space and Muon Space, and their ability to disrupt the infra-red results.

SAR X-band imaging performance saw a complete shake-up, with the three medalists being all new systems U.S. Umbra SAR gold, U.S. Capella Space Acadia silver, and Finnish ICEYE Generation 3 bronze. Similarly, the same three companies were top performers in SAR revisit, with ICEYE outpacing the competition due to its larger constellation size. Capella Space is a U.S. satellite manufacturer and Earth observation company and the first

American company to bring commercial SAR data to the broader market. Founded in 2016, Capella Space's Synthetic Aperture Radar SAR satellites enable the company to deliver the highest quality, high resolution SAR that are commercially available with the fastest order-to-delivery time, empowering organizations across the public and private sector to make informed, accurate decisions.

The Capella constellation has grown to 9 small satellites by the end of 2023. The first satellite of the Capella constellation launched in 2018. As of 2024 10 more satellites have been launched, with at least five more planned. 40) The radars are single polarization X-band systems, capable of operating at 500 - 700 MHz bandwidth in stripmap, spotlight, and sliding spotlight imaging modes.

While Chinese firms have made less progress in X-band SAR, they lead the pack in C-band SAR. C-band SAR provides lower-resolution radar imagery over larger areas and is particularly useful for environmental analysis, including global mapping, landform changes, and ocean monitoring. The aging Canadian RADARSAT-2 satellite earned a bronze medal and its follow-on system, the CHORUS-C satellite from MDA Space, is expected to compete favorably in future

rankings. It is worth noting that all commercial SAR companies will approach a resolution limit based on spectrum constraints set by the International Telecommunication Union.

Umbra, a vertically integrated space technology company operating the world's highest resolution commercial Synthetic Aperture Radar (SAR) satellites, was ranked first for its SAR data quality globally and second for SAR persistence. These achievements present a unique opportunity for Umbra to further establish the United States as a global leader in remote sensing and to ensure the world's investments come to the U.S. to advance American innovation.

Inspired by the U.S. National Geospatial-Intelligence Agency's (NGA) 2021 report comparing the performance of commercial satellite imaging systems, the recent rankings provides an independent assessment of global commercial remote sensing systems. The report takes an "Olympics-style" approach, ranking the top three systems across several performance categories. The 2024 report focuses primarily on advances in U.S. and Chinese remote sensing systems. Of the 11 performance categories, Chinese systems

took gold in five, U.S. systems in four, and Finland and South Korea each secured one gold medal.

"Winning a gold medal for SAR data quality, along with a silver medal for SAR persistence, highlights not only the strength of our systems but also the potential for America to reclaim its leadership in the global remote sensing market," said Todd Master, COO of Umbra. "With the right financial and regulatory support, U.S. companies like Umbra can retain their dominant position on the world stage. I encourage the U.S. Government to ensure that regulatory policies are crafted to keep pace with the speed of global innovation and to drive long-term success in capitalizing on the benefits of commercial remote sensing capabilities."

Since its founding in 2015, Umbra has established itself as a leader in remote sensing by offering breakthrough SAR imaging technology and patented satellite solutions. With its ability to provide all-weather, day-and-night monitoring, Umbra continues to set new standards in reliability, precision, and intelligence gathering enabling both government and commercial customers to achieve mission success.

SATCOM on the move market size and prospects

Flat-panel satellite antenna company, Kymeta recently announced that the Osprey u8 HGL, a hybrid geostationary and low Earth orbit terminal purpose-built for military users, is shipping out of their facility in Woodinville, Washington.

This marks the first commercially available multi-orbit terminal and the first multi-orbit terminal on Eutelsat OneWeb's LEO network. Kymeta announced the official launch in October last year and is fulfilling a backlog of orders.

SATCOM on the Move refers to satellite communication systems designed to provide continuous broadband connectivity to users and platforms in motion such as aircraft, naval vessels, ground vehicles, and unmanned systems. These systems integrate advanced antennas, modems, and tracking mechanisms that maintain stable links with satellites even during high-speed or dynamic movement across terrains and airspaces.

In 2024, the Kymeta team demonstrated in the field the capabilities of the new Osprey u8 HGL delivering resilient, auto-PACE ready communications for the armed forces to meet the demands of challenging and rugged military environments. The multi-orbit, multi-network capabilities of the Osprey u8 HGL terminal will offer even greater availability, while being durable, low power consuming, having low visibility, and easy to use

The emergence of multi-orbit architectures combining LEO, MEO, and GEO satellite networks presents a major growth opportunity. These hybrid systems allow seamless switching between orbits to maintain optimal connectivity, enabling enhanced resilience and global coverage. However, partnerships between satellite operators and equipment manufacturers are fostering the development of interoperable terminals capable of leveraging multiple frequency bands and network types. In addition, deployment of advanced, multi-orbit terminals that maintain robust, high-throughput communications for mobile military and defense platforms is expected to present significant opportunities.

For instance, in October 2025, Kymeta's Osprey u8 terminal leverages electronically steered flat-panel antennas to provide seamless multi-orbit connectivity across GEO, MEO, and LEO satellites, ensuring uninterrupted communications for mobile units. This multi-orbit approach addresses the U.S. Army's need for flexible, resilient, and low-latency satellite links in dynamic, on-the-move environments.

Initial feedback was overwhelmingly positive, with one military member stating: "This is everything we've been looking for in a terminal, form function and features. The LEO to GEO switching far exceeded our expectations. It's amazing that Kymeta is already delivering on the community's urgent need for multi-orbit SATCOM."

Others in attendance at Army field demonstrations commented, "I cannot wait to get started with these!" and "Wow! It tracks satellites over some very difficult terrain."

Based on application, the market is segmented into Command and Control (C2), Intelligence, Surveillance and Reconnaissance (ISR), situational awareness and navigation support, disaster response, remote operations and asset monitoring, and commercial mobility & in-transit connectivity. The Ku Band segment is expected to lead the market, contributing 37.15% globally in 2026.

The Command and Control (C2) segment accounted for the largest share in 2024, driven by continuous demand from defense organizations for secure, real-time communication links in mission-critical operations. SOTM systems enable high-speed data and video transfer between mobile command posts, ground vehicles, and airborne platforms.

In October 2025, OneWeb unveiled a lightweight, 9kg man-portable satellite antenna terminal designed as a backpack-sized solution to enhance the Indian Army's tactical communications by providing high-speed, low-latency connectivity up to 195 Mbps download via its LEO satellite constellation.

The global market is driven by the rising demand for uninterrupted, high-speed connectivity for defense, commercial, and emergency response operations across land, air, and sea platforms. The increasing need for real-time situational awareness, command and control capabilities, and autonomous mission operations is accelerating the adoption of mobile satellite communication solutions. Market growth is further fueled by the integration of multi-orbit satellite networks, AI-enabled network management, and the expansion of 5G non-terrestrial network capabilities that deliver resilient, low-latency communication links for users in motion.

The Ku-band segment captured the largest share in 2024, owing to its well-established ecosystem, wide coverage, and cost-effective bandwidth capabilities. It remains the preferred frequency for mobile connectivity across airborne, maritime, and land-based platforms.

The hardware segment held the largest share in 2024, owing to the high demand for terminals, antennas, and modems that enable mobile connectivity across dynamic operational environments. The growing deployment of flat-panel, electronically steered antennas (ESA) and multi-band terminals for land, air, and maritime applications has reinforced hardware's dominance in the SOTM ecosystem. The Hardware segment is projected to dominate the

market with a share of 52.61% in 2026.

A key trend shaping the SATCOM on the Move landscape is the integration of artificial intelligence (AI) and digital twin technologies for autonomous network management and predictive maintenance. AI algorithms enable real-time traffic routing, adaptive beam forming, and link optimization to enhance reliability and bandwidth efficiency.

Meanwhile, digital twin simulations are being used to model system performance across varying terrains and orbits, reducing downtime and improving deployment accuracy. This shift toward intelligent, self-managing communication networks marks a pivotal step in the modernization of global mobile satellite communication infrastructure.

"The Kymeta Osprey u8 has a unique capability to address government requirements in support of government PACE plans," says Ian Canning, Chief Operating Officer, OneWeb Technologies. "The Osprey supports multi-network/orbit requirements through the concurrent LTE/satellite configuration with the added benefit of now being able to add OneWeb LEO capabilities."

"In the contemporary military landscape, mobile connectivity has become indispensable for achieving success," says Jon Osler, Senior Vice President Global Sales and Services of Kymeta.

"Unlike any other sector, the military relies heavily on dependable, adaptable, and resilient on-the-go communication systems to fulfill its operational and training needs. We take pride in our longstanding partnership with the military, delivering cutting-edge solutions that meet and exceed expectations."

Rising demand for real-time, mission-critical connectivity

The global SATCOM on the Move market size was valued at USD 40.4 billion in 2025 is projected to grow from USD 46.1 billion in 2026 to USD 125.30 billion by 2034, exhibiting a CAGR of 13.30% during the forecast period. North America dominated the satcom on the move market with a market share of 39.20% in 2025.

Government defense agencies and space regulators are driving the establishment of interoperability standards, frequency coordination policies, and cybersecurity frameworks for secure mobile satellite communications. These regulatory initiatives ensure resilience and operational reliability for defense and military, emergency response, and critical mission applications.

Leading industry players such as Viasat Inc.,

Thales Group, L3Harris Technologies, Collins Aerospace, and Honeywell Aerospace are spearheading the development of compact, high-throughput SOTM terminals and hybrid SATCOM architectures that integrate with next-generation constellations such as Starlink, OneWeb, and SES O3b mPOWER.

In parallel, satellite operators including SES, Eutelsat Group, and Iridium Communications are expanding mobile coverage and bandwidth capacity to support real-time command, control, and data transmission for both defense and commercial platforms. The convergence of high-capacity satellite networks with AI-driven network management and low-latency communication protocols is accelerating the evolution of SATCOM on the Move capabilities.

The land segment accounted for the largest share of the market in 2024, driven by the extensive use of mobile satellite communication systems in defense ground vehicles, armored fleets, and command centers. Defense forces across major economies are integrating ruggedized SATCOM terminals and electronically steered antennas on vehicles to ensure uninterrupted command, control, and data exchange in dynamic operational environments. The Land segment is projected to dominate the market with a share of 50.08% in 2026.

However, the growing need for uninterrupted, high-speed communication across defense, emergency, and commercial mobility platforms is a major driver for SATCOM on the Move market. Armed forces, first responders, and logistics operators increasingly depend on real-time situational awareness and command capabilities that require continuous broadband connectivity even in remote or contested regions.

The deployment of new low Earth orbit (LEO) constellations and high-throughput satellites (HTS) is further enabling resilient, low-latency communications, strengthening the value proposition of SOTM systems for modern operations. Moreover, there is a rise in the expansion of uninterrupted 5G connectivity for mobile platforms such as aircraft, ships, and vehicles through low-latency LEO links.

In December 2024, ESA and Telesat achieved the world's first direct 5G Non-Terrestrial Network (NTN) connection with a Low Earth Orbit satellite using Ka-band, demonstrating real-time mobile connectivity through space. This development enables standardized 5G access via satellites for applications such as telehealth, autonomous transport, and in-flight broadband.

Despite growing adoption, the high initial investment associated with SOTM terminals, advanced antennas, and satellite bandwidth remains a key restraint. The integration of these systems into diverse vehicle architectures ranging from armored ground vehicles to naval platforms and aircraft often involves extensive certification, customization, and maintenance requirements. This complexity increases total

ownership costs and limits uptake, particularly among smaller defense forces and commercial fleet operators.

Satellite Communications for the Army's NGC2 Pilot

The US Army has chosen Kymeta's Osprey u8 terminal as its multi-orbit satellite communications system for the Next Generation Command and Control (NGC2) pilot program. The NGC2 initiative aims to modernize the army's command and control infrastructure by integrating advanced technologies to enhance operational effectiveness.

Kymeta's Osprey u8 connects to both geostationary and low Earth orbit satellites. It is designed for rapid deployment and flexible use, featuring a modular architecture that can be reconfigured for different missions. Its smart tracking capability maintains stable connectivity in challenging environments.

The decision to adopt the technology follows successful evaluations in several major army exercises, including Armored Formation Network On The Move, the Network Modernization Experiment, and Project Convergence Capstone.

Selected for its battle-proven capabilities and easy-to-use features, Kymeta terminals offer full-duplex data transport, meaning they can receive and transmit from a single aperture. The Osprey u8 provides multi-orbit connectivity across both geostationary orbit (GEO) and low Earth orbit (LEO) satellite constellations, featuring a modular, cartridge-based system designed for rapid adaptation to evolving mission profiles.

By supporting multiple data pathways, including commercial and government networks, the terminal minimizes dependency on any single source, prioritizing secure interoperability and operational continuity, even in degraded or contested conditions, making it a valuable asset for mission-critical applications.

Kymeta Chief Revenue Officer Tom Jackson, a retired US Marine lieutenant colonel, said that the company's manufacturing approach is "the exact type of innovation the US Army is looking for when it seeks new technologies from the commercial market to integrate into its existing capabilities."

"While today's mobile forces operating in remote environments may have communication access through a traditional very small aperture terminal (VSAT) or legacy COTM terminals, they do not have access to the high-throughput LEO constellations," said Rob Weitendorf, vice president, business development, Kymeta. "The u8 provides the needed capacity and seamless



connectivity between LEO and GEO satellites. We could not be more thrilled with the excitement our demo received from the Special Forces community at the event."

The U.S. Army's NGC2 pilot underscores the importance for dispersed teams to stay mobile in increasingly data-centric operations. Kymeta's unique technology based on metamaterials and software-defined features, such as proprietary pointing and tracking, enables superior performance and efficiency for communications on-the-move (COTM) and over the horizon, increasing the ability for forces to maneuver and remain survivable on the battlefield.

Another critical advantage of Kymeta's cutting-edge technology is its significantly lower power consumption compared to similar solutions across the industry. This makes it a perfect platform for COTM and contributes to its reduced thermal signature relative to competing technologies. This reduced thermal output combined with other Low Probability of Detection and Intercept (LPD/LPI) features, such as low profile and narrower beamwidth, allow the Osprey u8 to become less detectable when operating in hostile environments.

Tom Jackson, EVP Kymeta, Chief Revenue Officer and retired U.S. Marine Corps Lieutenant

Colonel, said that Kymeta's technological advantages over competitor terminals is derived from its metamaterials-based architecture.

"These advantages are rooted in our metamaterials-based architecture, which enables us to create terminals that use less power than others on the market. Other terminal manufacturers can try to engineer around this, but they can't replicate the technology that sits at the core of our product line," Jackson said. "This approach to manufacturing is the exact type of innovation the U.S. Army is looking for when it seeks new technologies from the commercial market to integrate into its existing capabilities which enables us to create terminals that use less power than others on the market.

Other terminal manufacturers can try to engineer around this, but they can't replicate the technology that sits at the core of our product line. This approach to manufacturing is the exact type of innovation the U.S. Army is looking for when it seeks new technologies from the commercial market to integrate into its existing capabilities."

"My experiences in the military equipped me with a crystal-clear perspective on how critical resilient, secure communications are to mission success," Jackson added. "When operating in unpredictable, high-stakes environments, modern units can't afford downtime, complexity, or systems that give

away their position. This move from the U.S. Army is a clear indication that they recognize that network resiliency is no longer a nice-to-have, it is an absolute necessity."

U.S. Army assessments including 'Armored Formation Network On The Move,' 'Network Modernization Experiment (NETMODX),' and 'Project Convergence Capstone' were critical in informing their decision to select Kymeta's technology.

The Middle East & Africa region captured 10.40% of the global market in 2025, generating USD 2.08 Billion in revenue, and is projected to reach USD 2.33 Billion in 2026. The Middle East & Africa (MEA) region is poised for notable growth due to increasing investments in defense communication infrastructure, homeland security modernization, and smart mobility systems.

The UAE, Saudi Arabia, Israel, South Africa and recently Nigeria are actively integrating advanced SOTM systems for land and air platforms to enable real-time command and control. Ongoing defense cooperation programs, coupled with the expansion of commercial mobile satellite services for oil and gas and transport industries, are expected to drive sustained market growth in the MEA region.



STARTUP SPOTLIGHT

ICEYE emerges as key supplier in Europe's shift toward imagery intelligence



tBetween 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 books2. 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 stage3, and the Kentucky River rose up to 14 feet above flood stage. 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. Today, Europeans are currently moving to improve their space-based capabilities. ICEYE, in particular, is becoming popular amongst European Nations. Poland, Portugal, Greece, The Netherlands, Sweden, Germany and Finland have all made agreements with the Finnish manufacturer to provide

Synthetic Aperture Radar (SAR) satellite capability for their respective armed forces.

As of 12th January 2018, the Finnish space industry company Iceye Ltd. launched its first satellite into orbit. ICEYE-X1, is space history's first synthetic aperture radar satellite weighing under 100kg. Two more satellites are planned to follow their initial proof of concept, later in 2018. The launch was a big milestone for the startup and their founders, that initially came out of the Finnish Aalto University and its startup accelerator.

According to the Finnish Business Information System, Iceye Ltd. was founded 16th of September 2014. This means they managed to plan, finance, build and launch a working proof of concept in less

than five years. The company's plan is to maintain a swarm of approximately 20 satellites from 2020.

The satellites will have the ability to send images in a near real-time flow. Applications based on this SAR data could be able to track ships, icebergs and analyse floods or forest damages. These planned applications are mainly intended for large organizations and governments. But, by harnessing the innovation potential of startups, other applications could be developed.

In July 2026, ICEYE successfully launched and deployed four new SAR satellites into orbit. Integrated via Exolaunch, the satellites lifted off on July 7, 2026, aboard the Transporter-17 rideshare mission with SpaceX from Vandenberg Space Force

Base, California. Each spacecraft has established communication, and routine commissioning operations are underway.

ICEYE has now successfully launched 76 satellites. This launch adds another fourth-generation (Gen4) SAR satellite to ICEYE's commercial constellation, while also delivering dedicated national missions satellites including those supported by ICEYE US and the Finnish Defence Forces' third satellite.

Gen4 delivers the world's highest-fidelity commercial SAR imagery and faster revisit over priority areas, with up to 16 cm resolution, a 400 km high-resolution field of regard, and more images per orbital pass for faster coverage of priority areas of interest. ICEYE's production rate is now doubling, from 50 satellites per year today to a target of 100 annually by 2027 and beyond, supported by a matching launch cadence.

ICEYE-built constellations are available as a fully sovereign capability, free from ITAR restrictions. ICEYE delivers the satellites as part of a complete, secure system that can be launched, deployed, and operational within 12 months, including ground segment, comprehensive training, and continuous software updates.

ICEYE recently delivered a fully operational sovereign space system to the Polish Armed Forces, from contract signing to operational capability in 12 months, among the fastest sovereign space deployments in history. The model is now being replicated across Europe, the Middle East, and Asia, and the pace is accelerating. Every sovereign system ICEYE deploys strengthens not only the nation that operates it but a broader network of intelligence. Seven governments to date across Europe have procured sovereign satellite systems from ICEYE, making it the leading provider of space-based intelligence.

For governments and commercial clients, ICEYE really has changed what is possible from Synthetic Aperture Radar (SAR) Earth observation. Its New Space approach has made it possible for clients to purchase one or more of the latest generation of ICEYE SAR satellites.

For the first time ever, ICEYE now makes it possible for governments and organizations to purchase one or more of their own ICEYE satellites rapidly delivered. This enables the company to image any location on Earth, day or night, with very high resolution, high frequency revisits, and at an affordable price. "We are the only organization in the world to offer high-precision SAR satellites for direct purchase", says the company's CEO.

Traditional SAR satellites are very large and carry very large antennas with limited revisit frequency and flexibility. ICEYE's small and agile SAR satellites are able to revisit the same location on Earth daily and even sub-daily, enabling a completely new level of change detection. ICEYE's large commercial constellation of SAR satellites now makes it possible for governments and commercial organizations to acquire data on any location on Earth, any time they need it, with very high resolution, high frequency revisits, and at an affordable price. A new era in SAR is being pioneered by ICEYE.

ICEYE has over 60,000 archive images covering locations around the world. The technical characteristics and global coverage of ICEYE products provide extremely valuable inputs for a variety of studies and application developments. The archive data used alongside new imagery is well-suited for things like change detection on the ground, the assessment of damages caused by natural catastrophes, and the monitoring of infrastructure integrity.

ICEYE has completely revolutionized the use of SAR Earth observation for governments and organizations, offering unprecedented access to critical and timely information on changes and activities. SAR provides highly accurate, reliable, and timely data for a variety of applications on land and at sea, day or night, and in any weather.

ICEYE operates and will continue to maintain the world's largest operational SAR satellite constellation, giving you unrivalled global access and revisit frequency measured in hours, not days or weeks. ICEYE's unique ability to make rapid technological advances designed to meet real operational needs has led to the creation of world-first capabilities like our Scan, Strip, Spot and Dwell modes, which provide images from 0.25 m resolution to 100 km in width and up to 84,000 km2 in area. This flexibility is not possible with other SAR NewSpace satellite designs.

Commercial satellite imaging market

The commercial satellite imaging market size is expected to see strong growth in the next few years. It will grow to \$8.36 billion in 2030 at a compound annual growth rate (CAGR) of 9.7%. The growth in the forecast period can be attributed to rising need for real-time and continuous earth observation data across sectors, increasing deployment of smallsat and cubesat imaging constellations, advancements in image analytics and AI-driven geospatial interpretation, growing adoption of satellite imaging for climate monitoring and sustainability applications, expansion of commercial services offering integrated imaging, data layering and bulk mapping capabilities.

Major trends in the forecast period include rising demand for ultra-high-resolution satellite imagery, increasing commercial use of multispectral and hyperspectral imaging, growing adoption of satellite data for disaster prediction and response, expansion of cloud-based satellite analytics platforms, increasing demand for satellite imaging in precision agriculture.

The increasing concerns with respect to national security are expected to propel the commercial satellite imaging market going forward. National security threats are any actions or events that pose a risk to the safety, stability and security of a nation or its citizens.

These threats can originate from a variety of sources, including foreign governments, terrorist organizations, or cyber-attacks on government agencies. Satellite imaging data plays a complementary role in preventing cyber-attacks on government agencies by providing valuable information for network monitoring, geolocation, early warning, response, and mitigation efforts. For instance, in November 2023, according to the 2023 ASD Cyber Threat Report by the Australian Signals Directorate, an Australia-based federal agency, during the 2022-23 financial year,

ReportCyber recorded nearly 94,000 reports of cybercrime, marking a 23% rise compared to the prior financial year. Therefore, the increasing concerns with respect to national security are driving the commercial satellite imaging market.

ICEYE's Sovereign Intelligence

ICEYE stands as a remarkable representation of Finnish innovation, reflecting a well-known Finnish strength: solving complex problems through practical engineering.

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.

Iceye nabs €1B at a €10B valuation amid growing demand for space intel

ICEYE, has closed just over €1 billion in growth funding. The round is led by General Atlantic with fellow Finnish company and industrial comms giant Nokia as an additional investor, among others. The round, a Series F, values Iceye at €10 billion and makes it one of the biggest tech startups in Europe.

The deal is coming on the heels of a very strong run for Iceye, and for space tech in general as part of larger communications and national defence strategies.

Its satellite tech is based on SAR (synthetic aperture radar), which is a system that uses microwave pulses that make it more effective in dark, cloudy and other conditions that would be more challenging for optical camera-based systems. Infrared is another variant on how satellites capture imagery. The company's intelligence, surveillance and reconnaissance software stack is called ISR Cell, and it's set up to work with ground stations and other earth-based systems.

As with other satellite startups in that space, the war in Ukraine pulled Iceye more squarely into defence use cases. That is because satellite is an important component of building more resilience communications systems, but it's also essential in helping to operate the new wave of defence tech that relies on GPS and other navigational tooling to work.

In Ukraine, Iceye says it has been used for strike planning and battlefield decisions on the frontlines of its war with Russia.

But the startup also has been seeing a lot of business coming out of that shift beyond Ukraine, as countries in Europe and elsewhere look to refresh their own defence posture and add more modern tooling into the mix. Satellite communications and intelligence have become cornerstones of defence systems, complementing and powering the data used by earth-based systems.

In line with that, countries across Europe and elsewhere have started to dedicate more investment to space. Germany, for example, in September 2025 announced it would pump €35 billion into space-based systems to bolster its military intelligence and reconnaissance Iceye has been one of the companies to benefit from Germany's push.

Iceye's pitch is that it gives countries the ability to build federated, sovereign communications, an especially hot topic these days as nations look for more resilient systems that are not inherently linked to and reliant on infrastructure and technology providers in other countries.

SPECIAL REPORT

Africa leaps ahead in technology transfer programs



In Africa, Morocco illustrates the potential cooperation between European and African space programmes. The country has become a key player in Africa's space ecosystem, boasting a sophisticated space programme, advanced ground infrastructure, and multiple satellites dedicated to Earth observation. One notable instance of collaboration was the International Conference on Micro and NanoSatellites, hosted by the KSF Space Foundation in Rabat, Morocco. The conference brought together delegates from 12 countries, including representatives from Morocco, Italy, Algeria, Egypt, and other nations and participants from renowned space organisations. Key themes of the conference focused on nano and micro-satellite architecture, guidance, navigation, control systems, and the potential for expanding African participation in space.

In February 2018, the Italian Space Agency co-organized the International Space Forum – African Chapter in Nairobi, which attracted high-level participants from twenty-nine African countries, including ministers, ambassadors, and heads of space agencies. This forum, held in collaboration with the International Astronautical Federation (IAF) and the Kenya Space Agency, was a major step in establishing a dialogue between Africa and Italy on space development.

In 2024, Italy hosted the Italy-Africa Space Conference and the Italy-Africa Summit, underscoring Italy's commitment to promoting partnerships with African nations. These events covered topics related to space education, technology transfer, and symbiotic partnerships between Italian

and African space organisations. Italian Minister of Foreign Affairs Antonio Tajani was prominent in advancing these dialogues, focusing on training, joint research, and mutual investments in space capabilities. At the 75th International Astronautical Congress (IAC) in October 2024, 12 African SMEs and startups were invited to showcase their innovations to an international audience of over 11,000 attendees. Supported by the Italian Space Agency (ASI) and the Italian Trade Agency, these companies represented diverse space technologies, from aerospace engineering to satellite solutions. This platform offered valuable exposure to cutting-edge developments to African companies, while Italy's support highlighted its ongoing commitment to Africa's space ambitions.

Recently, a dedicated team of engineers from the Kenya Space Agency (KSA) announced they have successfully designed, developed, and tested the Electrical Power Subsystem (EPS) for the African Development Satellite (AfDevSat) mission. The work was carried out at the Egyptian Space Agency (EgSA) facilities in Cairo, Egypt.

The project was designed to facilitate the launch of a pan-African satellite project named the African Development Satellite Initiative (AfDev-Sat) and the participants took courses in space project management, space sub-system design, CAD tools and design software orientation, satellite testing, among others at EgSA.

The primary focus of this project is hands-on training. The first phase covers the theoretical aspects, including lectures on

satellites and their composition and the second part covers the hands-on training. The engineers were trained at the EgSA facility- with state of the art laboratories, equipment and devices needed to develop mechanical parts, electrical boards, software for the satellite and carry out various simulations. They would also build and assemble a cubesat.

AfDevSat is a collaborative initiative bringing together six African countries, including Egypt, Ghana, Kenya, Nigeria, Sudan, and Uganda to design, develop, and launch a hyperspectral-imaging CubeSat. As part of this mission, KSA was entrusted with the responsibility of developing the EPS, the "heartbeat" of the satellite ensuring reliable power generation, safe storage, and efficient distribution across the entire platform.

The EPS consists of three core components: a Power Generation Board that harvests and regulates solar energy, a Power Distribution Board that ensures regulated supply and switching, and a Battery Management System that monitors, protects, and controls the thermal performance of an 8-cell lithium-ion pack configured in 4S2P. The Kenya Space Agency team, led by Capt. Jackson Koll together with engineers Mr. Brian Oure Omollo and Mr. Evans Yomu Kidada, worked tirelessly to deliver this critical subsystem. Beyond technical development, the program fostered collaboration, knowledge-sharing, and resource pooling among African space professionals, ensuring successful subsystem assembly, integration, and qualification within the set timeframe.

This milestone marks a defining moment in Africa's space journey, showing what is possible when nations unite around a shared vision. The success of AfDevSat not only strengthens Africa's space capabilities but also serves as an inspiration to the next generation of scientists, engineers, and innovators across the continent.

The trainees participated in many technical sessions, particularly related to simulations of satellite systems [such as orbital simulation], mission analysis and mission designs for satellites. The knowledge gained from this programme is to be applied to their home countries and be able to build dedicated satellite subsystems that can ultimately be integrated into each other to engineer a complete satellite.

As part of its educational project, the Egyptian Space Agency EgSACEO, Mohamed el Quosi, has said Egypt is working on a key project related to building 35 educational satellites. These satellites would allow students, specialists, and engineers to learn and perform programming. They would also be able to control the satellites.

Quosi made the statement at a symposium designed to discuss the prospects for Arab cooperation in the space industry, considering Egypt's expertise in space and satellites and its human resources.

In 2024, EgSA's board had announced an ££4 million (\$225,000) collaborative project with the National Aeronautics and Space Administration (NASA). According to the statement, the project would involve developing 35 educational cube satellites to train more space scientists in Egypt.

Quosi also said that Egypt is looking with great admiration and appreciation to the UAE model in making a positive change in the Arab world. He also considered the UAE an inspiring model for Arabs, lauding Hope Probe's mission and its noble global scientific goals.

Egypt is making preparations to receive its sixth satellite, MisrSat-2, that has been built using a grant from China and was shipped to Egypt.

Dr. Medhat Mokhtar, Chairman of the National Authority for Remote Sensing and Space Sciences (NARSSS), said that the Chinese grant for the satellite was agreed upon in January 2014, and that it will monitor and study Egyptian land resources to preserve the environment.

Mokhtar added that China has also funded an Egyptian facility to assemble satellite components at a cost of U.S.\$23 million, and a satellite that costs U.S.\$45 million. Egypt intends to use this assembly facility to complete the build of the new satellite using licensed Chinese components. Dr. Mokhtar stressed that the new satellite will be higher in terms of imaging accuracy compared to previous Egyptian Earth observation satellites. Dr Mohamed El Koussy, former senior official in the Egyptian space programme, said that work is also under way to establish another new facility for satellite manufacturing in Cairo's Fifth Settlement, and that construction will be carried out according to international standards and environmental requirements. "A delegation of about 20 engineers have been sent for training on how to build satellites in China over the past few months," El Koussy said. "The mission came back about two months ago, and satellite building will proceed for the next 24 months." The new MisrSat-2 satellite will also help with monitoring agricultural land and to take new high-resolution satellite images to assess developments compared with old satellite images, a technique known as change detection.

In a press release by the Egyptian Space Agency (EgSA), the joint team established as part of the technology transfer project between the Egyptian Space Agency and the Chinese government has completed testing the MisrSat-2. The testing confirmation came two weeks after MisrSat-2 passed stage A, stage B, electromagnetic compatibility (EMC) tests, and other subsystems tests at the Egyptian satellite AITC in Egypt.

According to the EgSA's press release, the initial phase of the testing process has been completed under the supervision of the China National Space Agency's (CSNA) Earth Observation and Data Centre team. This successful completion has allowed for the subsequent on-site testing and assembly of the Multi Transponder Mode (MTM) and Frequency Modulation (FM) experimental work on communication satellites, as per the original plan.

First SBAS open service
NigComSat-1R, the Nigerian Communication Satellite, is successfully utilising its L-band/ SBAS payload as the backbone in a

partnership between NIGCOMSAT Ltd, Thales Alenia Space and the Agency for Air Navigation Safety in Africa, and Madagascar, ASCENA to provide a Satellite-Based Augmentation System (SBAS) that broadcasts signals over the Africa and the Indian Ocean (AFI) region.

This aims to provide the first SBAS open service in this part of the world on NigComSat-1R satellite, a communications satellite managed and operated by NIGCOMSAT Ltd under the Federal Ministry of Communications and Digital Economy of Nigeria.

The open service was provided as part of the "SBAS for Africa and Indian Ocean" programme, which pursues the autonomous provision over the continent of SBAS services to augment the performances of the satellite navigation constellations GPS and Galileo.

The system prototype uses a reference stations network, the SAGAIE network, deployed by CNES (National Centre for Space Studies, France) and ASCENA with the support of Thale Alenia Space. The signal is broadcast via the SBAS payload on NigComSat-1R and uplink station in Abuja (Nigeria). It is compliant with the standards and recommended practices of the International Civil Aviation Organisation and the Minimum Operational Performance Standard developed by the Radio Technical Commission for Aeronautics (RTCA) organisation. It will be visible in the whole of Africa and the Indian Ocean up to the West Australia coast and also in Europe.

SBAS Project Manager, Dr Lasisi Salami Lawal, said that the development would improve GPS accuracy to within a metre and boost integrity, availability, and continuity of safety-related applications.

According to Dr. Lawal, the SBAS services is currently improving flight safety and efficiency in Africa, as well as support safety and commercial applications related to land, sea, and rail transportation which are beneficial to the economy.

The project manager further noted that the open service is essentially aimed at advancing earlier technical trials as well as partnering with airlines, field demonstrations for aircraft and rotorcraft, to demonstrate the benefits of the future operational safety-of-life SBAS services. It is expected to include Precise Point Positioning (PPP) and emergency warning service to populations, which performance will be proven through demonstrations.

"The signal-in-space is generated by a dedicated system tested and developed as part of the SBAS for Africa and Indian Ocean preliminary design phase, which is financed by the European Union and awarded to Thales Alenia Space, a joint venture between Thales (67%) and Leonardo (33%). The SBAS for Africa and Indian Ocean is based on the Multi Transponder Mode (MTM) and Frequency Modulation (FM) experimental work on communication satellites, as per the original plan.

The development, according to the satellite

company, will leverage on the Nigeria digital policy as led by Minister of Communications and Digital Economy, Dr. Isa Ali Ibrahim, which among other things emphasised the implementation of the regional satellite-based augmentation system.

The SBAS service, which is one of the several socio-economic derivatives of NigComSat-1R, is expected to grow the GDP and value proposition not only in the communications sector but also in aviation, maritime, rail transport, precision agriculture, survey, oil and gas, security of strategic national infrastructure and mass-market applications for sustainable development within and beyond Nigerian shores.

Africa, as center piece of research

Africa represents 20% of the Earth's land surface area, more than the USA, India, China and Europe put together, yet this region invested more than \$150 billion yearly on space activities, while Africa injected only under \$100 million translating to less than 0.2% of the global space budget in the same period.

Africa has an opportunity to exploit its geographic position and natural resources to promote economic growth, improve the quality of life of its people, and contribute to scientific knowledge. At the same time, Africa is facing major challenges in food security, rapid urbanisation, the sustainable use of the environment, and the need to educate a growing population.

Thirty-four of the fifty-four African countries are equatorial according to this definition. The equatorial African countries including Zambia, Malawi, Angola, Comoros, Democratic Republic of the Congo, Tanzania, Seychelles, Burundi, Rwanda, Gabon, Gambia, Republic of Congo, Kenya, Sao Tome and Principe, Uganda, Equatorial Guinea, Cameroon, Central African Republic, Cote d'Ivoire, Ethiopia, Ghana, Togo, South Sudan, Sierra Leone, Benin, Nigeria, Guinea, Djibouti, Guinea-Bissau, Burkina Faso, Senegal, Chad, Eritrea, and Sudan.

Africa cannot afford to remain a net importer of space technologies, as in the long term this will limit socioeconomic development and negate the African Union vision of "An integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena". Developing an adequate regional space capability has been hampered by the capital-intensive nature of the space sector and the lack of a formal governance structure to advance a collective effort. These difficulties must be overcome given the strategic value of a regional space sector in advancing the economic, political, environmental and social agenda of the

continent. Space applications are needed to achieve over 90% of the strategic objectives across the eight departments of the African Union Commission.

In South Africa, for example, the South African National Space Agency (SANSA) has taken over a pre-existing satellite test facility that is now known as SANSA Space Engineering. There are also several organizations with facilities and personnel capable of satellite design and technology development, including the University of Stellenbosch, the Cape Peninsula University of Technology and the SunSpace and Information Systems firm.

In the vastness of space exploration, South Africa often flies under the radar as a major contributor. However, according to Mike-Alec Kearney, CEO of CubeSpace, a satellite components manufacturer born out of Stellenbosch University's research labs, that perception is rapidly changing.

CubeSpace specialises in crafting satellite components deployed worldwide. Currently headquartered in Techno Park, a technology-focused science park nestled in Stellenbosch, the company represents South Africa's rising presence in the global satellite industry. "South Africa is now synonymous with top-notch space technology," Kearney proudly declares. "At conferences, when South Africa is mentioned, heads nod in recognition of our contributions." He recalls a time when South Africa's contributions to space technology were underrated, burdened by a stigma of inferiority. "But now," he asserts, "we have changed those misconceptions and are solidifying our position as major players in space tech."

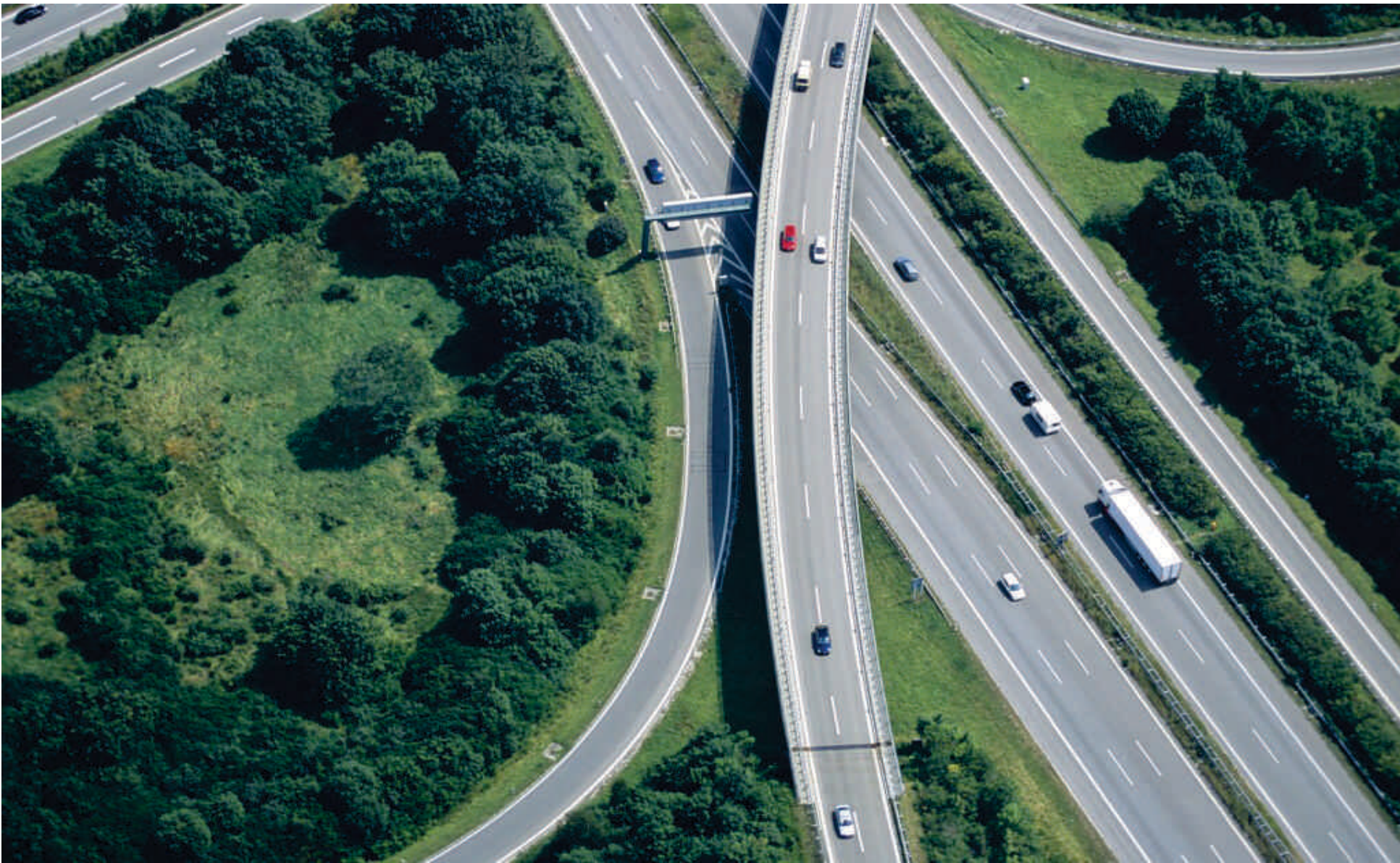
CubeSpace has emerged as a key player in advancing space exploration through its significant contributions to groundbreaking missions. Notably, the company has spearheaded the development of control systems for the United Arab Emirates' (UAE) lunar rover, a remarkable feat in space exploration. Presently, CubeSpace is actively engaged in crafting control systems for three more lunar rovers. These endeavours exemplify the company's commitment to pushing the boundaries of space exploration, with aspirations extending to lunar and Martian colonisation.

Throughout its decade-long journey, CubeSpace has produced over 5,000 components, including 300 intricate control systems, positioning itself as a leader in satellite innovation. "Control systems are the backbone of satellite operations," Kearney explains. "They ensure precise manoeuvrability crucial for many applications."

Although CubeSpace doesn't conduct satellite launches itself, its 55-member team locally designs, manufactures, and assembles components, making significant contributions to groundbreaking missions such as the UAE lunar rover. Kearney traces the origins of CubeSpace back to 2014 when it emerged as a spinoff from Stellenbosch University. The company's foundation lies in research conducted at the university, forming the basis for the development of its component designs.

With a diverse clientele spanning Europe, the US, and beyond, Kearney envisions CubeSpace as the premier manufacturer of

LiDAR is becoming an always-on intelligence layer



Power lines, rail corridors, metro extensions, highways, data centres, data cables. Wherever new infrastructure goes, it passes through landscapes that already contain natural assets, especially trees. The challenge is simple. How do we expand and upgrade infrastructure without unnecessarily removing the very trees that make cities and networks cooler, safer and more resilient.

For overhead powerlines, knowing the condition of both the network assets and nearby vegetation is essential. Digital images and aerial visual patrols give a useful overview of the corridor, but they have limits. You can see potential

infringements, yet it is hard to measure precise distances between conductors, trees and ground from a single aerial image, which often leads to conservative assumptions and resource intensive ground inspections.

For years, LiDAR operated primarily as a high-precision surveying tool used for terrain modeling, corridor mapping, and elevation analysis. Its role was largely restricted to post-processed datasets reviewed after field capture. That operating model has now shifted as industries adopt automation, connected platforms, and AI-driven operations. LiDAR is evolving into an active perception layer that

continuously delivers spatial intelligence into machines, digital twins, and network control systems.

In 2026, the most important Lidar trends are no longer limited to sensor accuracy or point density. The focus has moved toward automation, AI in LiDAR mapping, sensor miniaturization, multi-sensor fusion, and the rapid expansion of real time mapping systems.

These forces are redefining how spatial data is captured, interpreted, and deployed across critical sectors such as telecom, infrastructure, utilities, mobility, and smart cities. This evolution marks a defining phase in the

future of LiDAR, where LiDAR transitions from a post-processing tool for engineers to a live decision-making engine embedded inside autonomous vehicles, drones, telecom networks, factories, cities, and infrastructure corridors.

The surveying industry is moving into an era where data volumes are massive, timelines are shorter, and accuracy demands remain uncompromising. UAVs generate gigabytes per flight, photogrammetry and LiDAR produce dense 3D datasets, SAR provides all-weather coverage, and satellites deliver frequent refreshes. At the same time, clients demand outputs that are both legally defensible and

operationally precise. Choosing the right feature extraction approach doesn't just improve workflow efficiency but delivers results that clients can trust. For governments, automated feature extraction makes it possible to maintain up-to-date cadastral records at scale.

For utilities, it means quicker mapping of transmission lines across regions. For environmental agencies, it enables faster monitoring of land-use changes. In all these cases, automation delivers speed and consistency, while manual oversight provides the accountability and trust that stakeholders demand. This is where high accuracy LiDAR, combined with geospatial analysis, becomes the reference standard. Imagine a span where tree crowns appear to sit uncomfortably close to the line when viewed from above. By bringing LiDAR point clouds into a geospatial environment, that picture becomes unambiguous.

In the rapidly evolving technological landscape, the fusion of Light Detection and Ranging LiDAR and Artificial Intelligence (AI) is heralding a new era of innovation and efficiency. This synergy is not just enhancing our understanding of the physical world but is also redefining our interaction with it. Every conductor, tree and terrain point is captured in 3D. Clearances can be measured directly between vegetation and live conductors, not just to the ground. Conductor sag can be modelled span by span under different loading or temperature scenarios. When LiDAR is combined with high resolution aerial photography, utilities gain both visual context and centimeter level precision in one integrated view. Hidden vegetation infringements that are not obvious in 2D imagery become visible. Cutting can be prioritized where trees are predicted to breach safety distances, rather than along every span. Vegetation management programs become targeted and data driven, focusing resources where the risk is highest.

By linking geographic coordinates with descriptive attributes, GIS provides an unparalleled ability to observe patterns, relationships, and trends in both natural and built environments. This capability is transforming decision-making across sectors such as telecom, urban planning, disaster management, and environmental monitoring.

Globally, the GIS system market was valued at over \$9.80 billion in 2023 and is projected to reach \$17.76 billion by 2030, driven by digital transformation initiatives, increasing spatial data availability, and increasing applications of GIS in geology, defense, environmental, and disaster management. Modern GIS mapping platforms combine vector data including points, lines, polygons, raster data such as satellite imagery, aerial photos, elevation models, and point-cloud data especially, LiDAR with advanced analytics, machine learning, and real-time IoT sensor feeds.

According to the United Nations, over 80% of data managed by government authorities worldwide is spatial in nature, highlighting GIS's central role in modern governance. The result is a multidimensional, interactive representation of spatial realities, capable of revealing insights that

traditional tabular datasets cannot.

In 2024, the global GIS mapping market was valued at USD 9.4 billion and is expected to grow at a CAGR of 12.3% from 2025 to 2034, reaching USD 31.2 billion by 2030. The increasing demand for geospatial technologies in urban planning, infrastructure and location-based services is driving this growth. The mapping segment alone accounted for 33% of the market share in 2024, highlighting its importance in decision-making. North America currently leads the market, contributing over 81% of the revenue share, with projections to surpass USD 7.2 billion by 2034. The region's strong adoption of geospatial technology across various industries fuels this dominance.

According to Grand View Research, the global remote sensing technology market is projected to grow to around USD 55.36 billion by 2032, reflecting a CAGR of 11.79%. This impressive growth underscores the value of remote sensing analytics companies in today's information-driven era. These organizations transform raw data into actionable insights, distinguishing between mere data and valuable information.

In the geospatial sector, remote sensing analytics firms bridge the gap between data and information, utilizing advanced algorithms to convert vast datasets into meaningful insights that aid organizations of all sizes in making informed decisions. Geospatial data analysis, particularly change detection, has emerged as a cornerstone in monitoring our planet's evolving landscape. By harnessing the power of satellite imagery and advanced algorithms, organizations can extract valuable insights from geospatial data to inform strategic decision-making.

Change detection, a core application of remote sensing, is a crucial technique for understanding and managing environmental and human-induced changes by identifying alterations on the Earth's surface over time. This technique is essential for tracking ecological changes, urban development, natural disasters, and other phenomena. The core idea is to compare images of the same area at different times to detect notable differences.

Change detection in GIS leverages the integration of statistical and geospatial data analysis. Statistical data is acquired from diverse datasets, providing a robust foundation for temporal comparisons. Geospatial information, crucial for spatial analysis, is collected through advanced remote sensing platforms such as drones, UAVs, and satellites. The increasing preference for satellite-based change detection is attributed to its rapid processing capabilities and cost-efficiency, enhanced by the widespread availability of open-access satellite data. This approach enables precise monitoring and analysis of spatial and temporal changes, facilitating informed decision-making in various geospatial applications.

Advancements in 3D Data for change detection

Due to advancements in sensors, platforms, and algorithms, 3D data acquisition has become more accessible. Modern technology enables the collection of 3D data through spaceborne, airborne, and close-range methods, such as

image-based systems, LiDAR point clouds, Digital Elevation Models (DEM), and 3D city models. These advancements have significantly enhanced change detection or time-series data analysis in 3D, providing volumetric dynamics and yielding more accurate results.

State-of-the-art reviews of change detection methods now incorporate 3D data, transcending traditional 2D pixel or object-based analysis to include detailed geometric analysis. Recent advancements in 3D change detection using remote sensing and close-range data are enhancing capabilities for industry professionals and researchers alike, enabling precise detection and analysis of 3D spatial dynamics. These advancements have led to better practices in urban, environmental, ecological, and civil applications, addressing key issues in 3D change detection methods and concluding with remarks on algorithmic aspects of 3D change detection.

The fusion of LiDAR and AI: A game-changer

LiDAR technology has long been recognized for its ability to generate precise 3D representations of physical environments. By emitting millions of laser pulses and measuring the time it takes for them to return, LiDAR creates detailed point clouds that form the foundation for geospatial mapping and analysis. However, the true potential of LiDAR data is unlocked when it is combined with the capabilities of AI, particularly in the realms of computer vision and image processing.

AI algorithms are inherently data-hungry, thriving on extensive and detailed datasets to analyze, interpret, and make predictions. The rich, high-resolution datasets produced by LiDAR serve as an ideal feeding ground for these algorithms, enabling them to discern patterns and extract meaningful insights with remarkable accuracy. When AI meets LiDAR, the result is a powerful tool that can not only visualize but also understand and interact with the environment in ways previously unimaginable.

This fusion marks a significant turning point, especially in fields that rely heavily on accurate environmental modeling and analysis. The dense, precise data from LiDAR, coupled with AI's ability to learn and adapt, creates a dynamic duo that can accurately detect objects, predict environmental changes, and model complex ecosystems with an unprecedented level of detail. This combination is proving to be a game-changer, offering a new lens through which we can view and interact with the world around us.

The traditional approach to LiDAR data interpretation was a daunting task. It involved an extensive manual effort to label and categorize the vast amounts of point cloud data, identifying key features such as buildings, utility infrastructure, trees, and other landscape elements. This process was not only labor-intensive but also required a high level of specialized knowledge, making it a significant bottleneck in the workflow of geospatial analysis.

Advanced AI models equipped with sophisticated algorithms for computer vision and machine learning have taken on the challenge of automating the data labeling process. These models can swiftly navigate through the complex, unstructured data produced by LiDAR, identifying and categorizing objects with remarkable accuracy and speed. What once took hours or even days can now be accomplished in a fraction of the time, significantly streamlining the

workflow and allowing for a more efficient allocation of human expertise to more critical analytical tasks.

The marriage of LiDAR and AI extends beyond mere automation; it elevates the quality and utility of the insights derived from geospatial data. AI's inherent capacity for continuous learning and adaptation means that with each dataset analyzed, the algorithms become more refined and accurate in their predictions and interpretations. This leads to the creation of 3D models that are not only highly precise but also consistently updated to reflect the latest environmental conditions.

Such advancements have a ripple effect on the scalability of projects. With AI handling the heavy lifting of data processing, it becomes feasible to tackle larger areas and more complex environments, expanding the scope of what can be achieved through geospatial analysis. This combination of precision, efficiency, and scalability is transforming the way we approach environmental modeling, making it an indispensable tool in a multitude of applications.

Utilities and vegetation management

In the utilities sector, effective vegetation management around power lines is paramount for preventing outages and ensuring public safety. The integration of LiDAR and AI has brought about a significant leap forward in this area. Utility companies can now leverage these technologies to accurately predict vegetation growth patterns and identify potential encroachments on power lines. This predictive capability allows for proactive maintenance planning, reducing the likelihood of service disruptions and enhancing overall grid resilience.

The detailed 3D models generated by LiDAR and AI are proving invaluable in the realm of transportation and infrastructure. These models provide critical insights for the planning, design, and maintenance of infrastructure, from assessing road conditions to conceptualizing new transportation networks. By enabling a more informed decision-making process, these technologies are paving the way for infrastructure that is not only more robust and efficient but also better aligned with future needs.

Urban planners are increasingly turning to LiDAR and AI to create more sustainable, livable cities. The detailed insights obtained from these technologies assist in everything from monitoring construction progress to optimizing the design of public spaces. This data-driven approach to urban planning enables the creation of environments that are finely tuned to the needs of their inhabitants, fostering communities that are both vibrant and resilient.

LiDAR and powering a green future

In our hyper-connected world, the power to keep the lights on is not just about providing a service; it's about safeguarding economies and ecosystems. A growing challenge to this vital



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At the heart of this shift is the innovative combination of LiDAR (Light Detection and Ranging) and remote sensing analytics. LiDAR, which uses pulsed laser light to measure variable distances, creates intricate 3D representations of the Earth's surface.

With the help of advanced algorithms, remote sensing analytics can analyze LiDAR data and satellite imagery in real-time. This allows utility companies to track vegetation growth rates, anticipate potential threats, and mitigate outages before they occur. This data-driven approach represents a proactive shift away from previous reactive models, reducing outage risks by up to 50%.

Navigating the complexity of geospatial data

Harnessing the power of geospatial data presents utility companies with numerous challenges. Effective implementation of this

advanced technology requires expertise. The volume and diversity of data from sources such as satellites, drones, and ground surveys can be overwhelming. Ensuring its accuracy and precision is essential, given the significant implications of even minor errors. Utility firms need real-time insights, but the vast nature of geospatial data often slows down processing. Integrating these geospatial solutions with legacy systems is another challenge, revealing a skill gap within utility companies.

Such services encompass the entire lifecycle of geospatial data: acquisition, processing, analysis, and modeling. During processing, advanced techniques are employed to clean LiDAR data, remove noise, and classify points into categories such as ground, vegetation, and buildings. After processing, the data undergoes feature extraction where elements such as power lines and trees are identified.

By creating detailed 3D models of power lines and surrounding vegetation, utility companies

can visualize potential threats in their real-world context. These models, once integrated into Geographic Information Systems (GIS), enable the overlay of this data onto maps for deeper analysis and decision-making.

With profound expertise in geospatial services, the transformation of intricate LiDAR data into actionable insights is achievable. Managing the vast geospatial data sources with sophisticated processing mechanisms ensures utility firms are equipped with the most relevant insights. Rigorous validation processes showcase a commitment to data accuracy and precision. Recognizing the need for prompt decision-making in the utilities sector, advanced technologies are employed for real-time geospatial analytics. Stringent data security protocols protect against potential cyber threats, maintaining the integrity of critical information.

A deep understanding of both legacy and

modern systems guarantees smooth integration, minimizing potential operational issues. Skill gaps are addressed through specialized training sessions, enabling utility companies to harness the power of geospatial insights.

By providing detailed, accurate 3D representations of power lines and surrounding vegetation, geospatial services enable utility companies to better protect their substantial investments in vegetation management. These services enhance the efficiency of vegetation management activities, enabling utilities to adopt targeted, data-driven strategies. For instance, areas with fast-growing vegetation that pose a higher risk to power lines can be prioritized for maintenance. This saves time and resources, reduces the likelihood of power outages, and ensures optimal allocation of vegetation management budgets.

The next decade promises exciting advancements in the application of LiDAR and geospatial services in vegetation management. Anticipated innovations include greater AI and machine learning integration for automated feature extraction and predictive analytics, and the growing prevalence of drone technology for cost-effective LiDAR data collection. These innovations will empower utility companies to predict and mitigate potential issues before they escalate, boosting operational resilience and cost-efficiency.

As LiDAR technology and data processing techniques continue to evolve, we envision a future where vegetation-related outages become increasingly rare, resulting in a more reliable and efficient power distribution system.

LiDAR for tower audit

Telecom infrastructure has entered a phase where the volume, density, and complexity of tower assets are increasing far faster than the capacity of field teams to manage them. The rollout of 5G, and the preparations for 6G, have forced operators to rethink how quickly and accurately they can inspect structures, validate tenant equipment, ensure compliance, and maintain structural health at scale.

Traditional inspection methods built around climbing, manual photography, and checklist-based audits no longer match the operational tempo of modern networks.

This is why LiDAR for tower audits is accelerating from early adoption to mainstream practice by 2026. The shift is not happening because LiDAR is new, but because the operational environment of telecom towers now requires something only LiDAR can reliably deliver: dense, high-precision, machine-readable 3D intelligence that integrates into engineering, RF, and asset-management workflows without the limitations of human-only inspection.

As global LiDAR markets scale, from USD 3.1 billion in 2024 toward USD 13 billion by 2033,

the technology becomes more affordable, more ruggedized, and easier to operationalize. Likewise, the drone-based tower inspection market is projected to surpass USD 1.9 billion by 2035, driven heavily by telecom use cases requiring safer, faster, and more complete audit data. Within this landscape, LiDAR-based geospatial intelligence is emerging as the backbone of future tower operations.

Among the most immediate and visible benefits of LiDAR is the significant improvement in operational safety. Traditional tower audits require climbing ladders, navigating cross-braces, and working in proximity to energized equipment. These activities carry inherent risks: falls, electrical exposure, wildlife interference, and weather-related hazards. LiDAR operations transform this workflow. UAVs equipped with LiDAR sensors perform controlled flight paths around the tower, capturing complete geometric datasets while technicians remain safely on the ground or operate from remote locations.

LiDAR's core strength is precise distance measurement at high point density, enabling centimeter-level 3D models of complex assets like lattice and monopole towers. UAV-borne LiDAR systems consistently deliver accurate representations of antenna placement, mounting hardware, and tower geometry, enabling engineering teams to perform reliable RF simulations, loading assessments, and structural validations. Industry comparisons show that LiDAR-based models significantly outperform pure photogrammetry in 3D integrity and geometric accuracy, especially around edges, slopes, and overlapping structural elements.

By 2026, time efficiency becomes one of the most operationally significant benefits of LiDAR. Traditional audits often require multiple technicians, additional safety equipment, and several hours on-site per tower. In contrast, UAV and mobile LiDAR workflows capture complete datasets in minutes, not hours. Industry reports on drone tower inspections highlight that UAV workflows can reduce on-site inspection time per tower by 40–70%, depending on tower complexity and data requirements. The broader adoption of mobile LiDAR systems further increases speed by enabling drive-by or walk-by data acquisition of tower compounds and approach paths.

By 2026, LiDAR for tower audits will not be a niche innovation but a strategic capability integrated into geospatial, asset management, and network planning workflows. The convergence of maturing UAV regulations, falling LiDAR hardware costs, and the rise of AI-driven digital twins makes it possible to industrialize these audits at portfolio scale rather than as one-off projects.

For decision-makers, the key is to treat LiDAR tower audits as an end-to-end program, not just a sensor choice. This means establishing consistent deliverables—



digital twins, equipment inventory layers, SHM metrics, linking LiDAR outputs directly into OSS, GIS, and engineering systems, and aligning workflows with safety, compliance, and RAN performance objectives. When implemented this way, LiDAR increases accuracy, reduces field risk, strengthens regulatory readiness, and unlocks long-term cost efficiency across thousands of assets.

Why 2026 is a transformational year for LiDAR

The year marks the industry-wide shift of LiDAR from pilot deployments to scaled commercial infrastructure. Market projections from 2024–2025 already show that the global LiDAR industry is moving from approximately USD 3–4 billion in 2025 to well over USD 12–15 billion by 2030. Notably, no single sector is driving this acceleration on its own. LiDAR is now being

adopted at scale across autonomous mobility and ADAS, construction and civil infrastructure, mining and quarrying, power utilities and renewable energy, telecom and broadband rollouts, smart cities and disaster response and environmental monitoring and forestry.

What has truly changed is not just where LiDAR is used, but how it is used. Earlier, enterprises treated LiDAR as a periodic survey tool. Today, they increasingly require continuous, automated, real-time spatial pipelines. These pipelines are directly connected to asset management systems, digital twins, network operations centers, safety platforms, and compliance dashboards.

At the same time, AI in LiDAR mapping has moved out of research labs and into daily operations. Deep learning models now perform automated classification, object detection, change analysis, and quality control directly inside processing pipelines. In telecom, this enables live detection of tower geometry, line-of-sight obstructions, fiber corridor deviations, and vegetation encroachment.

This convergence of automation, AI, and real-time spatial intelligence is what makes 2026 a true turning point for large-scale LiDAR adoption.

One of the most structurally important LiDAR trends shaping 2026 is the transition from mechanically driven LiDAR systems to solid-state, chip-level LiDAR architectures. Traditional LiDAR systems depend on rotating mirrors and moving optical parts. While they are highly accurate, they also come with challenges including mechanical wear over time, calibration drift, sensitivity to heat and vibration and higher maintenance costs.

Solid-state LiDAR removes all moving parts. It uses electronic beam steering through technologies such as optical phased arrays, MEMS mirrors, and flash-based scanning. This makes the sensor more durable, compact, and energy-efficient. Between 2024 and 2025, market analysis showed that the solid-state LiDAR semiconductor market is expected to grow from around USD 3 billion in 2024 to nearly USD 19 billion by 2034. Much of this growth is driven by the automotive industry, where LiDAR adoption for advanced driver assistance systems and autonomous driving is accelerating at CAGR levels above 40%.

How reliable is intelligence on Iran's nuclear program?



In 2001, Iran reportedly began constructing a vast underground enrichment facility near the city of Natanz. In August 2002, the controversial opposition group National Council of Resistance of Iran held a press conference in Washington, DC, to disclose secret nuclear activities taking place near Natanz and Arak. The group called it a nuclear fuel production facility and a heavy water production plant that could be used in a still-unknown reactor to make plutonium for nuclear weapons.

The press conference received relatively little media attention despite the significant revelations, which accused Iran of having a secret nuclear weapons

program in violation of the NPT. Subsequently, determining the veracity of the NCRI's allegations and the transparency of Iran's actions was critical. Karim Sadjadpour, an Iran analyst with the International Crisis Group reported that "Whereas few Iranians are opposed to the development of a nuclear energy facility, most of the Iranians surveyed said they oppose the pursuit of a nuclear weapons program because it runs against their desire for 'peace and tranquility.'"

A survey of Iranian public opinion conducted in Iran by Trita Parsi for the Tharwa Project concluded that average Iranians make a distinction between

weaponization and access to nuclear technology. "Contrary to media reports," wrote Parsi, an Iran specialist at Johns Hopkins University School for Advanced International Studies, "support for an Iranian nuclear bomb was rarely expressed by ordinary Iranians during my many taxi rides. The vast majority of Iranians argued that going nuclear militarily would make Iran less, rather than more safe."

In any case, looking beneath the thin veneer of public unanimity exhibited by the regime, one gets the clear impression that a growing number of Iranians are raising serious questions or

expressing dissatisfaction over the regime's nuclear policy, especially among the more informed strata, but not limited to them. Some question or disagree in faceless cyberspace or anonymous press reporting, while other brave and reform-minded Iranians do it more openly and publicly.

A good example is Ahmad Shirzad, a nuclear physics professor at Isfahan University and a former member of the parliament, who recently asked where Iran would get uranium if it insisted on developing a program with no outside trust or help, given the fact that its own uranium mines could power one 1,000-megawatt reactor, namely, the Bushehr reactor for

only seven years. "There is a feeling that the nation is being led toward war on an issue about which only a handful of men were informed," said Shirzad.

Iranian journalist Hamid Muhamadian in his analysis raised the questions about the economic viability of turning to nuclear energy in light of Iran's scarce uranium reserves and the high costs of extracting Iranian uranium and implementing the nuclear program. Exposing the lack of uranium ore deposits in Iran, as was done by Shirzad and Zeidabani, may well have triggered the announcement in early May by Iran's deputy chief for nuclear research and technology of the finding of three new uranium ore sites in the center of the country.

Iran's nuclear program has generated widespread concern that Tehran is pursuing nuclear weapons. Tehran's construction of gas centrifuge uranium enrichment facilities has been the main source of proliferation concern. According to informed sources, gas centrifuges enrich uranium by spinning uranium hexafluoride gas at high speeds to increase the concentration of the uranium-235 isotope.

These centrifuges can produce both low-enriched uranium, which can be used in nuclear power reactors, and highly enriched uranium, which is one of the two types of fissile material used in nuclear weapons. Individual centrifuges are linked together in cascades for producing enriched uranium in quantity.

Highly enriched uranium can also be used as fuel in certain types of nuclear reactors. Iran also has a uranium conversion facility, which converts uranium ore concentrate into several chemical compounds, including uranium hexafluoride. Tehran's stated goal is to produce low enriched uranium for the government's current and future power reactors. Iran is producing enriched uranium in commercial and pilot enrichment facilities at Natanz, as well as Iran's Fordow enrichment facility.

However, BlackSky, a leading technology platform providing real-time geospatial intelligence and global monitoring recently announced that its geospatial imagery was used in a groundbreaking intelligence study that tracks and monitors activity at the Natanz nuclear facility in Iran.

BlackSky's high-revisit satellite imagery enabled researchers at Stanford University's Center for International Security and Cooperation to monitor the pattern of life at the Natanz nuclear facility and gain a better understanding of activity and events at the site. BlackSky's satellites provide high, intraday revisit capabilities, allowing Stanford University's Center's research team to receive multiple images a day, throughout the day, rather than just one image collected at

roughly the same time each day.

BlackSky satellites are also capable of capturing a sequence of up to 20 images within a matter of minutes, known as a burst collection, and then splicing them together. Instead of a single picture, burst collections are geospatially normalized and joined together to generate a moving sequence of activity. With BlackSky's assistance, the research team was able to witness trucks emerging from the facility's underground tunnels.

Within weeks, images from BlackSky revealed that the three huge underground structures were largely covered over with dirt and concrete, but their outlines could still be seen. The two largest ones each had horizontal dimensions of about 190 by 170 m, roughly the area of six football fields each. While huge by any standard, the size did not necessarily confirm the facility's purpose. Through a process of elimination and with help from trusted, knowledgeable sources, analysts became convinced it was a gas centrifuge plant, a highly sensitive facility able to make weapon-grade uranium for nuclear weapons.

"Observations that provide real-time, activities-based insights have the potential to change the world," said Dr. Patrick O'Neil, chief data scientist at BlackSky. "The BlackSky and Stanford University's Center research team demonstrated the power of combining rapid revisit satellite imagery, human domain expertise, and AI/ML techniques to identify and understand activity at Natanz, which was previously unknown to much of the world."

Allison Puccioni, a renowned imagery analyst and BlackSky consultant, assembled a leading research team at Stanford University, with help from Rose Gottemoeller, an internationally recognized diplomat, former NATO Deputy Secretary, and current visiting professor at Stanford. The pair enlisted two highly skilled principal research assistants in geospatial science to develop a sophisticated and innovative situational-intelligence program to monitor the Natanz nuclear facility.

Natanz is Iran's primary facility for advanced uranium enrichment and is an active political and military location driven by concerns about the country's nuclear operations. The BlackSky and Stanford research team set a leading example for using high-resolution satellite imagery, AI/ML, and deep analysis to deliver first-to-know geospatial intelligence for the world's nuclear proliferation communities. Meanwhile, satellite imaging company Planet Labs said it will indefinitely withhold visuals of Iran and the region of conflict in the Middle East to comply with a request from United States President Donald Trump's administration.

In the past two decades, technological developments have significantly increased the availability, accessibility, and quality of satellite imagery data, and changed how and by whom imagery can be used for treaty verification purposes. While individual states have long employed national technical means to monitor

others, the information has tended to remain largely classified and not shareable. Today, a growing number of international and non-governmental organisations use satellite imagery in various ways for their monitoring, reporting, and verification needs.

Impact of the attack: Satellite imagery analysis

On June 13, 2025, Israel initiated attacks on various locations within Iran, including nuclear-related facilities. Shortly thereafter, in the early hours of June 22, the United States conducted airstrikes on three Iranian nuclear-related sites. President Trump proclaimed the operation a success, boasting that the facilities had been "completely destroyed."

Among the targeted locations were facilities embedded in rugged underground rock formations. The U.S. Department of Defense acknowledged using bunker-busting bombs, penetrating munitions capable of reaching and detonating deep beneath the surface. Following these strikes, both Israel and Iran declared a ceasefire, effectively halting further attacks on Iranian nuclear facilities for the time being. This coordinated operation aimed to prevent Iran from acquiring nuclear weapons.

Satellite imagery revealed that there are ongoing construction efforts at a mountainous area just south of the Natanz enrichment site known by its tallest peak as "Pickaxe Mountain." This site was not visibly attacked in June and comprises two underground tunnel complexes, one still under construction, labeled the Pickaxe Mountain Tunnel complex, and another built in 2007 and called the 2007 tunnel complex.

Iran announced in 2020 that the purpose of the Pickaxe tunnel complex is to hold an advanced centrifuge assembly facility that can produce several thousand centrifuges a year. In addition, based on the estimated size of the underground halls, the Institute several years ago assessed that site could also hold a centrifuge enrichment facility. The Pickaxe tunnel complex is not yet operational, but construction has been steady for several years³ and now appears to be nearing the end, at least of the tunnel complex itself.

In addition, the outer security perimeter wall of both tunnel complexes, which started well before the war in early 2025, is completed, although additional security measures are still being constructed. Iran has never provided a reason for the 2007 tunnel complex. The 2007 tunnel site appeared dormant for more than a decade but was slowly reactivated about five years ago with dramatic changes to the inner security perimeters at its tunnel entrances since September 2023.

During the war, stocks of enriched uranium may have been evacuated from the main Natanz site, a suspicion that is increased by hardening and recent burial efforts at its tunnel entrances. In recent imagery, the 2007 tunnel entrances appear to have been modified to make them harder to access, perhaps to harden them against attack, perhaps to make inspections by the IAEA more difficult, if Iran did finally allow the IAEA to access its stocks of enriched uranium. However, given Pickaxe Mountain tunnel complex's declared connection to the Iranian enrichment program and the 2007 tunnel complex's possible role in storing enriched uranium, ongoing activities warrant close scrutiny. With the widescale destruction of Iran's other centrifuge related facilities, the Pickaxe Mountain complex is a potential candidate site for any Iranian reconstitution of its centrifuge program, from centrifuge component production to centrifuge assembly to uranium enrichment.

Since the 12-Day War in June, when Israel and the United States attacked Iran's nuclear facilities, causing substantial damage and destruction to Iran's sensitive nuclear sites, the IAEA temporarily "stopped all in-field verification and monitoring activities in Iran for safety reasons." The IAEA reports that "by the end of June 2025, the Agency had decided to withdraw all of its inspectors from Iran for safety reasons." According to media reporting, these safety reasons included threats from the regime.

It reports that, during the 12-Day war and according to the IAEA's analysis of satellite imagery, "one building was hit" at the Tehran Research Center, where "advanced centrifuge rotors were manufactured and tested," "two buildings were destroyed" at the Karaj workshop, where "different centrifuge components were manufactured," and a "workshop was hit" at Esfahan, where "centrifuge manufacturing" took place.

The location of the Karaj workshop has been publicly known, and the destruction is visible, as is the destruction of a building at the Esfahan complex labeled by the Israeli Defense Force (IDF) as involving centrifuge manufacturing. The location of the building at the Tehran Research Center remains publicly unknown.

Regarding the Natanz uranium enrichment facility, early Israeli strikes nearly completely destroyed the test plant and also damaged the power supply infrastructure. Subsequent Israeli attacks and analysis of satellite images following the U.S. military strike on the 22nd reveal the appearance of a new crater measuring over five meters in diameter.

Although the satellite images cannot be presented due to licensing constraints, the underground structure at Natanz is



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considered less fortified than the Fordow site discussed later. It is possible that the large-scale underground commercial enrichment facility was also destroyed. Additionally, the facility used for manufacturing and assembling centrifuges was likely damaged. Mr. Iwamoto assesses that "If the centrifuge assembly plant was destroyed, the impact on Iran would be more severe than the damage to the enrichment facility itself. It would significantly extend the time required to resume uranium enrichment activities."

Satellite imagery taken after the strike on the Fordow site clearly reveals openings in craters, suggesting targeted impacts. In conjunction with the attacks on Natanz, the U.S. Department of Defense has confirmed that a total of 14 GBU-57 bunker buster bombs—among the heaviest in their class—were deployed.

The uranium enrichment facility at Fordow lies approximately 86 meters underground, while the GBU-57 is estimated to penetrate up to 60 meters. Given the shortfall in reach, it is believed that multiple bombs were dropped on the same location to maximize penetrative capability. However, the deeper portions of the crater remain obscured in satellite imagery, and there is disagreement among experts regarding the extent to which key equipment, such as centrifuges, was actually destroyed.

Satellite imagery taken days prior to the attack clearly shows a convoy of trucks, suggesting that Iran may have relocated enriched uranium to a secure location. Based on this observation, some media outlets reported an initial assessment that the operation may have only delayed Iran's nuclear weapons capability by a few months.

The once orderly rows of gray-roofed buildings in Arak have been dramatically altered, with Satellite Image 2 revealing that nearly 70% of the facilities appear to have been damaged by the attack. The heavy water production units, marked in red, are reportedly in a state of ruin, while separate satellite imagery confirms a large breach in the reactor building highlighted in blue, suggesting near-total destruction of critical infrastructure, including the reactor itself.

Fortunately, as fuel had not yet been loaded into the reactor, the risk of a large-scale radioactive leak is minimal. This likely led Israeli forces to judge the operation as compliant with international law, notably avoiding violations of the Geneva Conventions. \

Iran's mountain facilities south of Natanz enrichment plant

In June 2026, the presidents of Iran and US signed a historic memorandum of understanding to end the war, with Iran committing to not procure or develop nuclear weapons; visa-viz to agree on a pathway to dilute its highly enriched uranium stockpile under IAEA supervision; and discuss the issue of enrichment. The two sides agreed to start technical talks, but these stalled after the US and Iran renewed fighting over the Strait of

Hormuz.

Satellite imagery of the Taleghan-2 site at the Parchin complex suggests that Iran is taking steps to repair and stabilize the site after it was struck in March 2026. The site included a buried chamber that could have been intended for high explosives testing.

A member of the Iranian Parliament's National Security and Foreign Policy Committee stated "now is the time for Iran to build a nuclear bomb, as it has already paid more than enough of the price associated with doing so." Satellite imagery taken over the last months show that Iran is continuing construction activities at the Natanz "Pickaxe" mountain, or Mt Kolang Gaz-La, in line with activity at the site prior to the June war. As of September 2025, Iran's visible activities point towards late stages of construction, including improving security, but represent neither an expansion of the site nor an acceleration of activity. They do not indicate an ability to quickly rebuild destroyed parts of its nuclear program.

At the Mount Kolang-Gaz La, satellite imagery taken in September 2025 show progress made with respect to the security perimeter, including the completion of the primary wall perimeter, which was still missing portions on the west side in late March 2025.

The security perimeter Iran established surrounds the entire mountain range, including the foot of Mt Kolang Gaz La and a nearby mountain housing a tunnel complex built in 2007. Imagery dated to September 22, 2025, show that as expected, the security perimeter is not only composed of wall panels, but now shows signs of becoming a double-perimeter: A fence is being built behind the wall, so that any intruder needs to scale the wall and cross an area that will likely become an electronic surveillance zone before facing the fence. Guard towers and a security patrol road can be expected in the future. In the meantime, absent lights, video cameras, motion sensors, watch towers, alarm systems etc. these current features are physical obstacles but likely ineffective against prepared intruders.

Imagery dated to late June and early August further show activity at the second eastern tunnel portal, which is labeled as the main tunnel portal in earlier Institute reports. Vehicles can be seen on the road leading in and out of the tunnel portal. This tunnel entrance is the only of the four that has not seen significant stabilization work, possibly due to unexpected issues in the encountered geology as evidenced by the consistent visible waterflow stemming from the entrance. It appears that Iran has finally turned its attention to finishing this last tunnel portal as the tunnel complex is otherwise nearing completion.

In parallel, a shift in the spoil pile near the eastern tunnel entrances is noted, likely due to finishing the main eastern tunnel portal and covering the tunnel extension frame of the auxiliary eastern tunnel portal with rock. As of September 22, various construction materials are visible in the small construction support area of the eastern tunnel entrances as well as along the road and on top a small area of the spoil pile. These are further indications that activities inside the tunnel are focused on completing ongoing construction rather than conducting major additional

excavation

Hardening of 2007 tunnel complex

An August 10, 2025, MAXAR Technologies satellite image shows that the tunnel entrances leading into the original tunnel complex dating from 2007, as well as alcoves that were built more recently, are being reinforced with slabs of thick concrete and then buried in soil. This is an apparent effort to harden the entrances and alcoves from any potential airstrike or sabotage operation.

The researchers have previously reported on this site, which was dormant for more than a decade and then was slowly reactivated about five years ago, with dramatic changes in the inner security perimeters at its tunnel entrances during the last two years. The two tunnel entrances are highly secured with entrance security buildings and moveable roadblocks leading to the upper one. The security perimeter of the upper tunnel entrance was changed and an elaborate extension with alcoves was added, where alcoves could have a multitude of uses, including housing utilities for the main tunnel.

Using concrete slabs as reinforcement was previously observed at the Fordow Fuel Enrichment Plant, where prior to the June 22 attack by the United States during Operation Midnight Hammer, the air ventilation shafts were reinforced with concrete pads. Iran's post-June rush to add these pads to the Natanz tunnel site raises important questions about whether Iran was able to move any nuclear material, specifically enriched uranium stocks, or nuclear-related equipment, into the facility before the U.S. struck the other sites on June 22. This concern is heightened by satellite imagery dated June 18, 2025, which shows a truck leaving the tunnel facility area at around 9AM local time.

Shahid Meysami research center

The Shahid Meysami research center is located west of Tehran, near Karaj, and is part of Iran's nuclear complex, according to the Israel Defense Forces. In July 2025, the Institute published a detailed assessment of the site and the damage done by Israeli airstrikes. This site is part of the Shahid Meysami group, a known subordinate of officially known as the Organization of Defensive Innovation and Research. The group was sanctioned by the U.S. Treasury Department in 2020 for undertaking projects that include testing and producing chemical agents and optimizing them for effectiveness and toxicity for use as incapacitation agents. The Israel Defense Forces identified the Shahid Meysami site as being "used to produce raw materials for the development of nuclear weapons."

The Times of Israel reported that the site was believed to house "plastic explosives and advanced materials used in nuclear detonation testing." Iran's detonation system, or multi-point initiators (shock wave generators) require highly purified plastic explosives in its channels.

Satellite imagery from October 21, 2025, from Airbus, and November 2, 2025, from VANTOR, show significant cleanup and clearing operations at several of the destroyed or damaged buildings, constituting salvaging as a possible prelude to reconstruction. So far, imagery does not show any effort to rebuild these buildings and reconstitute the lost capabilities there. Several destroyed buildings throughout the complex have been razed and large rubble piles have appeared. Imagery from November 2, 2025, shows the attacked area in the northwest of the complex, where three large dump trucks are visible and are being used to clear debris. Nearby, several sorted piles of what may be salvageable materials and equipment have appeared.

One destroyed building was fully razed and the foundation was repaved as of November 2. A close-up from October 21 shows the extent of clean-up compared to the aftermath of the strike, as visible on July 1. The razed building has been completely cleared, leaving an empty lot and a large rubble pile nearby. At the nearby blown out hangar-type building, the high-bay metal frame remains in place, however, much of the debris has been cleared and piled up. A large crane can be seen erected near a parked dump truck, likely used for moving and hauling debris. A nearby area has been cleaned up and an overhang was repaired.

Iran rapidly rebuilding sites hit by US 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, the Wall Street Journal reported recently.

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.

One set of satellite images showed that an access road leading to an Iranian missile base had been damaged by strikes in early March, the Journal reported. Several weeks later, a newly paved road could be seen leading to the base's entrance in Kangavar, western Iran, despite it having also been blocked by the strikes.

Other images obtained by the WSJ showed that as of early July, reconstruction efforts were underway at the Bandar Anzali port linked to the Islamic Revolutionary Guard Corps.

The satellite imagery report investigates Iran's Pickaxe Mountain, a deeply buried underground nuclear facility under construction near the Natanz uranium enrichment complex. The site, located in the Zagros Mountain Range, is designed to withstand even the most powerful bunker-buster bombs, making it one of the world's most fortified nuclear facilities. Satellite images reveal that Iran began excavating large tunnel complexes beneath the mountain around 2020. Western intelligence believes the site is designed for advanced uranium enrichment



and resilient against attacks. Amid rising tensions and threats, Pickaxe Mountain is now a focal point in the ongoing conflict, symbolising Iran's strategy to protect its nuclear ambitions by going deep underground.

It remains unclear just what has been placed at Pickaxe Mountain, as the United Nations' nuclear watchdog has never gained access to the site. But Trump on Tuesday talking with journalists in the Oval Office acknowledged the possibility Iran may have moved centrifuges there, potentially at a depth that would challenge even the most-powerful bombs in America's arsenal. "We'll be hitting that area probably pretty soon. And there's not a thing they can do about it," Trump said.

The new project at Pickaxe Mountain is being

constructed next to Natanz, about 225 kilometers south of Tehran, Iran's capital. Natanz, a mix of above- and underground facilities, has been a point of international concern since its existence became known two decades ago. Repeated sabotage attacks on Natanz, including one likely carried out by Israel that destroyed a manufacturing site for centrifuges, led Iranian officials to start work on the Pickaxe Mountain site. Commercial satellite images, including those published by Maxar Technologies, have shown continuous construction since 2020. They show new tunnel entrances, access roads, security installations and large amounts of excavated rock. Construction appears to have accelerated after an explosion damaged Iran's advanced centrifuge assembly workshop at Natanz in July 2020. Iranian authorities described the blast as

an act of sabotage Protected by anti-aircraft batteries, fencing and Iran's paramilitary Revolutionary Guard, the facility sprawls across 2.7 square kilometers in the country's arid Central Plateau. It has multiple entrances visible from satellite images.\

In 2023, an Associated Press story on Pickaxe Mountain included analysis from experts at the James Martin Center for Nonproliferation Studies that suggested Iran is likely building a facility at a depth of between 80 meters (260 feet) and 100 meters (328 feet). Digging has continued at the site in the time since, with some experts suggesting it could be even deeper underground.

Experts say the size of the construction project indicates Iran will likely be able to use the underground facility to enrich uranium as well as to build centrifuges. Centrifuges, tube-shaped devices arranged in large cascades of dozens of machines, rapidly spin uranium gas to enrich it. Additional cascades spinning would allow Iran to quickly enrich uranium under the mountain's protection.

Such underground facilities led the U.S. to create the GBU-57 bomb, which can plow through at least 60 meters of earth before detonating, according to the American military. U.S. officials reportedly have discussed using two such bombs in succession to ensure a site is destroyed. It is not clear that such a one-two punch would damage a facility as deep as the one at Pickaxe Mountain.



SPACE REPORT

How Japanese startup iSpace is navigating failure in New Space business

It is 8 a.m. on June 6th, 2025, at the ispace Mission Control Center located in Nihonbashi, Tokyo, Japan. It was the peak of another Japanese lunar exploration. After tracking the lunar lander for 142 days in space, and preparing for this moment for 15 years, the team must acknowledge the reality of the situation and make the inevitable announcement. The lunar mission is declared unsuccessful. This moment marks the second consecutive mission failure within two years.

Despite the failure, Takeshi Hakamada, CEO of ispace, maintains a steady voice when he turns his attention to employees, stakeholders, and curious space enthusiasts all over the world and declares that the vision remains unchanged. By 2040, Moon Valley will be the permanent settlement for 1,000 humans on the lunar surface.

With Mission 3 approaching and multiple interim goals to succeed with to enable human life beyond Earth, another failed mission has severe consequences. Hakamada and his team were at the forefront of lunar exploration, but as other space companies advanced and ispace's capabilities were questioned, the pressure intensified.

Despite established partnerships and over \$300 million secured to support the HAKUTO-R program for the first three missions, ispace knew that the actual test was not in conference rooms, but in space. The missions were observed from all over the world, and not succeeding would have an impact outside of the control room, as stakeholders would react. When the first lander approached the surface, the stakes were greater than ever.

Not only did June 6 represent a major technical setback, but also a hit for stakeholder trust and a financial loss of millions of dollars. Japan is not new to failures in space explorations. In November 1999, Tanegashima launch centre. The first "made in Japan" space launcher 'H-2', failed at sending a satellite into orbit for the second time. The country's reputation in launching capabilities is tarnished, and they prematurely ended its activities.

ispace, a global lunar resource development company with the vision, "Expand our planet. Expand our future.", specializes in designing and building lunar landers and rovers. ispace

aims to extend the sphere of human life into space and create a sustainable world by providing high-frequency, low-cost transportation services to the Moon. The company has business entities in Japan, Luxembourg, and the United States with more than 300 employees worldwide. ispace's vision is not to enter an existing market, it is to build a new one. An integrated system of communications, transportation, and resource utilization that will become a place for humans to call their home, beyond the Earth. But establishing a new market also implies operating without guaranteed demand or customers, limited regulatory precedents, and without proven business models. From the start, ispace had been driven by a desire to discover the unknown. But without a demonstrated track record, Hakamada could feel stakeholders' patience starting to fade.

Ispace's vision is to expand and sustain humanity's presence in space by utilizing resources available on the Moon. ispace manages Team Hakuto, a front-running team in the now closed Google Lunar XPRIZ. ispace developed flight qualified Team Hakuto's SORATO rover, which won the \$500K mobility milestone award.

As Team Hakuto originally only planned to develop a rover, the team needed to partner with another GLXP team developing a lander in order to be transported to the Moon. Team Hakuto signed a partnership in 2017 with Team Indus, which had a validated launch and become a finalist for the \$20 million Grand Prize. Unfortunately, neither Team Indus nor any other remaining team was able to raise enough funds to pay a launch contract and Google official declared the end of the contest on January 23, 2018.

When Japan launched its first satellite into space in 1970, it emerged as the first Asian country to complete this feat and only the fourth country in the world to do so after the Union of Soviet Socialist Republics (USSR), the United States and France.

"The world's space industry is in the throes of a major transformation," says Masayasu Ishida. An energetic Tokyoite, Ishida is a principal at the management consulting firm A.T. Kearney and co-founder and president of the Spacetide Foundation, an organization dedicated to promoting space businesses globally.

"For the industry to realize sustainable growth, a shift from the government to the private sector is urgently needed," says Masanori Tsuruda from the Ministry of Economy, Trade and Industry (METI). This shift is driven in part by shrinking government budgets for big projects as well as the many emerging possibilities for enterprises to profit from space.

However, business cannot go it alone in space because the capital costs and risks are too high. Companies need a supportive environment to be able to flourish in space. The Japanese government is now undertaking various initiatives to nurture the domestic commercial space industry. Ishida notes three areas in which government can help businesses invest in space: law and legislation, government procurement, support of innovation, and contests.

"Future space exploration needs innovative technologies like robotics, artificial intelligence, advanced communication, and new materials, which will be brought by non-space industries," he explains. "Japan is home to many of the world's leading industries, and has a variety of technological assets. Their involvement could be of help in the global space exploration effort."

Yasuhiro Yukimatsu, deputy director-general of the National Space Policy Secretariat, Cabinet Office, notes that Japanese companies and universities have developed micro-, nano- and even pico-satellite technology, which allows countries that have yet to join the space community affordable access to space. Ishida concurs: "Japanese space-related business players have unique technologies and are working on projects such as small launchers, space debris removal, and space resource mining."

No one reaches space alone. For ispace, each mission depends on close relationships with an extensive network of stakeholders. A key part of this ecosystem is ispace's public-private partnerships. Since the beginning, Hakamada knew that ispace's vision would not be achievable without these relationships. As the pressure increased, their legitimacy and support mattered more than ever.

The rise to a global organization

Every night, Takeshi Hakamada looked up at the glimmering stars spread across the black sky and imagined all the endless possibilities. His dreams started to become reality in 2010, when he formed Team HAKUTO to participate in the

Google Lunar XPRIZE.

To win the competition, running from 2007 to 2018, one team had to successfully perform a soft landing on the moon and transmit messages back to Earth. Team HAKUTO won a milestone prize and became one of the finalists, but the competition later ended without a winner. However, for Hakamada, this was just the beginning. It marked the start of ispace and helped his company secure \$90 million in funding.

Following the competition, ispace advanced into a commercial space tech company. All under the leadership of ispace founder and CEO, Takeshi Hakamada. As the company started to turn its lunar vision into a scalable global strategy, domestic operations in Japan were no longer sufficient. To gain better institutional support, stakeholder relationships, and access to international space programs, ispace expanded into a global organization.

Today, the company manages 317 employees across three countries. ispace, Inc. in Tokyo serves as the headquarters and center for mission design, engineering, and strategy. Ispace Technologies U.S. in Denver, Colorado, supports the technological development, and ispace Europe S.A. in Luxembourg plays a key role in resource exploration and commercialization. In addition to its own operations, ispace collaborates with space programs and institutional partners, as they provide both access and legitimacy.

Opening subsidiaries in the selected countries enabled ispace to initiate collaborations with space programs at the forefront of lunar exploration. With NASA's Artemis Program in the U.S., the European Space Agency and Luxembourg Space Agency in Europe, and the Japan Aerospace Exploration Agency in Japan. Together, these relationships provide the financial, technological, and regulatory foundation needed to realize a stable lunar presence.

Inside ispace

As the New Space sector grew, ispace emerged with a bold vision. What began as a competition team has grown into a global company, shaped by strategic decisions, an evolving business model, and key partnerships. Everything it does brings ispace closer to the Moon.

ispace operates in a market beyond Earth's surface. By creating "a world where the Earth and Moon are one ecosystem," ispace envisions a lunar society with permanent residents. However, the company's journey is highly challenging, consisting of multiple intermediate milestones. However, incremental missions planned before achieving their long-term goal are designed to gather data, demonstrate capabilities, build partnerships, and test and improve their lunar landers.

Recently, iSpace said Ron Garan, Chairman of the U.S. Board and former CEO, has concluded his tenure as Chairman. Ron Garan, a high decorated NASA astronaut and U.S. Air Force Colonel (Ret.), had led ispace-technologies U.S. for two and half years, overseeing exponential growth in the size of the company and maturity of its business development and engineering departments. He made significant contributions to establishing ispace-U.S.'s position in the American market and the global space industry.

During his time at ispace-U.S., the company opened a new manufacturing facility outside of Denver, Colo., expanded the number of employees from a few dozens to its current level of more than one hundred, opened the Summit Mission Control Center and advanced sustainable development of ispace-U.S.'s future missions including Mission 3 and the APEX 1.0 lunar lander.

"Ron joined ispace-U.S. as it was establishing a foothold in the United States, and since then has played a vital role as the representative to all of our stakeholders. He truly believes in the ispace vision to develop a sustainable ecosystem in which both the Earth and the Moon function together for a better future. I am grateful for his leadership for the past two and a half years. ispace-U.S. is now poised to undertake its first mission, and I am confident that Elizabeth will continue to oversee significant achievements," said Takeshi Hakamada, Founder & CEO of ispace.

Thus, in addition to developing its own lunar exploration technologies, the company transports scientific instruments and equipment for customers and external partners. In the next phase, ispace aims to move from offering transport services and progress to a lunar resource development company, focusing on the extraction and commercialization of resources such as water and minerals from the Moon.

This would not only plough resources back on Earth but also support the creation of



infrastructure in space. To build a sustainable resource supply chain on the Moon, ispace needs lunar ice. Processing lunar ice into water offers a highly energy-efficient way to obtain hydrogen and oxygen, which are critical resources for a lunar society.

With access to lunar ice, ispace can initiate the next step and start building fuel stations on the Moon. A prerequisite for repeat missions, long-term presence, and human settlement on the surface. These depots would form the foundation for a lunar infrastructure, allowing scheduled flights and supporting continued construction on the surface. Even though such a society is not yet a reality, each of ispace's missions is

designed to contribute to the future of "Moon Valley". By 2040, this community will have a functioning lunar economy, host a permanent settlement of 1,000 residents, and serve as a travel destination for 10,000 annual visitors.

I had entrusted ispace to successfully transport their payloads worth \$16 million. Including a deep space radiation probe, a food production experiment, water electrolyzer equipment, and a UNESCO memory disk. On June 6, 2025, over 500 employees, stakeholders, and government officials gathered in Tokyo. With their attention fixed on the large screen, they were ready to witness history being made. But two minutes before

the scheduled touchdown, the signal was lost, and the screening room grew silent. At 192 meters above the lunar surface, the lander's laser range finder malfunctioned, leading it to miscalculate the distance and fail to reduce speed.

Close to Mare Frigoris, a spot 900 kilometers from the Moon's north pole, RESILIENCE crashed. Representing ispace's second failed mission within two years. Soon after the mission control center announced the loss, Hakamada turned to the public. "We will strive to restore trust by providing a report of the findings to our shareholders, payload customers, HAKUTO-R partners, government officials, and all supporters of ispace." Japanese Prime Minister Shigeru Ishiba clarified his

SPECIAL REPORT



continuous support through a post on X, stating, "Expectation for ispace has not faded."

Later, when the technical analysis was released, Hakamada once again emphasized perseverance. "ispace will not let this be a setback. We will not stop here, but as determined pioneers of the cislunar economy, we will strive to regain the trust of all stakeholders and embark on the next mission. 'Never Quit the Lunar Quest.'"

As with the first crash, the Mission 2 failure also had

financial implications. After experiencing extensive sell orders on the stock market and closing at the daily limit-low, the stock price dropped 29% in one day. Although ispace's market capitalization remained over \$766 million, investors' confidence was tested once again. ispace's CFO, Jumpei Nozaki, approached this at a press conference saying, "We're not facing any immediate financial deterioration or distress because of the event." However, Jeremy Fix, Chief Engineer for ispace U.S.,

clarified that the company cannot endure repeated

mission losses, as it does not have "infinite funds."

Each mission had required substantial investment. Mission 1 exceeded \$100 million, and Mission 2 is expected to have involved a similar level of investment. The two failures not only affected credibility but also cash flow. With focus shifting towards the upcoming Missions 3 and 4, ispace raised new capital through a public share offering worth \$120 million. Additionally, the company received a \$42 million contract from Japan's Space Strategy Fund to construct a lunar satellite. The new funding was necessary both to cover increasing losses and to secure new capital for future developments. For

the fiscal year ended March 2025, ispace reported net losses of approximately \$79.6 million, five times those in 2024.

Making additional financial resources crucial to sustain the mission timeline. With a second failed mission, new challenges arise.

Not only to perform a soft landing on the Moon, but to convince the world that its vision was achievable and regain trust from investors.

The New space sector

Worldwide governments' roles have shifted; another space race is still unfolding. Governmental investment continues to increase, and in 2024, global public space budgets reached an all-time high of approximately \$122 billion.

However, governments are not the main drivers of the increased competition. Private investment has also grown rapidly, to \$7 billion in 2024, representing a 20% increase in one year. In 2024, commercial revenues represented 78% of the total industry activity.

By 2024, more than 330 companies across 91 countries operated in the space value chain. Contributing to a fragmented landscape where innovation unfolds in various directions.

Today, New Space has grown into a sector with multiple strategic opportunities and market segments. Companies operate within areas such as satellite services, space tourism, earth observation, climate solutions, national security, resource extraction, industrial opportunities, and science.

In 2023, the global space economy reached a market size of \$630 billion, with projections to triple in size by 2035 to \$1.79 trillion. The sector's performance has remained robust with year-over-year growth. By 2023, the annual revenue had nearly doubled compared to a decade earlier, reaching \$570 billion, and reflecting the five-year 7.3% CAGR.

Pioneering the lunar economy

As the New Space industry grew, Hakamada was determined to position ispace as a pioneer of the emerging lunar economy. A system of economic activities on and around the Moon that, in time, can support long-term human presence in space. In a public statement, he wrote, "Our goal is to build the cislunar economy, one in which the Moon and Earth are economically and socially connected."

But ispace was not only aiming to revolutionize the world with new technology. The team needed to move faster than competitors such as SpaceX, Astrobotic, Intuitive Machines, and Firefly Aerospace. In a field with no established pathways, ispace had to take substantial technological and financial risk. But Hakamada knew that if they succeeded, a completed soft landing would bring strong partnerships, visibility, and power to influence the industry.

To progress, constant technological innovation was required, but that also meant innovating under high uncertainty and risk. Every mission was not only worth years of investment but needed to assure stakeholders that ispace's vision was possible. Serving as both a technical demonstration and a signal to stakeholders that the lunar economy could become a sustainable industry.

The same challenges affected ispace's competitors. Companies across the New Space sector faced operational risk, limited access to funding, uncertain demand, long investment cycles, regulatory uncertainties, and questions about market maturity. But for ispace, the pressure was intensified. After two consecutive unsuccessful landings, stakeholders' trust had become more valuable than ever before. With few proven business models in the space economy to rely on, doubts were even more difficult to dispel.

ispace's public partners

Even though private companies have proven crucial for the industry's progress, governmental agencies

remain essential. Through these long-term partnerships, ispace unites public interests with private innovation, becoming a key player in the collective vision to make the Moon accessible. When founding ispace, Hakamada knew that the company would need institutional partners across the globe to succeed, and these relationships have evolved over time.

In 2016, ispace and JAXA signed their first agreement. Since then, JAXA has supported ispace through regulatory approvals, funding, technical expertise, and access to Japan's space innovation network. In Europe, both European Space Agency and Luxembourg Space Agency hold critical roles in ispace's future resource extraction. Before Mission 1 and 2, ispace partnered with ESA to gain access to the European Satellite Communication Network, Estrack.

The ground stations later handled communications between the lunar lander and mission control during the missions. While ESA offers technical capabilities, Luxembourg Space Agency has the regulatory framework enabling the future commercialization of lunar resources.

When ispace expanded to Europe in 2017, Luxembourg was the only European country with legislation granting companies ownership of the space resources they extract,⁷⁴ making it an essential partner for securing future revenue streams.

Since 2022, NASA has connected ispace to the Artemis Program, America's long-term lunar strategy. Through NASA's Commercial Lunar Payload Services initiative, ispace was selected to build the APEX 1.0 lander to support Team Draper's 2026 mission. This layered relationship has enabled ispace to become part of Artemis and NASA's return to the Moon.

Interdependent collaborations

According to iSpace, these public partnerships has been fundamental for ispace's operations. Without them, ispace would not have secured the funding, technical infrastructure, or regulatory framework to execute its missions.

With every partnership, Hakamada learnt that it was not just knowledge and capability that they were gaining. Every agency standing behind ispace signaled trust to other stakeholders. However, the benefits are mutual. Public agencies gain commercial efficiency, agility, and technical expertise, enabling them to execute lunar missions more regularly at a lower cost. But, for ispace, these partnerships also present constraints. It requires compliance with bureaucratic processes that do not always align with the team's flexibility and decision-making.

The collaborations distribute risk, both operationally, financially, and reputationally. When missions succeed, both partners benefit. When missions fail, the consequences affect every actor involved.⁷⁹ With this, new types of interdependencies take form. ispace relies on agencies for resources and mission opportunities, while agencies pressure ispace to deliver technological milestones.

As ispace prepares for future missions, the dependence of public agencies will continue. Success will not only be determined by technological progress, but also by maintaining trust, alignment, and collaborations with these central stakeholders. Moving forward, Hakamada knows that balancing collaboration and autonomy will be critical as ispace seeks to secure its position in New Space and the lunar economy.

iSpace next mission

The atmosphere inside ispace headquarters had started

to shift. After two failed landings, Mission 3 had become even more critical. It was no longer just a next step in ispace's lunar journey, but a defining one. Proof to themselves and the world that their vision was achievable.

The Mission 3 plans dated back to 2022, when NASA awarded Team Draper and ispace \$73 million. But the setbacks from previous missions forced ispace to reassess its approach. After the technical analysis of Mission 2, ispace announced that development costs and the change of landing sensors for Mission 3 would increase costs by almost \$10 million.

Earlier in 2025, the company had already declared that it would shift the originally planned engine system, which not only had financial consequences but also pushed the schedule from 2026 to 2027.

Despite the setbacks, the team was determined. The business development team continued to sign contracts with payload customers, engineers tested and refined the design, and Hakamada aligned operations across Tokyo, Denver, and Luxembourg. As the plans for Mission 3 were finalized, attention increased around the lunar lander that would be at the center of ispace's next attempt, APEX 1.0. During the 385,000-kilometer travel from Kennedy Space Center to the Moon's far side, Schrödinger Basin, nothing could go wrong. The lander was set to deploy two communications satellites to support future operations and transport 300 kilograms of government and commercial instruments, including electromagnetic sensors, a heat flow probe, and seismometers.

One evening, as Hakamada studied the updated plans for the landing sequence, his eyes wandered. In his office was a model of Moon Valley 2040, and looking at it caused both hope and frustration. A future with permanent human settlement on the lunar surface, built on sustainable resource extraction and a functioning lunar economy, was near but still far away.

While still recovering from the previous failures, the pressure for Mission 3 intensifies. Stakeholder relationships are tested, investors expect results, and public-private partnerships gain strategic importance. All while employees must adapt to new technical insights, and management needs to align various stakeholders to reach its ambition of pioneering the lunar economy.

Through the case and the following in-class discussion, students reflect on managerial challenges and strategic decision-making in an emerging, highly uncertain market. The case demonstrates the challenge of navigating failure in New Space and presents an industry where organizational legitimacy is as central as technology. Everything the team had worked for depended on what would happen during the journey to the Moon's south pole and APEX 1.0's landing. One successful touchdown could rebuild stakeholder trust, restore confidence, and enable the future he dreamt of. But in this moment, with the weight of the past years and Mission 3 approaching, one question began to grow. How many chances does a lunar pioneer get?

While still recovering from the previous failures, the pressure for Mission 3 intensifies. Stakeholder relationships are tested, investors expect results, and public-private partnerships gain strategic importance. All while employees must adapt to new technical insights, and management needs to align various stakeholders to reach its ambition of pioneering the lunar economy.

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BUSNESS REPORT

MDA Space: World's most technologically sophisticated geospatial company



In 2022, MDA reached new heights on multiple fronts – and we did it by executing, innovating and seizing new opportunities in the global space economy. As that market continues to emerge, MDA is capitalizing on it.

By the numbers, it was another year of strong growth: our revenues grew to \$641 million, up 34% year over year. We posted solid profitability with adjusted EBITDA (excluding non-recurring items)1 of \$141 million, up 26% year over year, and adjusted EBITDA margin (excluding non-

recurring items)1 of 22% driven by our team's execution. Our backlog at year-end stood at \$1.38 billion, up 59% over the prior year, and at a level that sets us up well for 2023 and beyond. I am also extremely proud of our sustained ability to fund growth with cash from operations.

In 2022, MDA generated \$57 million in operating cash flow which was reinvested in the business to support multiple growth initiatives. The space market continues to expand at a healthy clip, growing to US\$424 billion in 2022,

an increase of 8% over the prior year. MDA says the company is seeing more governments around the globe invest in space, with 86 nations spending a total of US\$103 billion in 2022, up 9% year over year. And that growth is projected to continue, with market research firm Euroconsult estimating that the space market will reach US\$737 billion within a decade, and the US Chamber of Commerce forecasting that the space economy will exceed US\$1.5 trillion by 2040. With more than 2,700 staff in Canada, the

United States and United Kingdom fully focused on this key market, MDA has an enviable talent pool to capitalize on this opportunity.

In terms of space infrastructure, spacecraft launch activity continued to unfold at a record pace; in 2022, a total of 2,521 spacecraft launched globally, an increase of 36% versus last year, with 89% of those spacecraft operated by commercial players and the majority comprised of communications

satellites. Last year, MDA Space made significant and strategic gains in some of the fastest growing areas of the space economy, announcing a steady stream of new strategic contracts to advance our position in the rapidly expanding market. In February, MDA took a sizeable step up the satellite market value chain when it was selected as the prime contractor for Globalstar's new low Earth orbit (LEO) constellation, which will support Apple's direct-to-device functionality.

In the same year, the Canadian Space Agency (CSA) awarded MDA the contract for the next phase of Canadarm3 which will see MDA leading the preliminary design of the next generation, industry-leading robotics system to be used aboard the NASA-led Gateway space station in orbit around the Moon.

In April, the company announced a first-of-its-kind development program with Lockheed Martin and General Motors to integrate MDA's commercial robotic arm technology on their planned human-rated lunar mobility vehicles which will be used by astronauts as part of NASA's Artemis program to return humans to the Moon. In May, MDA announced the first of two commercial robotics contracts with Axiom Space to provide external robotic interfaces for Axiom Station, now under construction and on schedule to be the world's first commercial space station in orbit.

Over the summer, MDA also announced a series of contracts with US prime contractors, including Lockheed Martin, York Space Systems and Airbus OneWeb Satellites to support a number of space security and LEO communication constellations.

And our team also made significant progress on CHORUS its next generation commercial Earth observation mission that will provide even greater capabilities and intelligence to help tackle global issues including climate change and the sustainability of the world's oceans, among others.

Incorporating C-band and X-band SAR satellites operating in a unique mid-inclination orbit, this revolutionary constellation will provide the most extensive radar imaging capacity available on the market, with higher imaging performance, higher frequency imaging, more imaging time per orbit, fast tasking, and near real-time delivery. MDA's team has already conducted the mission Critical Design Review (CDR) and started unit level build activities, both major development milestones in bringing to market this industry-leading innovation and capability.

More than 2,700+ highly skilled MDA staff are powering our growth and giving us the scope and scale to execute on

these opportunities and more.

A strategy to capitalize on market waves

With a diversified space technology portfolio that is already driving profitable growth, MDA is ideally placed to strengthen its market position and capitalize on multiple waves of the expanding space market as they evolve and emerge.

The company is leveraging world-leading competitive strengths in Satellite Systems, Geointelligence, Robotics and Space Operations to accelerate our growth, executing specific strategies for each sector while investing in research and development, manufacturing, product development, and in scaling the business. And we are seeing our strategy translated into tangible results.

Today, the company is seeing expansion in Satellite Systems, where the market for LEO satellite constellations is growing and where MDA is designing and developing constellations and satellites systems that enable a wide range of applications everything from communications and broadband internet to the Internet of Things (IoT) and direct-to-device mobile functionality. MDA's investments in digital payload technologies are accelerating our strong market position across this growing space communications sector.

The U.S. Chamber of Commerce estimates the global space economy will expand by over US\$1.1 trillion from current value to 2040, to US\$1.5 trillion annually. This growth is expected to be driven by continuous commercial and government investments in space, which reflects the importance of space in an increasingly global, sophisticated, and data-driven world. Commercial spending on space is being driven by heightened levels of equity investment, which have exceeded \$270 billion since 2013, according to Space Capital. Global government budgets for space also reached an all-time high of US\$103 billion in 2022, a 9% increase over 2021, according to Euroconsult.

The growing commercial space economy has resulted in government customers, including civilian space agencies and defence departments, seeking commercial collaboration in business activities. MDA has responded, and continues to respond, to several future government initiatives regarding co-investment by industry, and/or an industry services model to provide EO as-a-service, on-orbit robotics operations as-a-service, and space based communications as-a-service. The company see this on Government of Canada engagements on projects such as the Earth Observation Service Continuity program, Defence Enhanced Surveillance from Space program, the Enhanced Satellite Communication Project, Polar, and Canadarm3.

"The company is seeing growing need and interest for Geointelligence information and insight about what is happening around the

world, with rising customer demand for our existing Earth observation data and analytics services driving even greater interest in our next generation platform CHORUS", says the CEO. MDA's investments in CHORUS and in multi-sensor fusion applications to integrate output from multiple sensor types to create valuable information products for our global customer base continues our decades-long leadership in areas such as maritime domain awareness.

Industry 5.0 satellite constellations and technology

In Satellite Systems, MDA is building on our decades-long history of producing large, bespoke satellites for geostationary orbit to exceed customer expectations, while simultaneously addressing the new market demand for high volumes of satellites for non-geostationary constellations. The company is flexible and agile, and are committed to its customers' missions.

As a prime contractor and a supplier of satellite systems and sub-systems, commercial and government customers worldwide trust MDA to provide antennas, electronics and payloads in low Earth orbit (LEO), medium Earth orbit (MEO) and geostationary orbit (GEO). Its strategic vision to embrace new manufacturing techniques and software-defined satellite payloads has placed MDA in a global leadership position. MDA is well placed to support our customers now and into the future.

The company's next generation communication technologies consistently deliver space-based broadband Internet and direct satellite-to-device connectivity from non-geostationary orbit NGSO, which includes LEO and MEO satellite constellations as well as solutions that span the full communication frequency spectrum.

MDA is also building on its heritage of providing satellite subsystems for constellations such as O3b, Iridium NEXT, and OneWeb to bring next-generation capabilities to future NGSO constellations.

It's state-of-the-art high-volume satellite production facility in Montreal contains one of the largest compact ranges for satellite testing in the world. It also has one of the largest near field ranges in the world, and a wide variety of thermal, environmental, Passive Inter-Modulation and vibration test facilities. MDA also recently established a fifth generation manufacturing environment employing robotic assembly to rapidly manufacture satellite constellations.

MDA's new facility enables the company to act as a satellite prime contractor,

while also serving as Globalstar's new LEO constellation provider. As part of this contract, MDA will be responsible for designing, manufacturing, assembling and testing 17 satellites with the option for Globalstar to purchase up to nine additional satellites.

Recently, MDA also announced a series of strategic awards from US-based customers to support government space security and communications satellites. These awards, including a contract with Lockheed Martin to support the Tranche 1 Transport Layer LEO constellation for the U.S. Department of Defense (DoD) Space Development Agency, represent MDA's early entry into this growing market opportunity and are in line with our strategy to expand our role in the NGSO constellation market for both civilian and defence applications.

Enhancing how and when we see the world

In Geointelligence, MDA is providing vertically integrated Earth observation solutions, from designing and building C-band synthetic aperture radar satellites and multi-sensor ground systems, to satellite imagery, data products and analytic services. Since 1995, it's industry-leading capabilities have provided decision-makers with actionable information insights to address some of the world's most pressing challenges. Government and commercial organizations around the world trust MDA to provide them with the information they need, when they need it. As owner and operator of RADARSAT-2, MDA is proud to be one of the largest space-based radar information providers in world, collecting, processing and disseminating Earth intelligence from space to global customers. It's advanced Earth observation systems operate under all weather conditions, day or night, to provide access to near real-time imagery 24 hours a day, 365 days year.

MDA's extensive information archive covers approximately 90 billion square kilometres of the Earth's surface with more than one million images, serving as a vast foundation for change detection analytics.

MDA's full suite of advanced Geointelligence solutions provide its numerous customers with timely, accurate and mission-critical information. The advanced RadarSat sensors deliver information and actionable insights in minutes for a wide variety of applications and sectors, including environmental monitoring, maritime domain awareness, national security and defence applications, urban planning, land use, energy and resource utilization, and agriculture and forestry management.

While its end-to-end solutions include a full range of multi-satellite ground

stations that receive, process, distribute, archive and exploit imagery from RADARSAT-2 and other satellites. So far, the company have installed more than 70 receiving ground stations in more than 25 different countries, which, over time, have processed data from over 20 different satellites.

MDA's new multi-sensor Earth observation constellation, CHORUS, is in development and will open the aperture and the art of the possible harmonizing a multitude of unique perspectives to provide new insights about our planet.

Building on the legendary RADARSAT program, CHORUS will provide the most extensive satellite radar imaging capacity in the market in one system. With advanced C-band and X-band SAR, innovative new technologies and modern operations concepts, it will deliver next-generation Earth observation data, imagery and analytics, with tipping and cueing, client-controlled priority tasking, and subscription-based services.

"The greatest moments in Earth exploration happen collaboratively, when diverse insights and information are united to create something bigger and more meaningful. With C-band SAR, MDA can find a needle in a haystack. And with the addition of X-band data, the company will be able to thread that needle. By pushing the envelope and creating flexibility to integrate additional data sources and sensors, we change how and when we see the world."

One of its key defence intelligence programs is the Canadian Surface Combatant for which the company is designing and integrating the Electronic Warfare suite system for 15 Royal Canadian Navy warships. The ships are scheduled to be built over the next 20 years and are expected to serve the Royal Canadian Navy for decades. This program represents over \$1.5 billion of potential revenue for MDA. It's plan to leverage the Canadian Surface Combatant's sensor, laser warning, and electronic system technologies to serve international defence customers as they upgrade their naval fleets over time.

These back-to-back commitments signal not only the speed of the market opportunity before MDA, but the growing importance of the space economy on a national level.

Canada is not alone in taking bold moves and making new investments. Recognizing a growing business and industrial opportunity, more than 75 government space agencies now exist around the world. And as launch costs steadily decrease, more private companies are gaining access to space for the first time, spurring greater commercial activity and investments.





INTERNATIONAL REPORT

Why some universities generate more spin-out than others?

In 2024, two satellites that are the result of successful collaborations between the University of Sydney and industry and government partners were launched into space aboard a SpaceX Falcon 9 rocket, the Transporter-11, from Vandenberg Space Force Base in California, US.

Both satellite missions are led by training consortium, the ARC Training Centre and the University of Sydney. The small satellites, the Waratah Seed-1 and the CUAVA-2 were deployed carrying payloads that aim to expand NSW's space tech and research capabilities, demonstrate new space technologies and gain a better understanding of the space environment.

"I particularly acknowledge the funding and help provided by the Faculty of Science and the Provost for this successful launch," says the research team. The payloads started sending back telemetry on day one and will now spend several months in space gathering vital information to transmit back to Earth to help develop further leaps in space technology.

In a university setting, a "spinoff" is the result of the creation of an independent company through the sale or distribution of new shares of an existing business or division of a parent company, it is sometimes referred to as a spinout. In universities, University spinoffs or academic spinoffs mean "a special start-up company that is founded by an academic inventor with the aim to exploit technological knowledge that originated within a University setting in order to develop products or services".

However, the difference between a "start-up" and a "spinoff" is that a spinoff is created by the University or a Research institution, with technology owned by the University, financed by the University and managed by the researchers or academics of the University. Whereas, when a start-up has to buy the technology license from the University, as well as not has been funded and managed by the University.

When a startup finds a scalable business model, it ceases being referred to as a start-up. Start-ups are designed to go rapidly, make major changes or radical innovations, from which make impact to change the economy and the society, such as the cases of Microsoft, Apple, Google. The notion of a start-up is associated with uncertainty, breakthrough and always contains creativity, especially in a university setting. The "creative" factor, on one hand promotes the

viability of start-ups, but on the other hand, makes start-ups facing with financial risks.

Spin-out process typically begins with an 'invention disclosure' from an academic to the university. The academic informs the university that they have a discovery or technology with commercial potential. The technology is often at a very early stage so the academic may or may not have ideas about how to commercialise their research. The team in the university supporting commercialisation is typically called the technology transfer office. Then, the technology transfer office will work with the academic to analyse the potential commercial opportunity and decide whether to formally protect IP through a patent, at the university's expense.

The technology transfer office and academic will then jointly decide whether to licence the IP to an existing company for a licensing fee or use it as the basis for a spin-out. If the technology requires further development often referred to as translational, development, or proof-of-concept research, the university often supports this through translational research projects and grants, either from public funds or the university's own.

In some cases, the spin-out process can often take an unnecessarily long time, but there is no comprehensive data on the time taken for different steps in this process. One spin-out founder suggests that spin-outs take 4-12 months from the point at which the academic founder and technology transfer office agree to spin-out to completing all necessary processes to having all agreements and paperwork complete to establish the company.

For instance, life sciences spin-outs tend to have complex IP and seek external executives, whereas software spin-outs tend not to have patents and are more likely to have a sole academic founder as CEO. However, this is not a hard rule and there are instances where software has multiple contributors which can present complexities.

Academics engage with spin-outs in two primary ways, either leaving their academic position to work permanently in the spin-out or acting as a scientific advisor to the spin-out whilst retaining their university employment. A much smaller number of academics maintain both university employment and an executive role in the spin-out, although above a certain size of company this becomes impractical.

University academics are required to carry out a certain amount of research, teaching, and administration. Most universities have policies to enable academics to spend time on outside activities each year typically around 30 days. This time can be used for private consulting, advising spin-outs or other activities.

However, leaving academia for a spin-out can be a significant risk to an academic career. Routes back are limited, as years spent on the spin-out typically reduce the number of publications or other academic outputs that academic hiring decisions are heavily weighted on. This is the case even for spin-outs with demonstrable impact.

Some, although comparatively very few, universities or regimes operate a policy of IP being owned by academics, not by the universities, sometimes called 'professor's privilege'. Some academic literature suggests that this may increase the number of spin-outs, but a larger proportion of these spin-outs may be created to carry out further research and consultancy rather than to become high-growth ventures, which is not the outcome that supports the economic growth benefits. Professor's privilege gives academic founders freedom to operate independently of the university and the technology transfer office. This can remove friction from working through universities, but can also lose important benefits offered by the university.

For a successful commercialization, one of the first stages of the spin-out process is due diligence on the IP and securing it. This requires checking the funding history of the research that led to the IP, which can go back decades and across multiple research institutions. For patents, this also involves running searches for related IP ahead of putting in an application. This may need to be in multiple jurisdictions which inevitably adds time to the process. If knowhow is to be licensed, the due diligence can be more complicated due to the less formal nature in which knowhow is recorded. At this stage, it may be uncertain whether to create a spin-out or license out the IP.

Today, University-linked venture funds are emerging as influential investment vehicles, offering exclusive access to top student, faculty, and alumni founded startups and leveraging the power of alumni networks. This trend is reshaping the venture capital landscape, making these funds an increasingly attractive option while opening up venture as an asset class to accredited individual investors. Universities have

always had a big influence in venture capital. They provide breeding grounds for new technologies, fed by the billions of dollars in grants from both public and private institutions.

Spin-out executive management teams

Founders may wish to leave their university to lead a spin-out. The review has heard that this is more common with PhD students or post-doctoral researchers compared with principal investigators. However, some founders may feel more suited to act as Chief Technical and Scientific Officer and the spin-out may also seek a more commercially experienced individual for CEO.

Some founders often wish to maintain some academic link or position whilst still being involved, part-time, or as an advisor and consultant, with the company. However, flexibility is key and universities will need to continue to adapt and embrace different working models whilst not undermining their core mission of teaching and research. In some cases, there may be no academic founder willing to leave academia and the whole executive team would need to be recruited. Finding outside talent can take a significant length of time, especially where specialist skills are sought.

However, negotiating the deal between the university, spin-out founders and investors is a necessary part of the spin-out process. However, sometimes the negotiations can take an unnecessarily lengthy amount of time which is partly why some universities have adopted a standardised set of express deal terms to speed up the process. This can be good practice, provided that the express deal terms do not inhibit investment and are considered fair terms as identified by this review. Other universities seek to negotiate deals on a case-by-case basis. This can work if negotiations proceed quickly and on fair terms.

Arguably, the largest point of contention around deal terms is the equity share taken by universities. These have decreased from an average of around 25% to around 18% over the past ten years. In the current investment scenario, large stakes can make spin-outs less attractive for investment. This is especially the case, at later rounds of investment or for international investors who may be accustomed to universities taking lower equity stakes.

Nevertheless, spin-out founders often need a sufficiently large stake to have the financial incentive to continue with a spin-out instead of pursuing other lucrative options: if the founders decide to leave, the investors' capital is at greatest risk as the spin-out is less likely to survive. Recent

research suggests that larger university equity stakes reduce the chance of the spin-out receiving venture capital investment in less science-intensive companies, but not the amount of investment overall.

Many of the top UK universities are doing most deals at 5-15% equity, which is comparable to the US once different approaches on equity dilution and royalties are taken into account. However, the process of negotiating down to this level is often unnecessarily difficult, leading to delay, legal costs incurred on all sides, and loss of goodwill between negotiating actors. This is partly because some technology transfers have been slower to adjust their opening bids to reflect changing market norms, but can also be due to a minority of founders with an unrealistic view of their contribution to the spin-out demanding unreasonable terms.

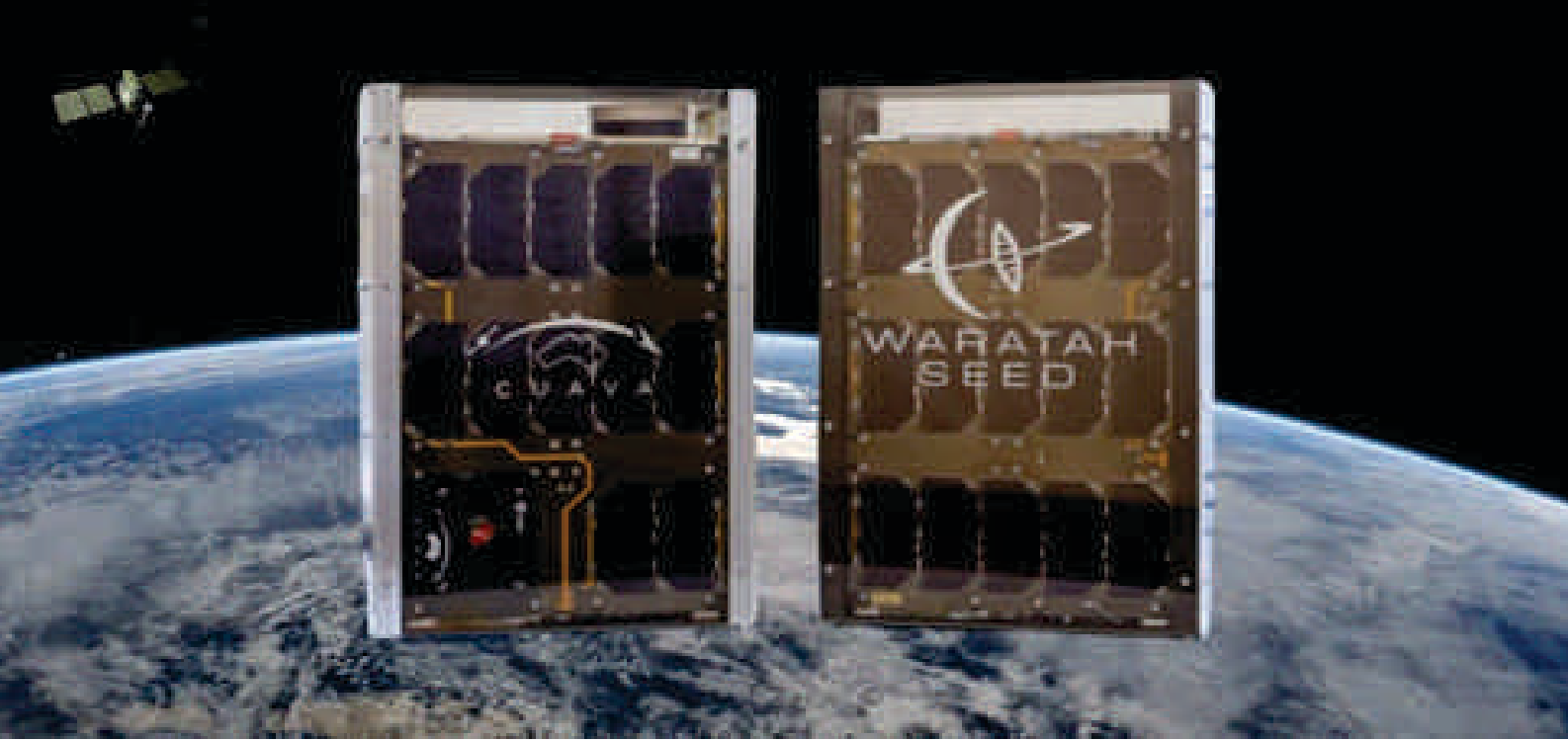
Our survey of spin-out founders revealed that negotiations on university equity stakes start at an average of 34%, but just over 1 in 4 founders reported that their university's first offer was 50% or more.

According to one UK report, Patents Act 1977 and Patents Rules 2007, the inventors of IP all have equal status. Universities usually leave it to co-founding inventors to decide who receives what share of founding equity in a company based on IP. The split of equity between founders joining the spin-out as permanent employees and those staying behind in the university often operating as an advisor has been found to be on average equal. However, investors opined that they prefer that founders working permanently in the company own the bulk of the founding equity to reflect the risk taken by the founder in leaving academia.

However, founders working permanently in the company should be properly rewarded and incentivised to continue engaging with the spin-out during what is often an uncertain and challenging process. Academics who remain in academia but work part-time or perform extensive consulting for the spin-out also need to be rewarded.

Financing university proof-of-concept research

Universities are increasingly offering PhD students access to training to develop commercial skills, thereby establishing an entrepreneurial mindset and the necessary commercial skills in the future generation of academic researchers. Therefore, 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. Today, running 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. Many 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.

Some university based programs are focused on developing early-stage research into practical solutions, involving developing a technical proof of concept or prototype.

In some cases, spin-outs leave a university too early, simply in order to access funding that is only available to businesses, due to a lack of development funds within the broader ecosystem. However, spin-outs that are created too early are less likely to succeed. Again, decisions on who gets funding are often taken by committees of academics who may lack experience and expertise on what research project has genuine commercial potential.

In 2022, UK universities made £244 million from licensing intellectual property, and only £86 million from sales in shares, which collectively equal 2.1% of their research expenditure. Income from both sources tends to be driven mostly by a small number of large successes, and both can fluctuate

considerably year-on-year. This income is disproportionately weighted towards universities with the largest research incomes; the few universities with the largest research expenditure made around 50% of licensing income and around 60% of share sales income in 2021/22.

The number of licenses has increased in recent few years, but the review has heard that large corporates are becoming less interested in direct licensing of university technology, especially for the most lucrative therapeutics licenses. Instead, corporate innovation is increasingly done by acquiring start-ups or spin-outs. Over the coming decades, there could be a shift from licensing to share sales revenues.

Equity investment and the role of investors

Investment into university spin-outs has increased considerably and in UK, the figure was estimated at £1.11 billion in the academic year 2016, 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.

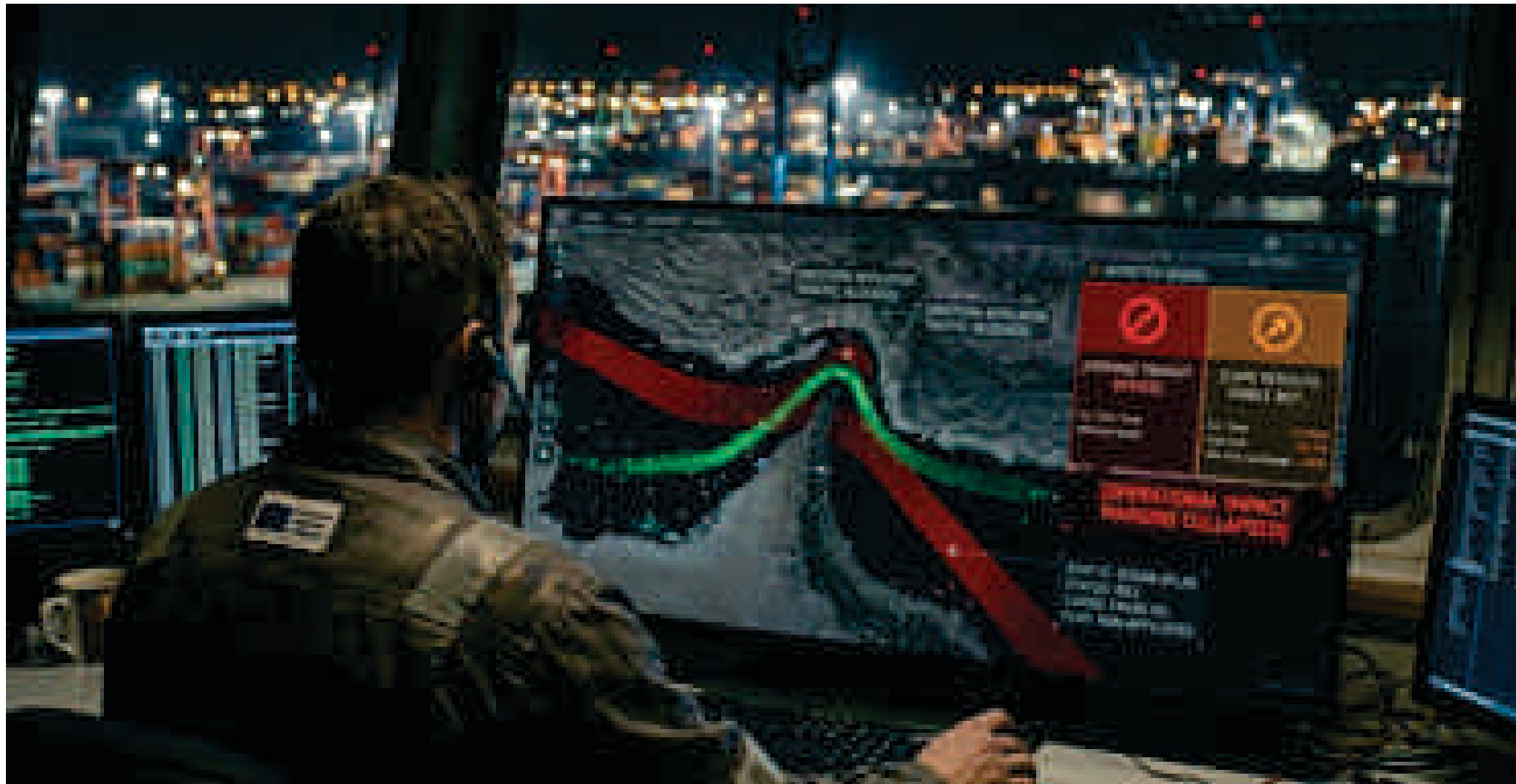
Most spin-outs are based on early-stage technology

that requires further development before becoming commercially viable. Due to the high overheads associated with R&D, most spin-outs rely on equity investment to fund their operations from the outset. Equity investment, especially from venture capital funds but also from angel investors, corporates, and private equity, usually comes with commercial expertise to help guide the business strategy and route to market. Outside the university environment, attracting finance was a key barrier to starting their spin-out that founders reported in our survey. This chapter explores the spin-out investment ecosystem in more detail.

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.

The creation of university-affiliated funds has coincided with large increases in the number of spin-outs and the amount of equity they have raised. Before Oxford Science Enterprises was founded, the University of Oxford launched 5-10 spin-outs per year. Since Oxford Science Enterprises was founded, it has launched around 20 in most years. The annual investment raised in Oxford spin-outs has also increased over the same period from around £100 million to over £1 billion.

Number of vessels with lost AIS signals in the Strait of Hormuz increases due to safety



Since the February 2026, there has been an increase in the number of vessels operating in the Strait of Hormuz with lost AIS signals for one day or more, yet another that this increase is linked to disruption in the Strait of Hormuz that has led to a sharp decline in maritime traffic and a breakdown of established shipping patterns.

Since the beginning of the US-Iran war, there has been an increase in the number of vessels that lost signals in the Strait of Hormuz. Most of the instances of vessels going dark in the Strait have been for over one day, sometimes a week.

These periods are so long that these may not be due to loss of signal, rather than intentionally turning off the transponder. Most of the cases where a signal was lost for longer have been vessels less than 5,000 dwt transiting the Strait of Hormuz. These vessels may be turning off their AIS signal to mask their

location for the safety of the crew and vessel, rather than illicit trade.

Ship traffic has collapsed to single-digit daily transits, with instances of only 1–5 vessels crossing per day compared to historical averages of over 130, indicating a collapse of over 85–90 per cent in traffic volume, as shown in Figure 4. This sharp fall is not merely cyclical but indicates risk-driven withdrawal by shipping companies, many of which have either suspended operations or delayed transits due to security threats and insurance constraints.

Vessels are increasingly being rerouted to longer alternative passages, including routes around the Cape of Good Hope, leading to more fuel consumption, higher transit times, and decreased fleet efficiency. This has contributed to heightened freight costs and delays across global supply chains, particularly for energy shipments. Additionally, the

disruption has resulted in port congestion and logistical bottlenecks in alternative routes, as shipping networks struggle to adjust to sudden route diversification.

As of the beginning of February 2026, numerous merchant vessels were trapped in the Strait of Hormuz along the Oman ship line and the Iranian port due to naval blockade, while vessels in the wider region were at risk from sea mines, rocket attacks and the threat of detention. The war has caused widespread disruption to global shipping, and is likely to exacerbate ongoing supply chain disruption, port congestion and crew crises caused by US war in Iran.

The ability to readily know the who, what and when of any transiting ship is a critical piece of intelligence. Satellite AIS (S-AIS) provides that knowledge in near-real time for any area of interest. This has been a

boon for marine operations, whether it is for better mapping and monitoring of protected areas, or policing marine pollution. S-AIS extends vessel tracking from just 50 nautical miles off the coast to a complete global picture of the world's shipping.

Satellite AIS technology can accurately monitor all vessels in the vicinity of protected areas, automatically issue alerts of any breaches to geofenced areas, determine traffic patterns and identify culprits of environmental offences in near-real time.

When coupled with historical information, it can also help trace illicit activity back to the offender, increasing the chances to catch violators. Additionally, Satellite AIS data can be integrated with other geospatial tools such as radar and optical imagery and GIS platforms, authorities have the intelligence to help bring their Areas of

Interest down to a manageable size and better prevent marine disasters.

A vessel's automatic identification system (AIS) plays an important role in commercial shipping, transmitting information about a vessel including its location to help avoid collisions. The use of AIS is mandated by the International Maritime Organisation (IMO) but the ability to turn it off and hide a ship's location has been increasingly used as a tactic to hide illegal or sanctioned activity. Short periods of AIS blackout are relatively common and can occur in areas of poor coverage.

As a general rule, long periods of lost signal when a vessel is operating in an area where sanctioned trade has historically taken place and when a draught change is observed are red flags that the ship has deliberately gone dark to mask its activity.

The shipping industry has been affected on multiple fronts, with the loss of life and vessels in the Strait of Hormuz, disruption to trade, and the growing burden of blockage. The industry also faces challenges to day-to-day operations, with knock-on effects for crew, the cost and availability of bunker fuel, and the growing threat posed by cyber risk.

At the start of the conflict approximately 2,000 seafarers were stranded aboard 94 vessels in the Strait of Hormuz, according to reports.

As of June 20, 2026, 84 merchant ships remained with nearly 500 seafarers on board. An estimated 1,500 seafarers have so far been repatriated with manning levels reduced, local ship keepers employed to replace crew, while some ships are in cold lay-up with no crew on board. For those that remain, the IMO called for the urgent establishment of a blue safe maritime corridor to allow the evacuation of seafarers and ships from the high-risk and affected areas in the Strait of Hormuz and the Iranian port. However, it is uncertain whether it will be safe for vessels to leave.

"Seafarers in the Strait of Hormuz are in a perilous situation, stuck on board vessels or in ports with dwindling supplies and under fire. This is yet another blow for the industry and global supply chains. Crew levels have not yet returned to normal levels, and now many seafarers may be unable to return home or rejoin ships," says one maritime expert.

"Despite the tragic situation, and the threat to seafarers caught up in the conflict, the direct impact on shipping from the war in Ukraine has so far been largely contained to the Black Sea," says Captain Rahul Khanna, Global Head of Marine Risk Consulting at AGCS. "However, the war is creating an additional burden on the maritime industry, which is already dealing with ongoing supply chain disruption, port congestion and a crew crisis caused by the pandemic."

A large part of the shipping sector will in some way be touched by the conflict, says Khanna. "In addition to the physical threats to shipping in and around the Strait of Hormuz from mines and rocket attacks, which is affecting trade, the

availability and cost of bunker fuel, and the safety and welfare of crew, many container companies have already pulled out of the Strait, while the tanker sector faces huge restrictions and disruption, as do bulk and general cargo operators shipping Qatar LNG."

During the Iran–Iraq war, attacks on tankers in the so-called "Tanker War" disrupted Gulf shipping and triggered international naval intervention. Today, the threat is more acute. The Traffic Separation Scheme that governs navigation through the Strait routes shipping lanes just outside Iran's 12-nautical-mile territorial waters, placing all transit within range of Iran's coastal artillery, anti-ship missiles, drones, and naval mines.

Military analysts have long assessed that just two well-placed attacks would suffice to halt commercial transit making a forced reopening effectively impossible without a sustained, large-scale military operation. In March 2026, the escalation of the conflict between the United States and Israel on one side and Iran on the other turned this scenario into reality. As Israeli–U.S. strikes on Iran escalated, the Strait shut down. Only Chinese-flagged tankers carrying yuan-denominated cargo have been permitted sporadic passage.

When analysts warn about the Strait of Hormuz, they mean oil and gas. But strip away petroleum entirely and a startling picture emerges: six nations behind this single chokepoint Iran, Iraq, Kuwait, Bahrain, Qatar, and the UAE are the world's leading suppliers in dozens of products that are not directly derived from crude oil.

The United States Energy Information Administration identifies the Strait of Hormuz as the most important oil transit chokepoint in the world. Any disruption, even for a short time, can push oil prices higher and disturb shipping flows. This vulnerability makes it a major concern for both exporters and importers of energy. Countries in Asia, like India, China, and Japan, depend heavily on Gulf oil passing through this Strait.

Impact on seafarers

The disruption in the Strait of Hormuz highlights a critical yet often overlooked dimension of maritime crises, the vulnerability of seafarers. Over the past decade, India has emerged as one of the world's top suppliers of trained maritime personnel, with its active seafaring workforce more than doubling from approximately 117,000 in 2014 to around 280,000 by 2023; the number of women seafarers has also increased significantly, from about 1,700 to over 10,000 during the same period.

Prior to the crisis, seafarers operating in the Gulf benefited from relatively stable conditions, characterised by predictable voyage cycles, regular crew rotations, and uninterrupted tanker traffic along a critical global energy corridor. The escalation has fundamentally altered this environment. According to the International Maritime

Organization (IMO), over 20,000 seafarers remain stranded in the Persian Gulf due to security threats, airspace restrictions, and suspended vessel movements.

India's large global seafaring presence, exceeding 300,000 personnel deployed internationally renders it structurally exposed to such disruptions. Even a limited number of attacks can generate disproportionate psychological and labour market effects, influencing career preferences, wage expectations, and bargaining dynamics with employers.

This risk has already materialised, with Indian casualties rising from three in the early phase of the crisis to at least five deaths and one missing as the conflict intensified, alongside cases of stranded crews and vessels unable to exit the region.

Beyond immediate safety concerns, the crisis underscores broader systemic labour risks associated with chokepoint disruptions, including forced contract extensions, heightened mental stress, and prolonged physical insecurity. Reports from global unions and Indian stakeholders further indicate a rise in seafarer abandonment cases in recent years, with India accounting for a significant share of documented cases worldwide,24 pointing to persistent governance gaps in ensuring timely wages, repatriation, and legal protection.

Potential marine claims and coverage issues

The disruption across the Strait of Hormuz and adjoining Red Sea corridors has triggered a sharp escalation in marine insurance costs, particularly in war-risk coverage, which is critical for vessels operating in conflict-prone zones. The insurance industry is likely to see a number of claims under war policies from vessels damaged or lost to sea mines, rocket attacks and bombings in the conflict zone in the Strait of Hormuz. Insurers may also face claims under marine war policies from vessels and cargo blocked or trapped in the Strait and coastal waters by the Iranian blockade.

More uncertain is the potential for non-war claims in hull and cargo insurance from vessels caught up in the conflict, explains Justus Heinrich, Global Product Leader Marine Hull at AGCS. "We can predict the various scenarios under war cover, but it is much harder to predict how non-war losses could develop for vessels trapped in Strait of Hormuz. There are potential issues around safe navigation, crew, maintenance and salvage for these ships if they are unable to leave."

Marine insurance policies typically exclude the seizure of ships or physical damage caused by war or hostile actions, such as damage from sea mines or attacks on vessels. However, most prudent ship owners will purchase additional [war insurance](#),

which will cover such losses for an additional premium, and for a limited period of time, typically seven days. Insurers are also not able to pay claims that are covered by sanctions. Cover for non-war related damage or machinery breakdown may still be available where insurers are not able to cancel hull and cargo policies for affected ships.

Shipping trapped or blocked in the Strait of Hormuz is a particular challenge. Even if safe passage is afforded out of the conflict zone, vessels may not feel confident in using maritime safe corridors or running the risk of sea mines. However, the longer vessels are trapped, maintenance and crew welfare will be harder to sustain. Some crews have reportedly abandoned their ships in the Strait due to security worries.

Prior to the crisis, war-risk premiums were typically in the range of 0.2–0.3 per cent of vessel value, reflecting relatively stable security conditions. Following the escalation, premiums have surged dramatically rising by over 1000 per cent in some cases to as high as 3 per cent of vessel value.10

This implies that for large tankers, insurance costs have increased from hundreds of thousands of dollars to several million dollars per voyage, significantly raising the cost of transporting energy. With most tankers valued between US\$ 200 million and US\$ 300 million, the new insurance rate of 3 per cent would imply a hull war risk premium of about US\$ 7.5 million, up from around 0.25 per cent, or US\$ 625,000, before the conflict began.

Given the legal and reputational risks, many companies including insurers have pulled back from trade along the Strait. However, insurers will be required to honor valid contracts until renewal, but certain claims have to be denied under sanctions and war clauses, says Heinrich. Cargo in storage or in transit may be damaged or abandoned due to the conflict or if a vessel is trapped in port. Trapped vessels or ships affected by sanctions may suffer machinery breakdown or damage by fire, collision or grounding.

Claims that arise under hull and cargo policies that are not directly related to the war could be difficult to resolve, involving complex legal questions and policy interpretation, explains Heinrich. For example, sanctions may prohibit a portion, but not all of an insurance claim. Claims involving trapped vessels could fall under hull insurance or war insurance, depending on the circumstance.

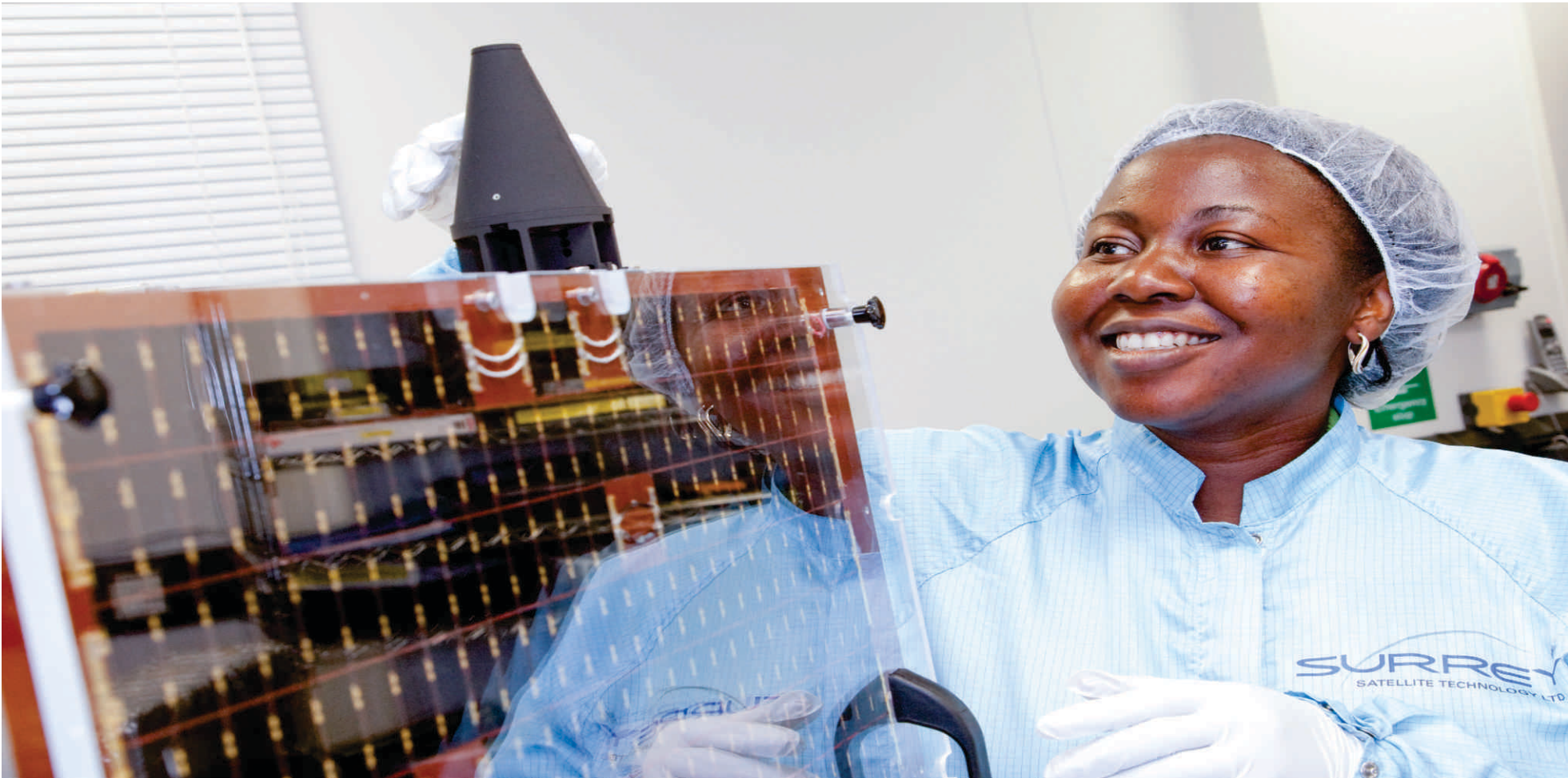
Renewals could also prove complicated for vessels affected by the conflict. For instance, vessels trapped in the Strait may need to continue to pay an additional premium to war insurers to maintain cover, which could become uneconomical if the conflict is prolonged. Trapped vessels may also need to renew their hull insurance to maintain cover. "We have identified vessels that are affected by the conflict and are keeping an eye on the status of these ships," says Heinrich.





SPECIAL REPORT

Africa jumpstart new space economy from know-how transfer



Azercosmos, the Space Agency of the Republic of Azerbaijan, recently marked a decade of operations in Africa by participating in Africa Tech Festival 2025, the continent's largest and most influential technology event. Held in Cape Town from November 11 to 13, the festival brought together more than 15,000 industry leaders, innovators, and policymakers from around the world.

For the past ten years, Azercosmos has helped power digital transformation across Africa by providing satellite communications that reach beyond traditional infrastructure. Azercosmos' satellite services have played a vital role in connecting communities, empowering progress, and unlocking new opportunities across the continent. During the festival, Azercosmos showcased Azconnexus, its advanced satellite broadband service designed to meet the region's growing need for high-speed, secure communication. Whether it's a rural village or a moving transport fleet, Azconnexus offers consistent coverage, helping bridge Africa's digital divide.

"Celebrating ten years of service in Africa is a proud milestone," said Sanan Hasanov Sales Director at Azercosmos. "We're dedicated to building a more connected future for the continent and Azconnexus is

designed to help make that happen." Festival attendees experienced firsthand how Azercosmos delivers satellite solutions for businesses, governments, and communities, empowering users with the tools they need to grow and succeed in a digital economy.

For satellite operator services, Africa is perhaps the largest emerging market. This conclusion follows, firstly, from the size of the potential user base, where the resource is more than half of the continent's population that does not have access to the Internet. On the other hand, according to an analytical assessment, reducing the "digital divide" in the African region is almost impossible with terrestrial data networks only, including cellular communications, since the expected income from the provision of services in the interior of the continent does not compensate for capital investments in building infrastructure.

Satellite communication is still regarded as the most efficient way to provide data transmission services to such regions. Expanding its use could increase the number of Internet users in individual African countries by more than 50 percent.

For internet services, demand is often strongest where connectivity is essential but traditional infrastructure is limited or unreliable. In Africa, that means a lot of interest around remote industrial sites such as mining, energy, and other field operations, as well as government locations and rural or hard-to-reach communities where fiber is impractical and coverage is inconsistent.

We're noticing a shift in coverage to disaster recovery, healthcare, education, and mobile network extension as high-impact LEO use cases. More broadly, outside Africa, we see the same pattern in public safety, utilities, healthcare, remote enterprise, and emergency response. The common thread is that organizations need dependable connectivity for applications, operations and decision-making, says Grant Kirkwood, CEO, Contrivian.

The conversation has moved on from simply getting connected, to focusing on performance, continuing how satellite fits into a wider network architecture. "That is especially true in Africa, where affordability still matters, but where institutions and enterprises also need dependable service to support digital transformation

and remote operations", he said..

Therefore, African countries themselves are demonstrating a desire not to remain predominantly consumers of satellite services. This desire is expressed both by planning activities for the study and use of outer space and by attempts to form the basis for long-term multilateral inter-African cooperation in this area. In 2020 compared to 2019, the total budget provided in African countries to finance activities for the study and use of outer space increased by 55 percent and amounted to about \$503 million. Although it is only 0.7 percent of related global spending, it would be unfair to consider it negligible, as it nearly doubled the cost of this activity in Canada.

Across much of the continent, customers are demanding reliable, high-performance connectivity and infrastructure that can be uneven outside major hubs. That creates a clear need for solutions that are don't depend on a singular access method. The growing requirements in Africa are often more demanding, with remote operations, limited terrestrial coverage and a strong need for reliability, making it a good fit for the Contrivian's solutions. Africa is a representative of where the market is heading. That's why it's so crucial how we scale Contrivian globally.

In 2022 compared to 2021, the budgetary expenditures of African countries provided for the needs of space activities increased by a rather modest amount 2.2 percentage points, while the Asian and European regions saw a decrease in the such expenditures. In physical terms, their value amounted to more than half a billion, which, although significantly lower than in Asia, Europe and North America, is higher than in other geographical regions.

In global terms, there are more than 7,389 satellites in orbit, with 4,084 operational and 3,305 inactive as of 2021. From 2020 to 2021, the number of active satellites has already increased by 27.9 percent. If just half of those commercial space proposals are successful, the space traffic created would more than double the number of satellites deployed over the last sixty years, and create more than six times the number of active satellites. Small satellites represent 75 percent of spacecraft launched from 2011 to 2020, and 94 percent of spacecraft launched in 2020.

Overall, the entire commercial space sector has grown significantly in recent years. Startup space companies garnered 1,212 investments between 2000 and 2020. In the year 2020 alone, three hundred and forty-two companies and individuals invested in one hundred and twenty-four startup space companies in more than one hundred and forty business deals. Total investments in 2020 amounted to \$7.6 billion. New investors continue to enter the ecosystem. Among two hundred and eleven first-time investors in 2020, one hundred and seventeen were venture-capital firms, twenty-nine were angel investors, and thirty-eight were corporations. Investors from the United States accounted for 36 percent of all investors in 2020. It should be noted that not all investors care about advancing the small-satellite industry. Part of the planning cycle for many investors in small-satellite startup companies is a profit-bearing exit strategy.

Over the next decade, the distinction between satellite and terrestrial networks will matter far less than in 2026. The shift is already happening, from separate access technologies into a single, integrated connectivity layer.

We're moving toward integrated connectivity with a focus on orchestration, fiber, wireless, LTE/5G and LEO are increasingly being combined and managed together, routing traffic based on performance and availability, according to Grant Kirkwood, CEO, Contrivian.

Over time, constellation will become more abstracted, where multi-constellation LEO becomes embedded with terrestrial infrastructure contributing resilience and coverage without being visible to the end user.

Organizations won't think in terms of 'satellite vs terrestrial', they'll rely on a single, software-defined environment that delivers consistent performance, regardless of how or where that connectivity is delivered.

Africa's rankings

Though, Africa represents 20% of the Earth's land surface area, more than the USA, India, China and Europe put together, yet these countries invest less than \$50 billion on space activities, while Africa injected only under \$100 million translating to less than 0.2% of the global space budget in the same period. In terms of performance in the space sector, South Africa, ranked in the top thirty countries globally, ranking 23rd in terms of its space budget and 30th in terms of scientific production in satellite technology, accounting for 0.87% of global publications in the domain.

Between 2018 and 2020, South Africa had the largest average public investment in the exploration and use of outer space among countries in the African region. The value reflecting the ratio of GDP to the amount of government appropriations for the "space" industry in 2020 puts South Africa in second place in terms of this indicator on the continent. In terms of the number of satellites launched into orbit,

it ranks second among African states. Basically, they are nanosatellites created for the practical training of specialists in the field of space systems.

Relying on Africa's own scientific and technical potential, historically the most significant in Africa, in creating satellite systems is an important feature of the South African space industry development strategy. Seven out of eight satellites of South Africa were created by the developers of this country.

At 13 satellites launched into outer space by the government, universities, and the space sector companies, South Africa is leading Africa as the most industrialised nation with most of the satellite component developed locally.

Approximately 20 space engineering companies are currently exporting \$1 billion of space qualified components, subsystems, and fully developed satellite systems to the global market, with the ambitious target of \$10 billion by 2030.

These space companies in the upstream space value chain require highly trained professionals beyond the highly theoretical graduates coming out of academic institutions who still need two years of intensive training. With Africa as the most youthful continent, and Youth Communities of Practice being established to represent the voice of young people, platforms like the National Space Conference and the National Earth Observation and Space Secretariat present networking opportunities between youth and captains of industry aimed at narrowing the supply and demand skills gap and co-developing customised solutions that the space companies can fund as investment in their future staff.

Q-KON Pty, Ltd, Q-KON, a leading African-based provider of satellite communication solutions, recently reached a tripartite strategic alliance agreement with Beijing Guodian High-Tech Technology Co., Ltd., and China StarWin Science & Technology Co. Ltd to offer Internet of Things (IoT) services supported by the Tianqi Low Earth Orbit (LEO) Constellation in South Africa. Tianqi, a satellite constellation developed and operated by GuoDianGaoKe Technology, has now reached its first phase with 37 satellites in orbit, forming a global network that provides services for smart cities, marine monitoring, emergency communications and environmental monitoring.

Under the collaboration, Q-KON was appointed the authorized service provider for the Tianqi Constellation's satellite-based IoT services in South Africa, leveraging its market expertise and distribution network to drive commercial operations next year. Meanwhile, Guodian Gaoke will provide the Tianqi LEO satellite constellation and related systems, enabling seamless integration with local businesses. StarWin, in turn, will supply and integrate certified ground terminals, ensuring compliance with South Africa's technical and regulatory standards to support end-user needs.

"Tianqi has filled a technological gap in China's low-orbit IoT satellite field. Its technical systems, performance and terminal indicators have reached internationally leading levels," said Lyu Qiang, chairman of the Beijing-based firm. Tianqi is now exploring the expansion into consumer markets, including smartphones, smart vehicles and wearable devices. The company plans to design and launch additional satellites in its second phase, aimed at enhancing consumer-level applications. Group CEO for Q-KON Dr. Dawie de Wet said, "This strategic alliance marks a significant milestone in our quest to service the African market through the application of leading satellite technologies by expanding the Twoobii portfolio to include an IoT service. Q-KON has always been committed to providing robust and relevant connectivity solutions, and our partnership with Guodian Gaoke and StarWin allows us to expand this commitment into the industrial IoT area.

The Tianqi LEO Constellation provides trusted industrial data connectivity services for the mining, transport, industrial and agriculture industries. By combining Guodian Gaoke's LEO global constellation, StarWin's compliant terminal technology, and Q-KON's deep market expertise, we can provide the critical infrastructure needed to drive productivity and ensure South Africa's

key industries remain globally competitive."

Guo Dian Gao Ke VP Mr. Zheng Said: "Beijing Guodian Gaoke Technology Co., Ltd., Chengdu Xunyi Satellite Communications Co., Ltd., and Q-KON have reached a tripartite cooperation agreement, marking the first project of the Tianqi Constellation in Africa. As a globally networked low-orbit IoT satellite system independently developed and constructed by Beijing Guodian Gaoke, the Tianqi Constellation provides low-power consumption and high-reliability communication services.

Algeria ranked second in terms of average public investments in the exploration and use of outer space among the African countries in 2018-2020. However, although South Africa was more than twice as large as Algeria in terms of GDP in 2020, the size of the South African "space" budget differed from Algeria's by only 13 percentage points. In 2020, it was Algeria that was the leader in Africa in terms of the ratio of GDP to government spending on "space" purposes.

With 6 satellites launched into orbit, Algeria, together with Nigeria, ranks third in the African region. Four of them were microsatellites for earth surface remote sensing, one spacecraft was a nanosatellite intended for training and acquiring practical experience by specialists, and one was a communications satellite.

In 2023, the Algerian high-resolution earth observation satellite ALSAT-2A, the first of a mini constellation of two satellites, celebrated its thirteenth anniversary in space. Placed into orbit by the Indian launcher PSLV-C15 on July 12, 2010, for a nominal lifetime of five years, the satellite continues its mission of providing high-resolution images 2.5 m from its heliosynchronous orbit at 670 km in altitude and evolves with a phase shift of 180° behind its twin satellite ALSAT-2B, which has accumulated almost seven years of activity after it was launched on September 26, 2016.

With 13 years in orbit, the AlSat-2A has made more than 80,000 orbits around the earth, which is about 900 million kilometres. The satellite has provided more than 73,000 images, nearly half of which were intended to promote sustainable national development and that of the African continent, representing the coverage of more than 10,878 million km² and the downloading of a volume of around 8.73 terabytes.

The AlSat-2B is a twin of the AlSat-2A and both were contracted by the Algerian government to Airbus Space Systems France in February 2006. Designed for a lifetime of 5 years, the AlSat-2A was placed in space on 12 July 2010 also by an Indian PSLV launcher. It is known that it was still in service in February 2019, but it is not known whether it is still in full operational condition today. The AlSat-1B is also located at an altitude of 670 kilometres, but its performance is lower, offering a resolution of 12 metres in black and white and 24 metres in colour. Smaller and heavier (103 kilos) than the AlSat-2, it was contracted in July 2014 and manufactured in the United Kingdom by Surrey Satellite Technology Ltd. It is part of an international constellation to which the government of Algiers belongs and has been

SPACE STARTUP PROFILE



providing images and data on natural disasters (DMC) since November 2005.

Before AISat-1B there was AISat-1, Algeria's first observation satellite. Manufactured by Surrey and weighing 92 kilos, it was sent into space on a Russian Kosmos-3M rocket on 28 November 2002 and is located 700 kilometres above the Earth. It ended its operational life on 15 August 2010.

In addition, Algeria also interacted with India when launching satellites. The Agency concluded 3 cooperation agreements with similar organisations from Argentina, Ukraine and France, signed 7 memorandums of understanding and cooperation.

Algeria has developed a national program for the exploration and use of outer space for a twenty-year period until 2040. The activities provided for by this program to be implemented in the near future include the recently launched AISat-3 Earth observation satellite and the AIComSat-2 communication satellite. The exact date of their construction is not defined.

AIComSat-2 has a payload for operation in the Ka band to provide data transmission services at 20 Mbps throughout the Algerian territory and in the

Ku band to ensure the availability of data transmission services at 2 Mbps in the territories of countries located in the north-western part of the African continent.

In the event of development of work on the creation of new satellite systems, which, of course, will require the involvement of foreign partners, the Senior Executives of the satellite industry in Algeria will certainly count on a very wide use of the national scientific and technical potential. Its core is formed by more than 1200 specialists in the field of development and operation of space systems trained as part of implementation of the state industry policy of Algeria. Thus, this state,

like South Africa, cannot be considered as a net consumer of technologies and services offered by foreign suppliers in the field of exploration and use of outer space.

Nigeria ranked third in terms of average public investments in the exploration and use of outer space among the African countries in 2018-2020, with the largest GDP in Africa. The country's size has been relatively constant, but the federal budget for 2021 provided for an

increase by 54 percentage points. Of six satellites were put into orbit by Nigeria, three were Earth observation satellites built by the British company Surrey Satellite Technology Ltd., while the NigeriaSat-X satellite was built by a Nigerian group of trainee engineers.

Two Nigerian communications satellites were placed into orbit, first NigComSat-1, due to a malfunction, was replaced by NigComSat-1R were built by China Great Wall Industry Corporation. The sixth satellite was created by the Federal Polytechnic University in cooperation with Japan for training and acquiring practical experience by specialists.

The National Space Research and Development Agency has over 3,500 employees. As of the beginning of 2021, the agency carried out 23 applied projects for the development of individual economic sectors. The scientific and technical potential of Nigeria allows the development of individual elements of satellite systems, in particular telemetry. However, when creating them, in general, interaction with foreign companies is necessary.

The next announced tasks in the field of space use

are the construction of NigeriaSat-3 and NigeriaSAR-1 earth observation satellites. As of 2020, a foreign contractor has not been selected for the construction order, and the start of work was scheduled for 2021.

At the same time, ensuring the possibility of independent performing all work related to the construction, testing and launch of satellites is called the strategic task of the agency. The Nigerian satellite communications system represented by Nigcomsat 1R is operated by the commercial company Nigerian Communications Satellite Ltd. Nigcomsat 1R has a payload in the C, Ka and Ku bands.

In the broadcast segment, only 5 Nigerian multiplexes are distributed via Nigcomsat 1R. In the segment of data transmission services, Nigcomsat participated in the implementation of the Nigerian National Broadband Plan providing access to the Internet at 10 Mbps for about 3,000 access points and connecting 700 cellular base stations to data transmission networks at 15 Mbps in areas poorly accessible for the construction of terrestrial telecommunication networks.

Nigcomsat lately commences the expansion of its sales services with improvement of the job

arrangement system, which has resulted in the creation of two subsidiaries namely Satellite Infrastructure Company aims to provide services to other operators and Satellite Broadcasting and Broadband Company focused on providing services to end users.

Nigcomsat is also looking to take advantage of economies of scale from the launch of two communications satellites namely NigComSat-2 and NigComSat-3. As of September 2021, the design of the NigComSat-2 satellite system was already underway, in particular, a request for quotation was sent. NigComSat-2 is planned by the customer as a high-performance satellite in the orbital position of 9.5°W. or 16°W with commercial payloads in Ka and Ku bands.

In general, the scope of the emerging areas in the exploration and use of outer space indicates the long-standing desire of Nigerian policy-makers to make this country a significant participant in at least the regional market for "space" services and technologies.

However, an insufficient amount of budgetary expenditures allocated by the state for the development of the "space" industry, the conflict of commercial interests between suppliers and consumers of "space" services and technologies have resulted in the fact that, even 20 years after

development of the "space road map", Nigeria remains at the initial development stage in this sphere. NIGCOMSAT 1R has been an essential component of the Africa's satellite communication industry, providing a variety of services such as direct-to-home (DTH) broadcasting, broadband connectivity, and government communication services. The C-band transponders on NIGCOMSAT 1R are primarily used for television broadcasting, while the Ku-band transponders are used for broadband internet and VSAT services.

Over the years, NIGCOMSAT 1R has been instrumental in providing communication services to various businesses and organizations. For instance, it has been used by television networks such as Nigeria's states networks and NTA for broadcasting major sporting events like the Premier league and the newsfeeds from all over Nigeria, including Sierra Leone. It has also been used by internet service providers to provide high-speed internet access to remote areas.

With the satellite's end of life approaching in November 2026, businesses and organizations need to make accommodations to transition services. For instance, entities currently dependent on NIGCOMSAT 1R's C, Ka, Ku band transponders need to be transitioned to different satellites to guarantee uninterrupted satellite communication services. Being proactive in the satellite transition ensures that businesses and organizations can keep up with the ever-evolving satellite industry and ensure continuous service. The process of moving from NIGCOMSAT 1R to other satellites requires careful planning and execution to avoid disruption of services. Depending on your number of terminals, not all satellite telecommunications companies will be poised to respond.

NigComSat Ltd was the first satellite company to launch one of the most modern telepoint services in the Sub-Sahara region, using the iDX 3.0 on DVB-S2 technology and the 2D-16state MODCOD technique on the iDirect hub system, as depicted in figure 8, through a 7.6 m Ku Band Antenna system with a fully redundant 100W BUC solution supporting multi-carriers.

NIGCOMSAT Gateways and hubs were deployed at the coastal areas of the country to gain access to the huge communication potential of the various submarine landing cables with terrabytes of capacity. The strategic deployment and implementation of a telepoint hub serves as an African convergence port, where the terrestrial fiber can connect and merge with the Communication Satellite Network. The Hub is a gateway for all satellite based networks into the Internet Superhighway with 7.6M antenna system co-located.

The fourth country in the African region in terms of the average public spending on the exploration and use of outer space is Egypt. However, in 2018-2020 the spending volume was constant, amounting to 40 million dollars annually. In terms of the number of space vehicles launched into near-Earth orbit, which amounted to nine units, Egypt became the regional leader as the actual number of space vehicles operated in orbit in the 4th quarter is 9 units.

Egypt's latest satellite, MISRAT-2 satellite was

launched in November 2023 and focuses on remote sensing, with high-resolution imaging technology to support various sectors, including agriculture, urban planning, and water management. The data generated by MISRAT-2 is collected on daily basis by the Egyptian Ground station, monitoring Egyptian territory and coastal lines.

NEXSAT-1 satellite, launched in February 2024, is indeed an Earth observation satellite designed to enhance the monitoring of environmental changes and natural resources. It is equipped with optical sensors that provide medium-resolution imagery, enabling applications in agriculture and disaster management. This satellite provided support for achieving the National Strategy for Sustainable Development through its data in conjunction with Misrsat-2 satellite data. The successful launch of NEXSAT-1, with partial development in EgSA, underscores EgSA's technical capabilities and marks a significant leap in the satellite technology demonstration.

Egypt becomes the first African country with the capability to assemble, integrate, and test (AIT) satellites, following the delivery of two China-funded prototype satellites for the MisrSat II satellite project. The executive officer of the Egyptian Space Agency, Sherif Sedky, stated that the tests conducted on the satellite models inaugurated the largest satellite assembly, integration, and test center in Africa and West Asia, built through a grant from Beijing. This center not only localizes the satellite industry in Egypt but also positions the country as a leader in technology transfer to Africa.

China's assistance in establishing Egypt's satellite assembly center as well as building a remote sensing satellite helps the country become Africa's pioneer in the space field, said Egypt's space agency chief in a recent interview. Sherif Sedky, CEO of the Egyptian Space Agency (EgSA), described Egypt's cooperation with China in the field of space technologies as "strategic" and "fruitful."

"Egypt's cooperation with China in the field of space is long-standing, the most important part of which is the establishment of the Satellite Assembly, Integration and Test Center (AITC), the largest of its kind in the Middle East and Africa, in addition to the design and manufacture of the MisrSat II satellite," said the EgSACEO.

The Egyptian Space Agency (EgSA) has recently launched a satellite for African development, a significant project designed to promote cooperation across the continent and enhance socio-economic progress using space technology. This satellite, scheduled for launch later this year, will offer essential data to bolster development efforts throughout Africa.

The satellite called "AfriSat-1" is a joint project by multiple African countries, led by Egypt in creating and launching it. AfriSat-1 aims to concentrate on important sectors like agriculture, climate monitoring, disaster response, and infrastructure development, offering detailed images and data to improve decision-making throughout the continent.

Dr. Mohammed El-Qousi, Chairman of the Egyptian Space Agency, emphasized the significance of the project for Africa. "AfriSat-1 represents a major milestone in our collective

efforts to harness space technology for the benefit of our continent," El-Qousi stated. "This satellite will provide valuable insights and data that are crucial for sustainable development and economic growth in Africa."

The initiative is part of Egypt's broader strategy to position itself as a leader in space technology within Africa and to promote regional integration through shared technological advancements. AfriSat-1 is expected to enhance capabilities in various sectors, including agriculture, where satellite data can improve crop monitoring and yield predictions, and environmental management, where it can aid in tracking deforestation and desertification.

The satellite project has garnered widespread support from African governments and international organizations. The African Union (AU) has endorsed the initiative, recognizing its potential to drive development and improve the quality of life for millions of Africans.

The satellite communication services segment in Egypt is represented by the commercial company Nilesat, which, operate communication satellite, Nilesat 201 (7°W) and two teleports. This satellite has a payload in Ka and Ku bands and is designed to serve users in North Africa and the Middle East. According to the operator, it delivers TV content to 270 million viewers and 56 million households. The key factor of the high load of the Nilesat 201 Ku-band beams can be considered the joint operation with Eutelsat in the orbital position of 7° W.

According to the technical parameters, the payload of Nilesat 301 is designed to operate in Ka and Ku bands. The Ku band will allow the provision of services in the states of Eastern and Southern Africa. It can be assumed that in order to increase the degree of use of the payload of this satellite, Egypt expects to use pan-African projects through the African Space Agency, which was formed in 2018, but has not yet passed the organisational stage. It is expected to begin operation on the basis of the international space centre being created in Egypt.

Recently, a Chinese Long March 2C rocket blasted off from the Jiuquan Satellite Launch Centre in China's northwestern Gobi Desert with the secretive payload. Very little is known about the satellite during its manufacture and launch. Its name is Horus-1, the God of royalty, of the sky, war and hunting in ancient Egyptian mythology. Very little is known about the most recent one it has put into space. It has remained top secret, both during its manufacture and its launch.

Egypt's latest satellite, Horus-1 "is a necessity for the country's growth", according to the space agency. The new observation satellite is dual-purpose, dedicated to military and civilian missions, which the EgSA president said will examine the soil of arable land, which will result in improving crop types, maximising profits and productivity.

Horus-1 will also monitor water sources, help anticipate natural disasters, monitor the occupation of state land and identify the location of illegal crops.

According to report, Horus-1 was manufactured by China's state-owned DFH Aerospace, with the participation of Egyptian engineers. **It has a mass of about 300 kilograms and has been positioned at an altitude of approximately 496 kilometres above the Earth.**

Emerging satellite governance framework



The Nigerian telecommunications industry is witnessing a revolution, largely due to the country's policy shift from monopolistic telecommunications markets to liberalized competitive markets. Today, the Nigerian Telecommunications market space is fully liberalized and totally private sector driven, having transited from full public driven sector through partial liberalization and now fully liberalized. Every segment including networks and applications services are open to competition and substantially licensed. This policy has brought about a substantial increase in foreign direct investment and unprecedented growth in network capacity and coverage in the country.

Recent statistics indicate that Nigeria grew from having one of the world's lowest teledensity rates with about 400,000 lines in 2000, to having over

147 million telecommunication subscribers by 2018. The NCC's statistics also indicate that Nigeria achieved a teledensity of 105.21 percent by the beginning of 2018 from 0.38 percent in 2000. Nigeria currently has the largest population of telecommunication subscribers in Africa, and also one of the largest in the world

The National Bureau of Statistics estimates that the telecommunications industry contributes about 8.69 percent to Nigeria's Gross Domestic Product GDP according to the rebased national GDP data. The industry is also regarded as the fourth pillar of the Nigerian economy in terms of GDP contribution and the fastest growing at a rate of 24 percent. Satellite internet has been around since 1996 with the introduction of Hughes Network System, where engineers applied existing satellite technology regularly used for radio and television to transmit

large files, drastically improving the connectivity experience over traditional dial-up technology.

The onset of new technologies comes with the promise of a more efficient and innovative future, but it also brings potential challenges and risks that must be carefully considered. Take the iPhone, for instance.

When Apple released the first iPhone, its enhanced user experience and appealing graphics were major advantages, but issues like inconsistent call quality and the lack of Bluetooth integration divided the cell phone user market. This is the same type of analysis that each sovereign nation must undertake when considering whether to adopt new technology to ensure that the rights and needs of their people remain the top priority.

Satellite governance framework

Satellite technologies have been providing telecommunications service throughout Nigeria for decades. Because satellites orbit far above the Earth, their footprint, or service area, covers nearly every part of Nigeria, providing instant, ubiquitous and reliable coverage.

In Nigeria, the Communications Satellite segment falls into Network services as well as Applications services. The segment, however, is dominated by foreign satellites with only Nigerian Communications Satellite playing in that space. Worthy of note is that the Network service segment is equally liberalized and open to Nigerians and foreigners alike who intend to launch satellites of Nigerian origin. Nigcomsat is

licensed by the Commission for the provision of Satellite services in Nigeria. The Nigerian Communications Act requires a license for any commercial communications transmitted via satellite to, from and within the Nigeria. Satellite transmission involves both a space station and an earth station to complete the transmission link. Thus, the commission licenses both space stations and earth stations.

Therefore, pursuant to its powers under Section 2 and Section 70(2) of the Nigerian Communications Act 2003 makes Guidelines to regulate the provision and use of all satellite communications services and networks, in whole or in part within Nigeria or on a ship or aircraft registered in Nigeria. The mandate and authority of the Nigerian Communications Commission NCC is derived from the Nigerian Communications Act 2003 NCA 2003.

According to Section 31, Subsection (1): No person shall operate a communications system or facility nor provide a communications service in Nigeria unless authorised to do so under a communications licence or exempted under regulations made by the Commission under this Act. In addition, Section 32, sub section (1) revealed that the Commission shall issue communications licences for the operation and provision of communications services or facilities by way of class or individual licences on such terms and conditions as the Commission may from time to time determine taking into consideration the objectives of this Act and the provisions of section 33(3) of this Act.

Based on the provisions of Section 121 sub section (1) Notwithstanding the provisions of any other written law but subject to the provisions of this Act, the Commission shall have the sole and exclusive power to manage and administer the frequency spectrum for the communications sector and in that regard to grant licences for and regulate the use of the said frequency spectrum.

Accordingly, "No person shall use or operate apparatus for the transmission of energy or communications or signals by space or earth stations except under, and in accordance with, an appropriate authorization granted by the Federal Communications Commission".

The Commission shall also ensure the protection from impermissible levels of interference to the reception of signals by earth stations in the Fixed Satellite Services from terrestrial stations in a co-equally shared band is provided through the authorizations granted under this part.

time determine taking into consideration the objectives of this Act and the provisions of section 33(3) of this Act.

Applicants and licensees of radio stations governed by this part must provide the Commission with the information required for Advance Publication, Coordination, and Notification of frequency assignment filings, including due diligence information, pursuant to the Radio Regulations of the International Telecommunication Union.

No protection from interference caused by radio stations authorized by other Administrations is guaranteed unless ITU procedures are timely completed or, with respect to individual Administrations, coordination agreements are successfully completed. A license for which such procedures have not been completed may be subject to additional terms and conditions required for coordination of the frequency assignments with other Administrations.

The Commission will submit filings to the ITU on behalf of an applicant, licensee, or other requesting party only after the party has filed a signed declaration of unconditional acceptance of all consequent ITU cost-recovery responsibility. Applicants and licensees must file the declaration electronically in the application file in the International Bureau Filing System (IBFS). The Commission will process and forward to the ITU up to five Advance Publication filings by an entity that are not accompanied by a complete space station license application.

The Commission may request from any party at any time additional information concerning any application, or any other submission or pleading regarding an application, filed under this part.

However, subject to subsection (3) of this section, the Commission shall from time to time determine and publish to the general public the communications services that qualify for class or individual licences or that are exempted from licensing.

Spectrum management

The Nigerian Communication Act confers spectrum management functions for the communications sector on the Commission and this includes the maintenance of records with respect to the use of the electromagnetic spectrum for wireless telegraphy at places within and outside Nigeria.

Accordingly, Section 121. Subsection (1) states that notwithstanding the provisions of any other written law but subject to the provisions of this Act, the Commission shall have the sole and exclusive power to manage and administer the frequency spectrum for the communications sector and in that regard to grant licences for and regulate the use of the said frequency spectrum. As observed in Section 122. Subsection (1) Subject to such exemptions as are contained in this Act or as may be determined by the Commission, no person shall intentionally transmit in any part of the spectrum to provide a service unless the person holds a frequency licence issued under this Part.

The Nigerian Communications Act confers spectrum management functions for the communications sector on the Commission and this includes the maintenance of records with respect to the use of the electromagnetic spectrum for wireless telegraphy at places within and outside Nigeria.

The Commission is required to decide whether to process an application for a satellite network filing based on the criteria set out in sections 4.4 to 4.9 of the Satellite Management Filing procedures for further processing with ITU.

In addition, applications and all related correspondence for satellite networks in planned and non-planned bands are required to be submitted by the applicant to NCC in electronic format, where possible, and in accordance with the format required by the ITU Space Services software.

So far, applicants must establish, that they have the required technical, financial and legal credentials to construct, launch and operate the proposed satellite system in conformity with their business plan. The applicant, according to NCC must be a company or organization registered, or having its headquarters, in Nigeria

Notwithstanding above, applicant must meet all relevant costs incurred by NCC and the ITU in the processing and coordination of the satellite network filing(s). Filing data, including alphanumeric data, is to be provided in electronic database format utilizing the latest versions of the ITU Space Services software.

Authorization for landing rights

All satellite space segment providers must obtain landing rights from the Commission before being allowed to provide services to users within the Nigerian geographical territory, including air space and territorial waters.

A satellite operator authorized by another Administration can request, on its own initiative, the authorization of the Commission to provide services in Nigeria. Once the approval of the Commission is obtained, a non-Nigerian space station is eligible to serve Nigeria and the name of that satellite shall be included in the list of "Authorized Space Stations".

All satellite space segment providers may permit only end-users who are licensed by the Commission to have access into their network either directly or indirectly through country representatives. Where an intermediate bulk agent or reseller in the supply chain leases a transponder or bandwidth from the space segment provider, for distribution to smaller users, the provider must ensure that all end-users accessing their network are licensed by the Commission before allowing access.

Space Segment providers must ensure that power flux densities of their transmitted signals are within the limits specified by ITU when the band in question is shared with terrestrial services.

Where the Licensee operate several satellites, a separate license is required for the constellation satellites in each separate band, especially C, Ku, Ka, since License conditions may vary from

band to band.

Space station authorizations

A license application filed pursuant to for a Geostationary Satellite Orbit, GSO space station or Non Geostationary Satellite Orbit, NGSO space station or space-station constellation must comprise a comprehensive proposal and must be submitted to the Nigerian Communication Commission.

For each space station transmitting and receiving antenna beam including telemetry and tracking beams but not command beams, applications must specify channel center frequencies and bandwidths and polarization plan. For command beams, specification should include each of the center frequencies within a 5 MHz range or a range of 2 percent of the assigned bandwidth, whichever is smaller, and the polarization plan. If the space station can vary channel bandwidth in a particular frequency band with on-board processing, specify only the range of frequencies in that band over which the beam can operate and the polarization plan.

Also, applicants must specify maximum EIRP and maximum EIRP density for each space station transmitting antenna beam. If the satellite uses shapeable antenna beams, specify instead maximum possible EIRP and maximum possible EIRP density within each shapeable beam's proposed coverage area. Provide this information for each frequency band in which the transmitting antenna would operate. For bands below 15 GHz, specify EIRP density in dBW/4 kHz; for bands at and above 15 GHz, specify EIRP density in dBW/MHz. If the EIRP density varies over time, specify the maximum possible EIRP density.

Due diligence

Finally, ITU Resolution 49 requires national administrations to make submissions to the ITU in respect of the construction and launch (including timings) of its satellite networks. In addition to the requirements of Resolution 49, NCC requires to receive commercial information from applicants for the purposes of due diligence to satisfy that a proposed satellite network has an adequate financial backing, that all relevant commercial and other contracts are in place or are about to be entered into and that there is a reasonable probability that the network will be brought into operation

According to section 41m sub section (1), the Commission shall, within 90 days of receiving an application for an individual licence under this Chapter, that is not the subject of a competitive bid process, howsoever called or designed, inform the applicant by written notice.

Within 90 days from the receipt of an application, the Commission shall be deemed, at the end of the period, to have refused to grant the individual licence unless the applicant receives a written notice approving the application for the individual licence after the period.





SATELLITE TRENDS

From Aalborg University to industry leader: GomSpace now manufacture one satellite each day

OGomSpace is a University spin-off founded on January 1, 2007 in Aalborg, Denmark by a group of 3 entrepreneurs; Lars Alminde, Karl Kaas Laursen and Morten Bisgaard, all of whom were Ph.D. students at the Aalborg University. The collective experience gained doing research and development at the university became the foundation of the company. Before the creation of the company, these entrepreneurs worked in different CubeSat projects, such as the European AAU-CubeSat, the AAUSAT-II, SSETI-Express and Baumanetz projects. The name of the company was gestated during their student years. Then, they were known as the "Grumpy Old Men" in academic circles as a consequence of their critical, enthusiastic and analytical approach to technology. The entrepreneurial spirit and their dream to "put something into space" drove them to become the world's first initiative takers for Nanosatellite missions.

Commercial from the start, GomSpace became an internationally recognized provider of Nanosatellites, subsystems and adjacent services. Headquarters at the Novi Science Park. NOVI Innovation A/S partially owned GomSpace. The first projects were carried out focusing on research with customers in the academic and science sectors. In 2008 the first hardware products were delivered to customers. The development of the company kept parallel to the CubeSats sector.

Company's business strategy

The mission of GomSpace is defined as," We help teams across the globe achieve their goals in space". This mission is supported by the company's vision, "To make Nanosatellites the preferred choice for customers who have demands for professional mission critical radio-based surveillance and communications solutions". In order to achieve that, the company defines its core strategy by being an" Independent horizontal supplier of technology for commercial service providers and government, education and research institutions – and spin-out activities in new untouched domains".

The company has defined key growth phases to follow along the years. The first one, the Current phase, is characterized by the building up of the company through investments in product development and facilities. The second one, the IOD phase, is characterized by a high degree of non-recurring engineering. Finally, the Constellation phase is based on the materialization of the IOD projects with high volume production. This will lead to new IOD projects.

GomSpace is nowadays transitioning between the Current and the IOD phases. Investments are still focused on the development of products and facilities, but the company already works on 4 IOD projects and is bidding on another 10. These 2 phases, the Current and the IOD, form the basis of the company's long-term goal of sales above SEK 1.5B by 2023 and the medium-term target of a gross margin over 50%. GomSpace offers in its portfolio two kind of products,

components and subsystems as a sub-supplier to other satellite manufacturers/operators or complete satellites or platforms called satellite solutions. The services and engineering involved in these projects also provide revenues. However, some are not yet available. They are viewed by the company in their business model as constellation management services and additional services. GomSpace can achieve profitability over time from this engineering effort as it could be re-used in similar projects. Thus, the company's movement towards the market's lead can be determinant to scale the business faster.

Nonetheless, the trend GomSpace is showing indicates that they are not interested in becoming a large-scale component supplier to competing satellite manufacturers but aims to be a full-service provider. That would include the satellites and adjacent services, launching services and constellation management. This trend is corroborated with the sales of 2017 and 2018. The first year showed that the sales were 65% of complete satellites and 35% of components. In 2018 the percentages varied to almost 80% and 20% respectively.

The strategy carried out by GomSpace can be summed up as" aggressively build out capacity in order to scale the business and be ready for the increase in demand when it comes". Its competitors have used less risky strategies growing with profitability, but their chances of keeping the pace of the rapid growing marked are much lower. GomSpace has secured a high market share with 32% announced planned CubeSats launches in 2019 and 42% in 2020. Thus, the strategy GomSpace has adopted seems to be working.

The beginning of first growth curve

By 2010, GomSpace started to investigate in air traffic monitoring capability and in 2011 they delivered their first integrated Nanosat platform. The team in 2013 announced the launch of GomSpace's first satellite, the GOMX-1. This experimental 2U CubeSat was developed by GomSpace in collaboration with DSE Airport Solutions of Aalborg, and the Aalborg University. Its primary mission objective was to demonstrate in space air traffic monitoring using its main payload, an ADS-B receiver based on Software Defined Radio.

Their secondary missions consist on qualification of other subsystems such as a NanoCam C1U colour camera for EO and system software. It successfully validated the feasibility of space based air traffic monitoring. At this point the company had 10 employees working for customers located in 30 countries.

However, the rapid growth of the Nanosatellite sector and its increasing commercial opportunities become the reasons behind GomSpace strategy shift in 2014. The company leaved its start-up phase and entered a growth phase with a new business focus. A renewed long-term vision embraced industrialization, aimed consolidation of the company and set the foundations for future large-scale Nanosats production. Regarding this expansion, an experienced CEO, board member and chairman of several companies, Niels Buus, was designated as managing director. However, this year also witnessed how the company second satellite mission couldn't get in orbit due to a launch failure of the cargo vehicle.

The GOMX-2 2U CubeSat primary mission was to evaluate components in space such as optical communications, new generation Software Defined Radio and a high-speed transceiver. However, in 2015, GomSpace's third Nanosat was successfully launched. The GOMX-3 3U Cubesat was a collaborative mission with the European Space Agency that began in 2014 and exceeded all expectations at its re-entry in 2016. Its objective was to demonstrate advanced capabilities and performance of 2nd generation ADS-B signal reception and geostationary telecommunication satellite spot beam signal quality through a reconfigurable SDR receiver. In addition, a third-party payload was flown in a miniaturized high data rate X-band transmitter from Syrlinks.

At the height of its momentum, GomSpace reached the yearly 1000 CubeSats subsystems delivered mark for the first time in 2015. 2016 was a key year for the development of GomSpace. On June 16 2016, the company was listed at Nasdaq First North Premier in Stockholm founding GomSpace Sweden. This provided GomSpace with additional capital and strengthened its position in the sector.

The company's founders also initiated projects based on their expertise. First, this was reflected in the agreement with the Danish Defence to deliver satellites for ships and airplanes traffic surveillance in the arctic, and the collaboration with Aerial & Maritime Ltd., to provide satellites with the same purpose for near equatorial surveillance, emphasizing in Africa.

In the same line, GomSpace agreed to provide radio platforms and antennas for the HawkEye 360 Pathfinder mission. Finally, the delivery of a full CubeSat platform was done to AISTECH. This company plans to set up a CubeSat network of 25 satellites capable of asset tracking and bidirectional communication, thermal imaging from space, aviation tracking and position management. It should be fully operative by 2020.

Finally, the Initial Public Offering came with positive growth consequences. The group acquired NanoSpace AB, completing their portfolio with satellite propulsion systems. The acquisition from the Swedish Space Corporation strengthened GomSpace market position in Sweden as well as adds participation in projects funded by the ESA. With

the goal of facilitating access to launch services for the group customers, GomSpace opened a new subsidiary in Denmark, GomSpace Orbital ApS. This movement was done expecting contribution on a long-term basis. The group also increased the ownership of the subsidiary Aerial & Maritime Ltd to 47.3% based on the turn-key contract of CubeSats at low inclination Equatorial orbit.

GomSpace would design, deliver, launch and commission the constellation of Nanosats. By the end of the year, GomSpace Sweden AB counted with 77 employees, 43 more than in 2015 from 30 staff and 61 more than in 2014 with just 16 employees.

The year 2017 was sweet for the GomSpace group. After restructuring in 2016, the company's growth turned out to be higher than planned. Thus, the number of employees raised up to 176, 99 more than the previous year. Among them, the management team acquired experienced people in similar positions to handle the growth challenge. The new board of directors impuled the parent company change of name from" GS Sweden AB" to "GomSpace Group AB".

More subsidiary offices were opened around the world; in Singapore, USA and Luxembourg. The first two will help operate the company's activities in their respective continent markets though GomSpace ASIA Pte Ltd and GomSpace North America LLC. The third one, GomSpace Luxembourg S.A.R.L., comes as a partnership with the Luxembourgian government to operate satellite constellations, data processing and distribution offered as a service. The office must count with 50 workers by 2021.

GomSpace headquarters also experienced an update with the new office spaces on Langagervej in Aalborg, Denmark, covering about 6,500m. The intention behind it is to develop a new production area capable of manufacturing" one satellite a day". Regarding the company's accelerated expansion, GomSpace issued 1.75 million shares in order to strengthen the company's financial position in a short timeframe. Directed to a selection of Swedish and international institutional investors, the private placement resulted at SEK 95 million. In addition to this, another economic injection arrived in the form of a grant by the Innovation Fund Denmark. The DKK 2.5 million contract aims to develop a large constellation management system and new radio components to improve broadband constellation communication.

Nonetheless, other major events occurred to GomSpace in 2017. The most important

happening in February, when the company sealed a procurement agreement with Sky and Space Global (UK) Ltd., to develop and deliver a constellation of 200 satellites. With the first satellite planned to be delivered in 2018, the 4-year-period delivery agreement is valued between EUR 35 million and EUR 55 million respectively. A similar agreement occurred with already-customers AISTECH. GomSpace agreed to supply up to 100 CubeSats for their constellation. The framework agreement was valued up to EUR 12.5 million. Related to the office opening in Singapore, GomSpace also signed a Memorandum of Understanding (MoU) with the Civil Aviation Authority of Singapore (CAAS) and Singapore Technologies Electronics.

It aims to explore the application and deployment of space-based Very High Frequency communications in the Singapore region for air traffic management. GomSpace associated company A&M obtained an investment of USD 5 million to work in their CubeSats constellation. The consequences of the investment include the expansion of the constellation to 8 Nanosats, a solid foundation that will accelerate the development of the company and the reduction of GomSpace ownership share in this spin-off company from 47% to 39%.

At the beginning of 2018, a constellation of 2 6U Cubesats was launched, the GOMX-4. The project included the Technical University of Denmark, the Danish Defence and ESA. Its main purpose was to demonstrate satellite communication between CubeSats using Inter-Satellite Link. The two satellites shared the operational components and primary Inter-Satellite Link payload but differed in their secondary payloads. The GOMX-4A incorporates ADS-B, AIS and imagery payloads. On the other hand, the GOMX-4B is equipped with a propulsion module, a Chimera board, an Hyperspectral camera and a star tracker.

During the year, many in Orbit Demonstration projects were started, showing a favourable development of the company and the sector. But more specific contracts were signed. The ESA signed a EUR 1.575 million contract with GomSpace to develop the Mega-Constellations Operations Platform (MCOP) at the Luxembourg's office. It aims to offer constellation operations services for small satellites. The close partner and client AISTECH entered a contract to acquire 6 CubeSat platforms for EUR 1.4 million under the framework agreement previously signed. Kleos Space agreed on a contract with GomSpace that will provide them with a CubeSat constellation for an approximated value of EUR 4.42 million. Finally, A&M inked a MoU to develop a satellite constellation and ground network worth USD 100 million.

Regarding the success of the company, GomSpace revised its long-term targets during 2018. This included targets for sales over SEK

1.5B in 2023 and gross margin above 50% in the medium term. Moreover, the growing market in which the company operates makes GomSpace to continue prioritizing growth, meaning that shareholders should not expect dividends in the short to medium term.

Financial capital was also captured through 2 new issues of shares. In March an accelerated book building procedure was carried out to finance and facilitate accelerated expansion. The issue provided SEK 125M and was intended to Swedish and international institutional investors. The second issue occurred at the end of the year. This preferential rights issue was subscribed for by 84.5% and GomSpace received about SEK 251 million in proceeds amounting before transaction costs. This almost doubled the company's capital and number of shares, resulting in about SEK 3.66M and 52.27 million respectively.

The year 2018 also brought an important downturn. Sky and Space Global missed the payments of overdue invoices at SEK 33.317 million related to the Critical Design Review amounting to SEK 20.55 million and the payment for Batch 1 running into SEK 12.766 million. Working capital was negatively affected with a relatively low gross margin of 25%. The project was scaled down to minimums and later put on hold. This led to overcapacity and therefore re-direction of resources to other projects as well as non-revenue generating activities. The low capacity utilization resulted into reductions in staff at the end of 2018. After the reduction, the number of employees was recorded at 231, still 32 more than a year before.

2019 started with the announcement of a new payment plan for Sky and Space Global after the analysis of their cash flow situation. It was found that they would be able to solve their economic situation. The payment would be eventually received by March 2019. During the first quarter of 2019 GomSpace signed a contract with the ESA to join the advanced Nanosatellite HERA mission as well as a MoU with 2Operate to boost constellation management with AI. The first one will see GomSpace develop a 6U CubeSat for scientific tasks and eventually landing on the Didymoon asteroid, named Juventas. It will be the first deep space CubeSat developed by GomSpace. The MoU with 2Operate seeks to evaluate terrestrial telecom standards and existing AI solutions in future satellite constellations in a robust and efficient way. This strengthens both companies collaboration regarding the MCOP project at the Luxembourg office.

EO Market Segment

GomSpace's competences is based on radio technology. This technology has turned out to be specially interesting for Nanosatellites due to its size and capabilities. Consequently, the

company offerings are dedicated to the Nanosatellites sector. The revenues come from 5 different sources, including subsystems, complete platforms, payloads, constellation management and additional services.

The company profitability relies on the fact that the engineering time can be re-used in similar projects. The modularization and versatility of the components make them adaptable to be incorporated in CubeSats with diverse purposes and missions. GomSpace supplies components as well as complete projects, but their main goal seems to become a full-service provider. They are becoming reluctant to supply components to competing satellite manufacturers while the launch services and constellation management functions keep building up.

GomSpace focuses its sales in 4 different business segments; Academia, Commercial, Defense and Science. The biggest segment is the Commercial, due to the Sky and Space Global and AISTECH major contracts. The Science segment has gained more weight with time, becoming the second most important segment and diminishing the Academic. The Defense segment appears with a marginal revenues percentage in last position. It is observable that almost three fourths of the revenues of GomSpace come from the Commercial segment.

The GomSpace business segments also have different importance around the world. The company distributes its sales revenues in 6 geographical regions. GomSpace divides its major goods or services between satellite solutions and platforms, payloads and subsystems. The satellite solutions refer mostly to entire CubeSats platforms while the other group gathers the subsystems and payloads sold separately. During Q1 2019, 75% of revenues were from satellite solutions while only 25% were due to the second group.

At GomSpace, the global tracking of assets by satellites is starting to be widely generalized. The information broadcasted is standardized and gains relevance with time. GomSpace has strong experience with vessels and aircrafts tracking through the reception of AIS and ADS-B signals respectively. These technologies have been improved through their GOMX-1 and GOMX-3 missions. Thus, GomSpace is able to develop entire on-demand Nanosatellite constellations for tracking based on high coverage and revisit times. In addition, other tracking solutions can be designed using their radio technology payloads building blocks. Some companies like A&M or AISTECH already benefit from this solution.

At the moment, full two-ways communications between various devices is gaining importance nowadays. GomSpace provides it through satellite based IoT, allowing remote management of assets, herd tracking, fleet management or smart metering. In order to implement the IoT technology, GomSpace based the solution on their RF and signal processing experience. That includes low-power front-end electronics, Software Defined Radio, signals ranging from high-frequency to Ka-band, the utilization from simple monopole antennas to complex patch arrays and complex signal processing. Finally, GomSpace also assists with the corresponding IoT ground terminals.

Similarly, GomSpace provides a more generalized communications solution than the previous ones. Based on the aforementioned RF and signal processing experience, the company developed the bespoke communications system. It includes advanced features such as ISL capabilities, satellite power generation and distribution to support demanding radio payloads and station keeping capabilities. This technology was tested onboard the GOMX-3 mission. Sky and Space Global benefits from it.

GomSpace views EO Nanosatellites as a cost-efficient entry level platform before going to higher resolutions. These cost-effective constellations can provide medium resolutions with high temporal update rates. GomSpace has developed different systems for EO purposes such as IR, hyperspectral and optical sensors. The GOMX-4 mission aims to demonstrate new hyperspectral imaging payloads for GomSpace.

Military, intelligence and security solutions have special requirements that GomSpace claims to be able to provide. Tested and well-proven platforms may include the previous 4 solutions; tracking, IoT, communications and remote sensing. However, unique defence projects also need skilful handling. For instance, discretion, strong data encryption and other cyber-security measures. New space based capabilities integrated into Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) infrastructures and additional Electronic countermeasures resilience are required. GomSpace has vast experience in this field, participating in projects like the Ulloriaq Arctic Surveillance/GOMX-4 project with the Danish Defense or the HawkEye360.

According to GomSpace, science missions helps to understand the universe and beyond can get benefited from cost-efficient Nanosatellites. They can also be used as a first approach before big ticket missions. The company offers science customers a flexible product portfolio that can result in effective mission platforms. They may include mature propulsion technology, ideal for deep space attitude control, formation flying, rendezvous and docking. GomSpace claims to be experienced in space missions, understanding and supporting them with low costs and risks.







SATELLITE TRENDS

How iceye is leading the charge in the new space economy



The recent decade has witnessed a considerable rise in space exploration from different private companies. One company that has successfully managed to enter the space exploration sector is ICEYE.

Founded in 2014, it is a Finnish company that provides detailed information about the world via satellite imagery which serves the entire globe and was founded by Rafal Modrzewski and Pekka Laurila. Since its inception, the company has grown steadily; its objectives have proven to be essential in the world, leading to funding from different sources to develop the company.

In 2014, the company proved that synthetic aperture radar could be applied to monitor dangerous ice features like pack ice. The company received a €2 million

grant from the Horizon Programme of the European Union, which aimed to determine whether the ICEYE SAR system could be integrated and pilot-tested to perform its functions. It was also an opportunity for the company to attract more private investors by showing what they were capable of.

The company's growth over the years proved that it was becoming successful, especially in a period where large space corporations like NASA, Blue Origin, and SpaceX dominated the industry.

ICEYE funding

ICEYE has received over €300 million in funding since 2014. This includes investments from Space Capital, the European Investment Fund, and the British Business

Bank. The first round of funding came in 2012 from the EU Executive Agency for SMEs, which provided €2 million in grants. After that, ICEYE received €13 million in Series A funding in 2017. The funding round was led by DNX Ventures and had the objective to scale up operations, including manufacturing the company's SAR technology built from off-the-shelf components and launching additional satellites.

In January 2018, ICEYE became the first organization in the world to launch a SAR satellite with a launch mass of under 100kg. In May of the same year, the company raised €34 million in Series B financing. The capital was allocated to enlarge the analytics services for its clientele, refine its SAR satellite system, and finance further launches of ICEYE SAR satellites.

ICEYE track record of successes continued over the years, and in September 2020, the company announced its Series C stage for €87 million, led by returning investor True Ventures. Starting with the first-ever small SAR satellite launched in January 2018, ICEYE has successfully launched 5 satellite missions.

This funding enabled ICEYE to speed up the expansion of its Synthetic Aperture Radar (SAR) satellite network with more satellites, making data accessible around the clock for all continents, carrying on the progress of innovative radar imaging technology, and creating a spacecraft production facility in the United States.

In February 2022, ICEYE secured the latest funding round up to date.

An additional €136 million were raised in Series D funding, bringing the total funding to €304 million since 2014. At this point in time, ICEYE has launched 16 satellite missions since its beginning in 2018, and with the new capital, the company is hoping to increase the size of its satellite constellation and technology, which will lead to faster access and more frequent visits to their satellites.

US Expansion

ICEYE's expansion into the United States represents an exciting opportunity for the company to tap into the world's largest space-based products and services market. The United States has a vibrant and growing space industry, with a strong demand for advanced imaging and remote sensing capabilities. By establishing a presence in the United States, ICEYE will be well-positioned

to serve this market and capture a share of the growing demand for space-based data and services.

In addition to the size of the market, the United States also offers several other advantages for ICEYE. The country has a well-developed infrastructure for launching and operating satellites, as well as a strong network of partners and customers. This will provide ICEYE with the resources and expertise it needs to successfully grow and expand its operations in the United States.

The expansion into the United States also represents a strategic opportunity for ICEYE to extend its reach and gain access to new customers and markets. By establishing a presence in the United States, ICEYE will be able to expand its satellite constellation and provide

more frequent and accurate imaging of the Earth's surface. This will enable the company to better serve its existing customers and attract new ones, helping it to continue its rapid growth and expansion.

Progress of ICEYE throughout the years

ICEYE is an innovative space technology company 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. 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.

well-positioned to remain a leader in the space industry for years to come.

Partnerships in the New Space Economy

ICEYE has established partnerships with a number of companies and organizations in the aerospace industry in order to advance its mission of providing high-resolution imaging and data collection from space. These partnerships include collaborations with other satellite operators and manufacturers, as well as partnerships with organizations that use satellite data for a variety of applications.

One of ICEYE's key partnerships is with Airbus Defence and Space, with whom they have collaborated on the development and launch of their satellites. This partnership has allowed ICEYE to access Airbus's expertise and technology, as well as its global network of satellite ground stations.

The collaboration with Airbus has been instrumental in helping ICEYE to launch and operate its fleet of satellites and has helped to position ICEYE as a leading player in the new space economy.

ICEYE has also partnered with companies and organizations that use its satellite data for a variety of applications. These include partnerships with insurance companies that use ICEYE's imagery to assess damage from natural disasters, as well as partnerships with governments and organizations that use the data for environmental monitoring and disaster response.

These partnerships have allowed ICEYE to expand the reach and impact of its satellite technology and data and have helped to demonstrate the value and usefulness of satellite imagery and data for a wide range of applications. In addition to its partnerships with other companies and organizations, ICEYE has also established partnerships with academic institutions and research organizations. These partnerships have allowed ICEYE to access the latest research and expertise in the field of satellite technology and Earth observation and have helped to drive innovation and progress in the space industry.

For instance, ICEYE has partnered with the European Space Agency (ESA) on a number of research and development projects and has worked with universities and research institutes to develop new technologies and applications for the satellite data. Another important aspect of ICEYE's partnerships is its collaboration with other satellite operators and manufacturers. This has allowed ICEYE to share knowledge and expertise, as well as to pool resources and capabilities in order to advance the state of the art in satellite technology. For example, ICEYE has partnered with Arianespace, the world's leading satellite

launch provider, to launch its satellites into orbit.

Overall, ICEYE's partnerships have been critical to the success and growth of the company. By collaborating with other leading companies and organizations in the space industry, ICEYE has been able to accelerate its progress and expand the reach and impact of its satellite technology and data. These partnerships will continue to be an important part of ICEYE's strategy moving forward, as the company looks to unlock the full potential of the new space economy.

ICEYE technology use cases

The use cases of ICEYE Technology are varied and include applications in a variety of markets such as agriculture, disaster management, maritime, security, mapping, and many more. The most prominent use case of ICEYE Technology is the monitoring of crop health and crop performance.

ICEYE is able to monitor the health of crops with its high-resolution SAR imagery and multi-spectral images. Using this data, farmers can gain an accurate, real-time view of their crop health and performance. This data can then be used to accurately plan and adjust farming activities, such as fertilization, irrigation, and pest control.

Another use case of ICEYE Technology is the monitoring of natural disasters. A SAR system can provide accurate and detailed information on the location and severity of natural disasters such as floods, earthquakes, and landslides. This information can then be used to aid in disaster management and relief efforts. SAR data can also be used to track the disaster's progression and predict future disasters.

A third use case of ICEYE Technology is maritime surveillance. ICEYE's SAR system can provide detailed information on the location, size, and speed of ships in the ocean. This information can be used to identify illegal activities such as drug and human trafficking, as well as to monitor the movement of ships in shipping lanes to prevent collisions.

Finally, ICEYE is being used for security and defence applications. The SAR system can be used to detect and identify objects, such as vehicles and people. This data can then be used to monitor borders, detect intruders, and protect

critical infrastructure.

Challenges faced by ICEYE

Funding is perhaps one of the most critical challenges faced by New Space Companies like ICEYE. Space Venturing is highly capital intensive and requires extensive support from different sectors to emerge successfully. The astronomical costs of setting up a Space Company need to be considered well enough before venturing into this sector.

Securing initial capital investment for ICEYE was a major hurdle. Although the company is doing considerably well today, it is important to understand that funding remains a major issue. The company is constantly innovating better ideas and new approaches to space exploration. Specifically, SAR technology requires research that costs a lot of money.

This puts intense pressure on the company as it constantly seeks investors and private individuals to pump adequate finances into it. The industry is also highly competitive, leading to whether the funding received would be successfully translated to value for their clients.

Technology development is another major challenge experienced by companies like ICEYE. Having a unique and reliable product requires extensive research, resources, and dedication from the company. It means that better technological alternatives have to be developed to realize it. Without the necessary technological advancements, it would be impossible to develop the space technology that is currently being used at ICEYE.

Companies that have been in this sector for longer have more advanced technology than new start-ups. The resources required to develop new technology in space exploration can be so demanding to a point of halting certain operations in the company.

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.

Shortly, it will likely focus on developing more advanced satellite technology capable of collecting higher-resolution images and data sets as well as more accurate positioning and tracking. In addition to its own products and services, ICEYE is also partnering with other space companies such as Spaceflight and launch provider Rocket Lab to develop new applications in the space economy.

For instance, the company has recently announced its collaboration with Rocket Lab on the development of a new satellite-based tracking system. The system would allow users to track and monitor objects in space, enabling them to conduct space exploration with greater accuracy and efficiency.

As the space economy continues to grow and develop, ICEYE will remain at the forefront of innovation and technological advancement. In the coming years, the company will continue to improve its existing products and services, develop new applications for the space economy, and partner with other companies to make space exploration more accessible to everyone. The sky is not the limit for ICEYE, the future of space exploration is only beginning.

The new space economy has revolutionized the way we look at the world and what is possible from a business standpoint. ICEYE is a prime example of this revolution, providing insight into the power of satellite imagery and the potential for leveraging its capabilities to increase our understanding of the earth, optimize business processes, and generate revenue.

As ICEYE continues to evolve and grow, its innovations will undoubtedly continue to shape the future of the new space economy. With these technological advances, we may soon see the dawn of a new era in which space-based businesses become commonplace and reap the benefits of these new opportunities.

Moving forward, ICEYE is committed to driving innovation and collaboration in the space industry, to unlock the full potential of space technology and its applications. Continues R&D investments are required, but also partnerships with other companies and organizations in the space industry are key. By working together, ICEYE and its partners can help to accelerate the growth of the new space economy and create a brighter, more sustainable future for us all.

SATELLITE TRENDS

Large financings reached a new high in Q2 2026



Q2 2026 marked a landmark moment for the commercial space sector as SpaceX completed its long-awaited IPO, listing on Nasdaq under the ticker SPCX. The company initially priced 555.6 million shares at \$135 per share, raising approximately \$75bn.

Following the full exercise of the underwriters' over allotment option, gross proceeds increased to approximately \$85.7bn, making it the largest IPO in history. Shares traded significantly higher following the listing, briefly pushing SpaceX's market capitalization above \$2tn. The significance of the IPO extends far beyond its scale.

Few would have predicted a decade ago that a space company would become one of the world's most valuable listed businesses, ultimately joining the ranks of the

Magnificent 7 alongside the dominant technology platforms of the internet and AI eras. The milestone reflects SpaceX's evolution from a launch provider into a diversified infrastructure platform spanning launch, communications, national security, space transportation, and AI. Beyond the record-breaking financing, the IPO is likely to create a powerful positive feedback loop across the broader Space technology ecosystem. The listing has generated substantial liquidity for early investors, employees and founders, creating a new cohort of wealthy stakeholders with deep sector expertise and established conviction in the long-term growth of the space economy. As seen in previous technology cycles, a portion of

this capital is likely to be recycled into the next generation of startups through angel investing, venture funds and company formation.

Shortly after SpaceX's record-breaking IPO, Blue Origin reportedly launched its first-ever external fundraising round, seeking approximately \$10bn at a reported \$130bn valuation. The move marks a significant departure for a company that has historically been funded almost exclusively by Jeff Bezos. The fundraising comes despite near-term headwinds. In late May, one of Blue Origin's New Glenn rockets exploded during a static hot-fire test, delaying the company's progress in the heavy-lift launch market.

Nevertheless, Bezos and CEO Dave Limp have set an ambitious target to return New Glenn to flight by the end of 2026. If completed,

the transaction would be the largest private financing ever raised by a SpaceTech company and would further reinforce the exceptional capital formation environment in the sector.

Shortly following the close of the quarter, China successfully completed its first-ever controlled recovery of an orbital rocket's first stage, marking a major milestone in the country's pursuit of reusable launch technology. During the maiden flight of the Long March-10B rocket from Hainan on 10 July 2026, the booster separated from the upper stage, performed a guided powered return, and was captured by a net mounted on a sea-based recovery platform, a world-first approach that differs from SpaceX's drone ships and landing pads.

The achievement marks the first time a nation other than the United

States has demonstrated a controlled propulsive return of an orbital-class booster. While China remains behind SpaceX's Falcon 9 in operational cadence and reusability, it has now achieved the critical technological milestone required to unlock lower launch costs and higher launch frequency, further intensifying competition between the Chinese and US space ecosystems.

Amazon's \$11.6bn acquisition of Globalstar and Rocket Lab's \$8bn acquisition of Iridium highlight that the most valuable assets in satellite communications are often not the satellites themselves, but the spectrum rights, customer relationships and regulatory approvals behind them. For Amazon, Globalstar brought licensed mobile satellite spectrum, an operational satellite network, and an established relationship with Apple, whose iPhone and Apple Watch satellite services already run on the

network.

The acquisition accelerates Amazon Leo's direct-to-device ambitions, allowing it to enter the market with existing customers, distribution channels and globally authorised spectrum already in place. Rocket Lab's rationale was similar. Iridium provides a global communications network, licensed L-band spectrum and a large base of government, enterprise and industrial customers that would have taken years and billions of dollars to build organically. The deal also transforms Rocket Lab from a launch and spacecraft manufacturer into an operator of critical communications infrastructure, significantly expanding the company's addressable market.

The startup round up
Helsinki-based Iceye operates world's largest constellation of intelligence gathering radar satellites.

The business has raised more than \$450m of venture capital investment, making it one of Europe's best financed SpaceTech and defense related startups.

Iceye was recently ranked by Fast company as the 20th most innovative company in the world and the second most innovative company in the space sector. Most satellites use optical camera similar to those found in a smartphone to capture information about the earth. However, these optical cameras and sensors don't work for two-third of the world, as at any one time they are covered by cloud or darkness.

In order to collect actionable, timely intelligence, it is essential that you can do this regularly and reliably. Unlike optical cameras that can't see in the dark or through clouds, Iceye's satellites use radar to create synthetic images known as synthetic aperture radar or SAR to image the earth day and night, rain or shine. Prior to Iceye, only a handful of wealthy governments could afford these SAR satellites since it typically cost hundreds of millions for each satellite. By taking a novel approach and looking to repurpose microelectronic components designed for terrestrial applications, ICEYE was able to reduce both the size and cost of these satellites by a factor of 100x. This has enabled Iceye to launch a constellation of 48 of its satellites, making it the biggest commercial SAR constellation in the world. These satellites are capable of capturing information anywhere on earth every hour at a resolution of as little as 25 cm. When fused with AI this data can be extremely powerful generating actionable intelligence about change anywhere on the planet that Iceye's technology has detected in close to real time.

Iceye support the intelligence gathering of governments and militaries by selling images taken by their satellites in addition to selling nation states their own satellites where there's pressing need for sovereign control. Iceye's government customers span North and South America, Europe, the Middle East and Far East. Iceye is able to serve customers worldwide because, unlike American-based competitors, they are not restricted by US ITAR export controls.

HawkEye 360 is the world's leading commercial provider of Space-based radio frequency ("RF") data and analytics. It operates its own constellation of satellites to collect, identify, process and geolocate a broad set of RF signals generated on

Earth from very high frequency radios, radars, cell towers, satellite phones, emergency beacons and more. Its advanced analytical products help first responders save lives, law enforcement halt hidden illegal activities such as illegal fishing and telecoms operators utilise spectrum. Its capabilities include mapping signals of interest, creating surveys of global spectrum usage and providing deeper visibility of maritime activities. In November 2021, the Company invested \$25.0m (£18.7m) in the company's \$145m Series D funding round. The Company was the co-lead investor in this round alongside Insight Partners.

Astroscale is the global leader in the Space sustainability market. The company has built a set of capabilities around in-orbit monitoring, refuelling, upgrading, repairing and disposing of satellites. Ongoing and planned missions are focused on demonstrating capabilities around end-of-life disposal of low Earth orbit satellites, active removal of Space debris and life extension of satellites. In November 2021, the Company invested \$12.5m (£9.4m) in the company's \$112m Series F funding round. The round was led by THE FUND Limited Partnership in Japan and also included backing from Japan Growth Capital Investment Corporation and AXA Life Insurance Co.

Pixxel is developing a constellation of satellites for the frequent collection of high-resolution hyperspectral imagery. Its imagery has the ability to 'see' in 50x more detail than conventional optical images in spectral bands invisible to the naked eye. The data is used to better understand the chemical contents on the ground, which is crucial for sustainability applications such as the monitoring of crop health, measuring climate risk, classifying biomass or detecting pipeline leaks. The business launched its first satellite in April this year and is currently completing trials with a roster of large corporate customers primarily across agriculture, mining and carbon sequestration. In March 2022, the Company invested \$3m (£2.3m) in the company's \$25m Series A funding round led by Radical Ventures. The funding is being used to deploy the first phase of Pixxel's constellation.

Tomorrow.io is an innovator in the weather prediction market offering actionable insights to enterprise customers. It offers decision-making services to industries particularly impacted by weather including aviation, railways, shipping, utilities, insurance and logistics. Customers receive hyper-local weather-based information paired with recommendations for operational decision-making such as staff rotas and consumer communications. The business provides its services to customers through its enterprise software as a service ("SaaS") web and mobile platforms powered by proprietary

AI analytics. It is currently also developing a radar and microwave-based weather satellite constellation to expand its source data and enhance its product capabilities. In June 2022, the Company invested \$5.0m (£4.2m) in the business. The funding is being used to advance the development of the business' satellite constellations.

Follow-on investments
£51.3m of additional funding was invested into nine companies during the period. This deployment was consistent with the strategy articulated at the time of the Company's IPO of seeking to increase the level of support for those portfolio companies which we have the greatest conviction in.

In July 2021, the Company invested \$3.1m in LeoLabs, which is the world's first and only supplier of commercial radar tracking services for objects in low Earth orbit, through a combination of primary and secondary share subscriptions. This investment formed part of the company's \$65m Series B funding round, which was led by Insight Partners. The funding is being used to continue the build out of LeoLabs' network of antennas around the world, with new sites continuing to be added in line with expectations.

Commercial contract wins during the period included OneWeb, which means LeoLabs now has the world's three largest constellations, Starlink, OneWeb and Planet – as customers. As a result, the company is providing operational support for more than 2,400 active satellites, representing approximately 60% of all operational satellites in lower Earth orbit.

In August 2021, the Company invested a total of \$2.6m in Xona Space Systems which is developing the world's first smallsat GPS constellation in low Earth orbit which has the capability of addressing the shortcomings of public GPS systems by delivering centimetre level accuracy along with enhanced security. This formed part of Xona Space System's \$10m Seed funding round where the Company was the lead investor. In May 2022, the Company invested a further \$2.5m (£2.0m) in a \$12.5m convertible loan note round which included investment from Lockheed Martin. The latest funding will be used to launch and test the company's initial demonstration satellite payloads, the first of which was

launched into orbit in May 2022.

In September 2021, the Company invested \$25.0m in the \$37m Series B funding round of ALL.SPACE (formerly Isotropic Systems), which has developed an antenna which can connect up to 5 satellites uniquely in any orbit (LEO, MEO and GEO). This provides resilient connectivity for mobility in cars, boats and planes addressing a multi-billion Dollar market opportunity. The Company was the lead investor in this round, investing alongside AEI Horizon and Promus Ventures, with the funding being used to bring the company's first product to market. Post investment, ALL.SPACE achieved all targeted technical milestones, winning significant contracts through the period with marque customers in the communications and defence markets.

In October 2021, the Company invested £4.0m in Satellite Vu, which is developing an infrared imaging satellite constellation with high resolution which is capable of monitoring the heat signature of any building on Earth every few hours. The Company was the lead investor in the £15m Series A funding round investing alongside Molten Ventures, Contrarian Ventures, In-Q-Tel and Lockheed Martin Ventures. The funding is being used to launch Satellite Vu's first satellite, which is expected to take place in 2023.

In December 2021, the Company invested \$25m in the \$136m Series D funding round of ICEYE, originally one of the Retained Assets. The Company was the lead investor in this round investing alongside BAE Systems, Cobham Ventures, True Ventures and Molten Ventures. ICEYE has built the world's first and largest constellation of miniaturised satellites that use radars to capture information about the Earth, day and night and in all weather conditions. The funding is being used to continue to build out the company's constellation and further develop its information solutions for monitoring and mitigating natural catastrophes.

In February 2022, the Company invested \$2m in Edgybees, a software company which has developed an AI powered augmented reality platform using satellite data for real-time information overlays for any video stream enabling defence, public safety and critical infrastructure command centres to accomplish life-saving missions. The Company invested as part of an internal \$8m bridge round to further the company's capabilities for standardising satellite imagery from any source.

Spire Global has in recent quarters delivered consistently strong results, with recurring revenue as at 30 June 2022 of \$85.3m, a year-on-year increase of 133%. Spire has a broad customer base which it serves with data and analytical products drawn from its giant satellite constellation of over 100 smallsats, which collect advanced weather data and tracks maritime and aviation traffic flows. With \$72.5m of cash and access to a \$120m credit facility at 30 June 2022, the business has indicated that it is now funded through to cash flow breakeven, which it expects to achieve within the next 24 months. In line with our continuing confidence in the company, we invested an additional £2.5m into the company in early 2022.

Although the timing of the launch of its first demonstration satellite suffered from a series of delays, AST SpaceMobile has made solid progress launching its first satellite, BlueWalker 3, in September 2022, the largest satellite ever launched in low Earth orbit. AST SpaceMobile is now undertaking in-orbit direct-to-cell phone testing on six continents, including North America. It has now filed in excess of 2,400 patent claims worldwide and has developed relationships with mobile network operators who collectively have more than 1.8bn subscribers around the world. The business had in excess of \$200m of cash and cash equivalents at 30 June 2022.

With SpaceX now trading alongside the world's largest technology companies, space has firmly entered the mainstream as an investable category in its own right. The industry's maturation is increasingly attracting broader pools of capital and expanding the universe of investors able to participate in the sector. We are particularly interested in the second-order effects that may follow. As early SpaceX employees and investors realise liquidity, we expect a new wave of founders, operators and angel investors to emerge, creating a virtuous cycle of talent, capital and company formation across the space ecosystem.

At the same time, global competition is intensifying. China continues to close the capability gap through advances in reusability, the deployment of large-scale satellite constellations, and the emergence of domestic space champions pursuing public market listings. This increasingly competitive geopolitical backdrop is also helping drive investment into defence and national security-focused space companies, including businesses such as True Anomaly, Starfish and Turion. While we would not expect every quarter to replicate the exceptional funding levels seen in Q1 and Q2, a potential \$10bn Blue Origin raise would further extend what is already shaping up to be the strongest funding environment in the history of the space sector.





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